

451

BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL
WESTERN ZONE BENCH, PUNE

ORIGINAL APPLICATION NO. 168/2024 (WZ)

IN THE MATTER OF: -

PRATAP LAL TELI

APPLICANT

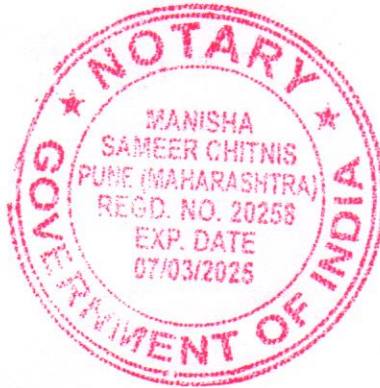
VERSUS

MEMBER SECRETARY, STATE LEVEL
ENVIRONMENT IMPACT ASSESSMENT
AUTHORITY AND ORS.

RESPONDENT(S)

INDEX

S. no.	Particulars	Page no.
1.	Reply on Behalf of Respondent No. 3 i.e. Central Pollution Control Board.	
2.	Affidavit on Behalf of Respondent No. 3 i.e. Central Pollution Control Board.	
3.	Annexure-R3-I: Copy of CPCB Guidelines for Development of Greenbelts (March, 2000)	



Place: Pune

Date: 07/01/2024


(Pratik D. Bharne)

Regional Director

क्षेत्रीय निदेशक / Regional Director
केंद्रीय प्रदूषण नियंत्रण बोर्ड
Central Pollution Control Board
क्षेत्रीय निदेशालय, पुणे / Regional Directorate, Pune
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय, भारत सरकार
M/o Env't. Forest & Climate Change, Govt. of India
सर्वे नं. ११०, हीराबाई धनकुडे हॉल, बाणेर रोड, बाणेर, पुणे - 411045
Sr. No. 110, Hirabai Dhankude Hall, Baner Road, Baner, Pune-411045

BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL
WESTERN ZONE BENCH, PUNE

ORIGINAL APPLICATION NO. 168/2024 (WZ)

IN THE MATTER OF: -

PRATAP LAL TELI

APPLICANT

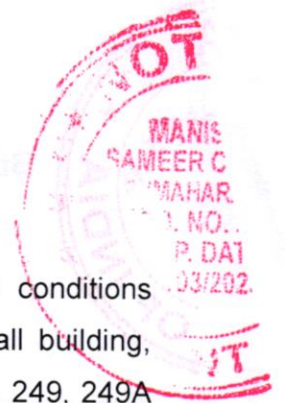
VERSUS

MEMBER SECRETARY, STATE LEVEL
ENVIRONMENT IMPACT ASSESSMENT
AUTHORITY AND ORS.

RESPONDENT(S)

REPLY ON BEHALF OF RESPONDENT NO. 3,
CENTRAL POLLUTION CONTROL BOARD(CPCB)

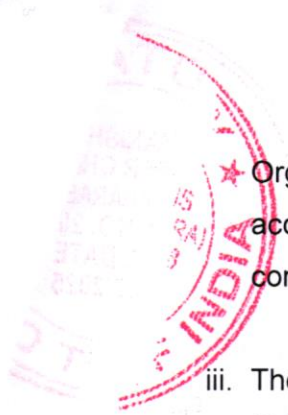
1. That, the Hon'ble National Green Tribunal, Western Zone Bench (hereinafter referred to as "Hon'ble NGT") vide its order dated 13/11/2024 in Original Application (hereinafter referred to as "OA") no. 168 of 2024 has sought the reply of Central Pollution Control Board (hereinafter referred to as "CPCB") in the instant matter. Thereby, the reply is made in succeeding paragraphs.
2. That at the outset, the Answering Respondent (CPCB) deny all claims, contentions, allegations and averments against the Answering Respondent (CPCB) in the above OA contrary to anything stated or submitted in this reply. Nothing in the OA may be deemed to have been accepted or admitted by the Answering Respondent (CPCB) for want of a specific denial or on the ground of non- traverse, save any averment which has been expressly admitted hereinafter.
3. That, CPCB is a Statutory Board constituted under Section 3 of the Water (Prevention and Control of Pollution) Act, 1974 (hereinafter referred to as "Water Act, 1974"). It performs the functions under the Water Act 1974, The Air (Prevention and Control of Pollution) Act 1981 (hereinafter referred to as "Air Act, 1981"), and The Environment (Protection) Act, 1986 (hereinafter referred to as "E(P) Act, 1986").



4. That, this matter is related to violations of Environment Clearance conditions linked to Environment Clearances issued for the construction of a tall building, situated at CS No. 2.1629 & 1A/1629 of Lower Parel Division, Plot No. 249, 249A & 249B of Worli Scheme No. 52, of G-South Ward, Mumbai. In present application it is also alleged that construction had been carried out without effective plantation of trees as per environment norms, without leaving requisite open spaces, without providing requisite area for the developmental plan amenities, violating condition of conversion of land from industrial to residential etc.

PARA-WISE SUBMISSION

5. That, the averments made in Para nos. 1.1 to 1.9 are regarding details of the Petitioner and Respondents, cause of action arises in present matter, and relevant judgment of Hon'ble Supreme Court, which are matter of record. Further, following are humbly submitted:
- i. That, clause 2 of the Environmental Impact Assessment Notification, 2006 (hereinafter referred to as "EIA Notification, 2006") provides for the Requirements of prior Environmental Clearance (hereinafter referred to as "EC") and as per the said clause, the project proponent of the projects or activities which are falling under the category 'A' of the Schedule of the EIA Notification, 2006, shall obtain the EC from the Ministry of Environment, Forest and Climate Change (hereinafter referred to as 'MoEF&CC') and for the projects which are falling under the 'B' category of the Schedule of the EIA Notification, 2006; the project proponent shall obtain EC from the State Environment Impact Assessment Authority (hereinafter referred to as 'SEIAA') before carrying out the construction.
 - ii. The CPCB has classified building and construction projects based on their sewage generation potential into red/orange category. Projects generating sewage between 50 to 100 KLD are categorized as orange, however, project generating more than 100 KLD sewage are categorized as red. All projects under red and orange categories are required to obtain consent from respective SPCB/PCC. The Manual on Sewerage and Sewage Treatment System (2013), published by the Central Public Health and Environmental Engineering



Organization (CPHEEO) prescribes to manage the sewage/wastewater according to on-site sanitation methods with respect to Building and construction projects generating sewage less than 50 KLD.

iii. The State Pollution Control Boards (SPCBs)/Pollution Control Committees (PCCs) are the concerned authorities for granting Consent to Establish (CTE), Consent to Operate (CTO) and Authorization for any applicable residential/ industrial establishment(s) in the respective State/Union Territory.

6. That, the averments made under the heading 2.0 "FACTS IN BRIEF" (2.1) are stating about Respondents and need no reply from this Answering Respondent (CPCB). Further, it is humbly submitted that, submissions made at Para 3 of this reply are re-iterated and are not repeated herein for the sake of brevity. It is also humbly submitted that this Answering Respondent has published a guidelines titled "Guidelines for Development of Greenbelts" during March, 2000. Objective of the said guidelines to enlist the plant species suited to various bio-climatic conditions, to evolve a theoretical model for design & development of green belt for optimum attenuation of air pollution. The said guidelines also outline on the choice of plants for green belt development, for removal of particulate matter and gaseous pollutants. Copy of the said guidelines is given at **Annexure-R3-I**.

7. That, the averments made under the heading 2.0 "FACTS IN BRIEF" (2.2 to 2.21) which are stating about Respondents, Project Plan of the Project Proponent (PP) i.e. Respondent No. 6 in this matter, about the land under reference and planning of conversion of it, land use change and its consequences, obtaining Environmental Clearance (EC) and obtaining of two more ECs for expansion (mainly vertical extension) by the PP and violations of the various EC conditions committed by the PP from time to time. In this context, it is humbly submitted that the above averments may suitably be answered by the respective Respondent and violations, if any, under the concerned Acts/Rules are to be dealt by the respective agency as per provisions stipulated under such Acts/Rules. Further, it is also humbly submitted that submissions made at Para 5 of this reply are re- iterated and are not repeated herein for the sake of brevity.



8. That, the averments made under heading "3.0 GROUNDS" (3.1 to 3.6) are about the various Grounds for filing the present Original Application by the Applicants, which have already been mentioned/commented in above paras of this reply by this Answering Respondent (CPCB) and hence, need no further comments by this Answering Respondent (CPCB).

Further, it is humbly submitted that the above averments may suitably be answered by the respective Respondent and violations, if any, under the concerned Acts/Rules are to be dealt by the respective agency as per provisions stipulated under such Acts/Rules.

9. That, the averments made under the heading "4.0 LIMITATION" are about limitations for filing the present Original Application by the Applicants and hence, need no comments from this Answering Respondent (CPCB).
10. That, the averments made under the heading "PRAYERS" (A to H) are about various prayers submitted by the Applicants and hence, need no comments from this Answering Respondent (CPCB).
11. That, in light of the above submissions, this Answering Respondent No. 3 i.e. CPCB shall abide by any order(s) or direction(s) passed by this Hon'ble Tribunal in the present Original Application.

Pratik D. Bharne

(Scientist 'E' & Regional Director)

Central Pollution Control Board

क्षेत्रीय निदेशक / Regional Director

केंद्रीय प्रदूषण नियंत्रण बोर्ड

Central Pollution Control Board

क्षेत्रीय निदेशालय, पुणे / Regional Directorate, Pune

पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय, भारत सरकार

M/o Env't. Forest & Climate Change, Gov't of India

सर्वे नं. ११०, हीराबाई धनकुडे हॉल, बाणेर रोड, बाणेर, पुणे - 411045

Sr. No. 110, Hirabai Dhankude Hall, Baner Road, Baner, Pune-411045

BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL
WESTERN ZONE BENCH, PUNE

ORIGINAL APPLICATION NO. 168/2024 (WZ)

IN THE MATTER OF: -

PRATAP LAL TELI

APPLICANT

VERSUS

MEMBER SECRETARY, STATE LEVEL
ENVIRONMENT IMPACT ASSESSMENT
AUTHORITY AND ORS.

RESPONDENT(S)

AFFIDAVIT

I, Pratik D. Bharne, working as Scientist 'E' & Regional Director in Central Pollution Control Board, Regional Directorate, Survey No. 110, Hirabai Dhankude Multipurpose Hall, Baner Road, Baner, Pune, do hereby solemnly affirm, declare on oath and state as under:

1. That the deponent is authorized representative to represent the Respondent CPCB in the present case, and as such, I am well conversant with the facts and circumstances of the present case on the basis of the information derived from the official records, and hence, I am competent and authorized to verify, sign and swear this affidavit on behalf of the Respondent CPCB.
2. That the accompanying reply may be read part and parcel of the present affidavit as I am competent to swear this affidavit.
3. That the contents there of are true and correct on the basis of the record maintained during ordinary course of business of CPCB and available records and documents and the contents of the same are read over and explained to me and are not repeated herein for the sake of brevity.



Pratik D. Bharne

DEPONENT

क्षेत्रीय निदेशक / Regional Director
केंद्रीय प्रदूषण नियंत्रण बोर्ड
Central Pollution Control Board
क्षेत्रीय निदेशालय, पुणे / Regional Directorate, Pune
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय, भारत सरकार
M/o Env't. Forest & Climate Change, Govt. of India
सर्वे नं. ११०, हीराबाई धनकुडे हॉल, बाणेर रोड, बाणेर, पुणे - 411045
Sr. No. 110, Hirabai Dhankude Hall, Baner Road, Baner, Pune-411045

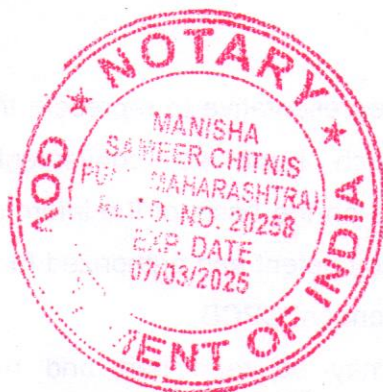
VERIFICATION

Verified at Pune on this day 7th of January 2025 that the contents of the above reply are correct and true on the basis of the record of the cases as mentioned in the day to day affairs of the CPCB. Nothing has been concealed therefrom or mis-stated.

DEPONENT – Respondent No. 3

क्षेत्रीय निदेशक / Regional Director
केंद्रीय प्रदूषण नियंत्रण बोर्ड
Central Pollution Control Board
क्षेत्रीय निदेशालय, पुणे/Regional Directorate, Pune
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय, भारत सरकार
M/o Env't. Forest & Climate Change, Gov't. of India
सर्वे नं. ११०, हीराबाई धनकुडे हॉल, बाणेर रोड, बाणेर, पुणे - 411045
Sr. No. 110, Hirabai Dhankude Hall, Baner Road, Baner, Pune-411045

COUNSEL for Respondent No. 3



Noted & Registered
At.Sr.No..18/2025

BEFORE ME

MANISHA SAMEER CHITNIS
NOTARY
GOVERNMENT OF INDIA

07 JAN 2025



Annexure-R3-I

Programme Objective Series :
PROBES/75/1999-2000

**GUIDELINES FOR DEVELOPING
GREENBELTS**



**CENTRAL POLLUTION CONTROL BOARD
MARCH 2000**

Programme Objective Series :
PROBES/75/1999-2000

GUIDELINES FOR DEVELOPMENT OF GREENBELTS



CENTRAL POLLUTION CONTROL BOARD

(Ministry of Environment & Forests, Govt. of India)

Parivesh Bhawan, East Arjun Nagar

Delhi - 110 032



दिलीप विश्वास
अध्यक्ष

DILIP BISWAS
Chairman

केन्द्रीय प्रदूषण नियंत्रण बोर्ड

(भारत सरकार का संगठन)

पर्यावरण और वन मंत्रालय

Central Pollution Control Board

(A Govt. of India Organisation)

Ministry of Environment & Forests

Phone : 2204948

FOREWORD

Green vegetal cover is not only pleasing to the eyes but also beneficial in many ways such as conservation of bio-diversity, retention of soil moisture, recharge of groundwater and moderation of micro-climate. Yet another important role of vegetal cover, which is not well recognised, relates to containment of pollution. Besides acting as a carbon sink, certain species of plants can even absorb the pollutants while others can thrive in polluted atmosphere.

Raising of green belts with right types of species can serve as a useful buffer to contain the menace of pollution from different sources. With this in view, a study was commissioned by the Central Pollution Control Board (CPCB) for enlisting the plant species suited to various bio-climatic conditions. The study was also intended to evolve a theoretical model for design and development of green belt for optimum attenuation of air pollution. Apart from morphological features affecting the plant response to pollutants, the other important considerations in optimisation of green belt development include : distance from the source of pollution and dispersion of pollutants under different atmospheric stability conditions. An exercise was also made to identify the species which are suitable for revegetation of mine spoils, degraded habitats and stabilisation of fly ash dumps.

The report provides a mathematical model to optimise the specifications of a green belt. The report also contains a list of 200 species recommended for raising of green belt under specific bio-climatic regimes.

I am thankful to Prof. S. B. Chapekar, University of Pune, Shri R. K. Kapur, Nuclear Power Corporation, Mumbai, Shri V. K. Gupta, Atomic Energy Regulatory Board, Mumbai and the team of my colleagues including Dr. B. Sengupta, Shri Lalit Kapur, Dr. Sajeév Paliwal and Shri M. K. Gupta for their collective efforts in bringing out the publication.

Based on the inputs provided by CPCB and information contained in this report, a scheme for raising green belt for pollution abatement and environmental improvement has been launched in Tamil Nadu.

We hope, the guidelines and information contained in this report will be useful to all concerned "with environmental cleaning through greening"


(Dilip Biswas)

CONTENTS

	Page No.
Executive Summary	1
1 Introduction	2
2 Plant-Pollutant Interactions	4
3 Theoretical Model for Development of Green Belt	19
4 Agro-climatic Zones of India	34
5 Choice of Plants for Green Belts	39
6 Stabilization of Fly-ash using plants	44

Appendix

A Bioclimatic Zones of India	50
B Description of Plants Recommended for Green Belts	66
C Zonewise List of Recommended Plant Species Bibliography	167
D References	196

EXECUTIVE SUMMARY

Chapter 1 : Introduction

Green belts are recommended for containment of air pollution in the human environment, especially in industrial and urban environs. Improvement of aesthetics is a bonus derived through the presence of greenery in these areas.

Chapter 2 : Plant-Pollutant Interactions

Advantages notwithstanding, green plants are not a panacea for the environmental ills. As living organisms, plants have their limits to tolerate toxicity of air pollutants and to function as pollution ameliorants. Nature and levels of sensitivities of plant species towards anthropogenic air pollutants, are discussed.

Chapter 3 : Theoretical Models for Development of Green Belts

Green belt as a back-up to technological pollution abatement measures could substantially reduce pollution hazard. Mathematical model to optimize dimensions of green belts is presented and explained here.

Chapter 4 : Agro-climatic Zones of India

A vast country encompasses a variety of agro-climates suitable for different types of plant species. Zones and subzones of India are described, along with their soil types (as Appendix A) to assist in selecting plant species for cultivation, suitable to agro-climates.

Chapter 5 : Choice of Plants for Green Belts

Plant species suitable for removal of particulate matter and gaseous pollutants differ in their morphological characteristics. Sizes and shapes of crowns, periodic phenomena like leaf-shedding, also contribute to plant efficiency for pollution abatement. Discussion on these points is followed by description of a large number of plant species (in Appendix B), stressing characters useful for sorption of pollutants. Combining information in chapters 4 and 5, zonewise lists of plants recommended for green belts are presented (in Appendix C).

Chapter 6 : Stabilization of Fly-ash with Plants

Coal is likely to be used on an increasing scale for power generation, and will lead to aggravation of pollution problem due to fly-ash. Stabilisation of ash with plants provides available solution. Strategies for achieving the same, are discussed in this chapter.

CHAPTER-1

INTRODUCTION

Most of the human activities generate pollution of one or other types and of different magnitudes, to which all the organisms are exposed. More often than not, exposures to some pollution types are considered unavoidable. Resistance of organisms help them overcome the hazards caused by such exposures. At the same time, organisms, especially animals tend to avoid, or move away, from pollution. By avoidance or by tolerance, organisms struggle and survive in polluted environments.

Such survival however, is hardly desirable and has limitations, in terms of health and vitality of organisms. Hence, it is imperative that pollution is controlled at the source itself. Numerous mechanical devices are available for controlling pollution at the process level itself. Some trace amount however, is still likely to get released. This is especially true of air pollutants from thermal power plants, swelling and refining processes, autoexhausts, mining and quarrying, etc. It is often stated that zero pollution process is only hypothetical. With more than 99% efficiency of pollution abatement machinery, some amount of pollution still gets released in the atmosphere. Such pollution too is of wide occurrence.

Green belts are thought to be effective in such scenarios, where green plants form a surface capable of sorbing air pollutants and forming sinks for pollutants. Leaves with their vast area in a tree crown, sorbs pollutants on their surface, thus effectively reduce their concentrations in the ambient air. Often, the sorbed pollutants are incorporated in metabolic stream and thus the air is purified. Plants grown in such a way as to function as pollutant sinks are collectively referred to as green belts. •

An important aspect of a green belt, some times overlooked, is that the plants constituting green belts are living organisms, with limits to their tolerance towards air pollutants. As a result, crossing the threshold limits in terms of pollution load, would lead to injury to plants causing death of tissues and reducing their absorption potential. Sink efficiency of unhealthy and dead tissues and leaves is known to be extremely low, thus defeating the very purpose of a green belt. In short, a green belt is effective as pollution sink only within the tolerance limits of constituent plants.

Species of plants are studied for their relative sensitivities towards different air pollutants. Thus, we recognise species sensitive to SO_2 , species sensitive to O_3 , or sensitive to HF, etc. In terms of tolerances however, it is difficult to identify species that are selectively tolerant to pollutant species. Statements like HF-sensitive gladiolus is tolerant to SO_2 , is obviously not accurate. Moreover, an industrial or urban scene invariably consists of several pollutants rather than a single pollutant. Pollution sinks hence, aim at cultivating plants that are tolerant to air pollutants in general, rather than tolerant to SO_2 , to HF, or to O_3 , etc. Scattering of a few known sensitive plants, (including selectively sensitive species) within a green belt however, do carry out an important function of indicating the presence of pollutants which the tolerants would not indicate.

Two types of approaches are recognised while designing green belts - i) Source oriented

approach and ii) receptor- oriented approach. Both these approaches have their own advantages and limitations. It is generally felt that the first approach is advantageous where a single industry is situated and the pollutants emitted by the same are sought to be contained. The latter approach is desirable in urban- industrial complexes with multiple sources of pollution in an industrial - urban mix. A very large proportion of polluted areas in this country, where human settlements are intricately mixed with industries, form examples deserving the second approach for green belt designing.

Whereas, it is easy to state that tolerant plant species should form green belts, it is very difficult to state confidently about several other aspects about the belts, e.g. i) which bio-geographic regions of the country are suitable for what plant species, ii) what extent soil quality contributes to the sources (or otherwise) of growth of plants in the belts, iii) what should be the distance, width and height of the belt with reference to pollution source, iv) what is the ideal density of plant crowns, and v) what are the limits of pollution dosages upto which green belts would function optimally. Attempts are made in the following chapters, to seek answers to these questions, on the basis of our present knowledge in this field. It is felt that experience gained from functioning of green belts being planned in the country, would give reliable answers.

Apart from functioning as pollutant sinks, green belts would provide other benefits like aesthetic improvement and providing possible habitats for birds and animals, thus re-creating hospitable nature in an otherwise drab urban- industrial scene. One of the worst examples of the latter type of scene is provided by deposits of coal-ash from thermal power plants. The problem is on the rise in the country, where coal is a fuel long-lasting surety of availability. Covering of ash using plants - another type of green belt is recommended to overcome the hazards posed by ash. The last chapter in this report is devoted to the problem of ash stabilization and making ash-dumps environmentally acceptable.

CHAPTER-2

PLANT - POLLUTANT INTERACTIONS

A large amount of information has been generated about the nature of plant-pollution interactions; very little authentic information in Indian context has been generated about the role of plants in absorption of air pollutants. Most of the information available is from "Forest Vegetation as a Sink for Gaseous Contaminants" (Smith, 1981). As per the discussion therein, even sensitive plants like alfalfa have been used for estimation of sink efficiency of plants.

Another point to ponder is about the areas where green belts should be set up. Obviously, since a green belt is expected to neutralize pollutants, their location should aim at screening off the source of pollutants from society. Areas around industrial establishments, residential areas and roadsides, should be the ones targetted for green belts.

Plants are living organisms and hence are prone to suffer toxicity of air pollutants like any other organism. Still, they are expected to scavenge pollutants from the ambient air through the limited capacity they possess for sorption, and neutralize the absorbed pollutants. Major primary pollutants of industrial origin are considered here.

The philosophy is that when primary pollutants are taken care of, formation of secondary pollutants will not reach menacing proportions. Primary pollutants of concern are - SO_2 , HF, NO_x , CO, CO_2 , NH_3 , H_2S , Cl_2 , SPM and organics. Industrial and man-made sources of these pollutants are given in Table-2.1. Common secondary pollutants are also included in the same Table.

Since the project aims at mitigation of air pollutants with plants, discussion here is confined to air pollutant interactions with plants. Other forms of life are not considered. Mode of absorption of a pollutant by plants and fate of the pollutant inside plant body are given. Rate at which a pollutant is absorbed, total amount that can be absorbed and form of the pollutant in which it ends inside the plant, determine the success of the scavenging process. It is known that when pollutant is absorbed at a rate higher than the rate of its assimilation, accumulation takes place, resulting in plant injury and ineffectiveness of the green belt.

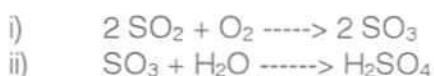
SO_2 : Though several oxides of sulphur may be the result of industrial processes, SO_2 is considered to be the most important one. Background level of SO_2 in the atmosphere is 0.001 ug L^{-1} or less (Kellogg et. al., 1972). About 10^9 million metric tons (mmt) of SO_2 are estimated to be added to the earth's atmosphere every year (Helbwachs, 1983).

Quantities of SO_2 liberated by different types of industries, are given in Table-2.2. Emission of SO_2 by different types of fuels is given in Table-2.3. In India, SO_2 emission was 6.76 mmt in 1979 and is expected to reach 13.19 mmt by the turn of this century (Kumar and Upadhyay, 1981).

SO_2 enters plants mainly through the stomatal apertures. Cuticle and wax on leaf

epidermis and suberin on stem being impervious, more than 95% of the pollutant enters a plant through the routes of gaseous exchange. Hence stomata, their structure, position and functions are important in the entry of gas in a leaf. Once inside the leaf, it passes into the intercellular spaces of mesophyll and gets absorbed on the wet cell-walls to finally diffuse gradually into the cell sap (Knabe, 1976). Whereas absorption of SO_2 by mesophyll tissue of a leaf is proportional to the stomatal conductance (Winner and Mooney, 1980), diffusion of SO_2 into cell sap is a function of its water solubility, which is fairly high (Table-2.4).

Chemical reactions leading to leaf injury or absorption of S from SO_2 into the metabolic stream have been described variously. A widely accepted view is that SO_2 inside leaf gets oxidised to SO_3 , which in turn combines with water to form sulphuric acid.



The acid thus formed, upsets the critical balance between inorganic and organic sulphur in plants affecting several metabolic processes, leading to reduction in productivity. Slow absorption of SO_2 on the other hand, especially when the rate of SO_2 absorption equates the rate of S utilization as a nutrient, leads to improvement in productivity. These possibilities of diametrically opposite effects on plant productivity due to SO_2 absorption, are presented in Fig.2.1.

The adverse effect of SO_2 on chlorophyll pigments leading to reduced productivity may be considered under two cellular pH conditions. At pH 2.2 to 3.5, the free H^+ ions generated in the cell from the splitting of H_2SO_3 into SO_3^{2-} and H^+ , displace the Mg^{2+} from chlorophyll molecule to degrade the latter into phaeophytin molecule, a non-photo-synthetic brown pigment (Rao and Le Blanc, 1966). At pH above 3.5, SO_2 affects the thylacoid membrane of chloroplast by causing oxidation of carotenoids through generation of O_2^- from HSO_3^- (Pieser and Yang, 1978). The unprotected chlorophyll molecule then is oxidised and lost. Free O_2^- also increases level of H_2O_2 in the presence of SOD (superoxide dismutase), leading to oxidation of chlorophyll molecules. SO_2 is also considered to reduce chlorophyllide synthesis, through its effects on ascorbic acid (Keller and Schwager, 1977).

Initial visual symptom of foliar injury caused by SO_2 is the formation of marginal and interveinal chlorotic, bronzed or necrotic areas, starting with dark green or dull colouration, with water-soaked appearance. Necrotic areas extend and are visible on both epidermal surfaces. Older leaves having just attained full expansion are the most susceptible ones.

NO_x : Three types of oxides of nitrogen are collectively referred as NO_x . These are N_2O (Nitrous oxide), NO (Nitric oxide) and NO_2 (Nitrogen dioxide). High temperature reactions in the presence of air lead to oxidation of atmospheric nitrogen, giving rise to oxides of nitrogen. Whereas background level of NO_2 is only $1.9 \mu\text{g m}^{-3}$, that of N_2O may be as high as $450 \mu\text{g m}^{-3}$ (Urone, 1976).

On absorption in leaves across stomatal apertures, NO_x react on cell walls to form HNO_2 and HNO_3 , the former being more toxic. pH drop and reaction of acids with unsaturated compounds causing isomerization and free radical formation, lead to toxicity. Nitrosamines

are formed, cellular pH is lowered and acetate metabolism inhibited, leading to growth suppression (Mudd, 1973; Taylor et al, 1975; Zeevart, 1976).

Injury symptoms are visible as discoloured spots of gray-green or light brown colour. Bleached or necrotic spots in interveinal areas of leaves is a later development, appearing as stripes in advanced stages.

NO_x are not considered to be of major concern as phyto-toxicants, since several studies suggest that levels sufficient to injure vegetation would be far above known or monitored ambient levels. Importance of NO_x in the atmosphere however, lies in the fact that they are the raw material for formation of important secondary pollutants like O_3 , Smog and PAN.

HF : Fluorine is a universally distributed element, hence is to be found in all places-soil, water and air (Treshow, 1970). About 0.05 mgm^{-3} is present in air and in traces in surface waters and in soil. Some parts of Rajasthan are reported to have unusually high concentrations of the element in soils. Combustion of fossil fuels, smelting of ores like bauxite and reduction of phosphatic rock in the manufacture of fertilizers, are some of the industrial processes, responsible for release of HF in the atmosphere. Few to several hundred pounds of fluorine is released into the atmosphere every year, according to several estimates (Treshow, 1970).

Fluoride enters leaf through stomata, and from the intercellular spaces of mesophyll, diffuses into vascular tissues. It moves along transpiration stream towards leaf tips and margins, where accumulation takes place. Due to absence of visible injury, such accumulation goes unnoticed for long. In some sensitive plants, injured tissues in tips and margins have shown values of 50-200 ppm HF concentrations. In tolerant species visible injury was not noticeable even at 500 ppm concentration level.

Chlorosis of leaf tip is the first visible injury. With increasing accumulation, the injury may extend along margins and inwards along veins. Injured, brown or dead areas of leaves become necrotic, leading to premature leaf fall (Weinstein, 1977).

CO and CO_2 : Incomplete combustion of fuels including fossil fuels, leads to formation of CO. Automobiles are the commonest source of CO. Oil refineries, metallurgical operations, etc. are other sources of significance. Annual global input of this toxic gas is estimated to be 6 billion tons (Seiler, 1974).

CO is not a phytotoxic gas. Green plants function as natural sinks for CO (or its readily converted form, CO_2). Soil and oceans are also vast sinks for the gas. Since CO gets gradually oxidized to CO_2 , which is absorbed and utilized by plants on large scale, and since increase in CO_2 concentration from its normal 300 ppm to higher levels are still non-toxic to plants, CO or CO_2 are not treated as serious phyto-toxicants.

NH_3 : Decomposition of organic matter of different origins including excreta, fertilizer breakdown, coal combustion and releases from industries lead to pollution by ammonia. Though localized, ambient concentrations of 20 ppm have been recorded (Cholak, 1952).

Blackening and bleaching of leaves, spotting, brown lesions between veins and colour change of fruits, are symptoms of injury by ammonia.

Generally, emission of NH_3 is of an accidental nature, during transfer and transportation or due to poor maintenance of containers. Best control of NH_3 is achieved through proper care and maintenance at 'in house' level.

Cl₂ : This pollutant is also a result of industrial accidents, escape from manufacturing processes and leakages from cylinders and sewage treatment systems. Chlorosis, reddening, stipple and necrosis of leaves are reported to be injury symptoms on plants.

Exposure of sensitive plants like radish and alfalfa to 10 ppm of Cl_2 for 2 hours, showed foliar injury, while plants like tobacco, zinnia, corn and sunflower were injured when exposed to the same concentration for 4 hours (Brennan, et. al., 1965). Chlorosis, stipple, necrosis and reddening were the types of injuries observed on foliage of plants exposed.

Hydrocarbons (HC) : Organic compounds containing carbon and hydrogen are emitted from automobiles, oil refining processes and chemical factories. On reaching ground, the HC are degraded by soil micro-organisms. In traces, HC like ethylene gas acts as a growth hormone by stimulating formation of lateral buds. At pollution levels however, it causes distortion of foliage, excessive curvature in growth, chlorosis, senescence and flower abscission (Smith, 1981).

H₂S : Pattern of injury caused by this pollutant is different from that by others. Necrosis and death of young tissues is reported rather than that of old tissues. Tips of leaves are also injured. Injury at chronic levels of the pollutant is unknown, toxic levels are found to be much above the known ambient concentrations of the gas. The most sensitive plant species have been reported to be injured at 86 ppm ($12 \times 10^4 \text{ ug m}^{-3}$) after 5 hours exposure (US EPA, 1976).

SPM : Suspended particulate matter is released during metal refining, by foundries, cement factories and as fly ash from thermal power plants, mine tailings, etc. and autoexhausts. Heavier particles, above 1 μ diameter size, tend to settle while finer and lighter particles remain airborne for days together and travel for hundreds of kilometers over wind currents. Chemical dusts are more injurious and under humid conditions, their phytotoxicity increases further (Chaphekar, 1972).

Finer particles clog stomatal apertures and prevent gaseous exchange by leaves. Physical weight on foliage and a film of dust causing rise in leaf surface temperature are other hazardous situations for plants. Dust particles deposited on stigmatic surfaces of flowers reduce effective pollination and hence fruit yields.

Dust is captured by leaves of plants, leaf epidermal outgrowths like hairs and scales, hairy axils of stems and leaf bases, etc. (Das, 1981).

Mixtures of pollutants : In India, as in several other places, many industries are located in the same region and the air is a mix of several pollutant gases. A large number of studies indicate synergistic nature of pollutant mixture effects on plants. It is practically

impossible to assess the pollutant removal efficiency of plants under the numerous possible combinations of mixing proportions of different pollutants detected. Bearing in mind however, the synergistic nature of the reactions, it is again emphasized that the concentrations of ambient pollutants have to be well below the threshold limits of tolerance (e.g. as cited in Table 2.5), for plants to function effectively for removal of pollutants.

The sensitive plants indicate injury symptoms due to air pollution, that are specific to the type of pollutant. Ranges of dosage of the pollutants to which sensitive plants respond, are given in Table-2.5.

A large amount of research has been carried out in India, during the last two decades. Compilation of this work has been presented in a comprehensive Table 2.6.

Within their limits of tolerance, plants absorb pollutants and to that extent remove the same from ambient air. The plant uptake of air pollutants as investigated by Hill (1971) and Bennett and Hill (1973, 1975), appeared to follow the following order :

HF > SO₂ > Cl > NO₂ > O₃ > PAN > NO > CO.

The rate of pollutant removal is found to increase linearly as the concentration of the pollutant increased over the ranges of concentration that are encountered in ambient air and which are low enough not to cause stomatal closure. Pollutants are absorbed most efficiently by plant foliage near the canopy surface where diffusion process is high due to favourable light conditions. An example of the magnitude of absorption of pollutants by seedlings of plants is given in Table-2.7.

Smith (1981) has given estimated absorption of gaseous pollutants by dry soil and vegetative surfaces to emphasize relative differences in their efficiencies to remove pollutants (Table 2.8). He also assessed pollutants removal efficiency of a 'Model Forest Hectare' developed by U.S. EPA, in which composition of plant species is as follows:

Species	No. of trees Planted	Tree surface area (m ²)	Total vegetative area (m ²)
Maple	69	36.8	2.54 x 10 ³
Oak	69	36.1	2.50 x 10 ³
Poplar	69	52.5	3.63 x 10 ³
Linden	69	23.0	1.56 x 10 ³
Birch	69	27.2	1.88 x 10 ³
Pines	700	4.2	2.90 x 10 ³

This hectare, consisting of 5-year old plants, is estimated to remove gaseous pollutants annually in quantities as :

O₃ - 9.6 x 10⁴, SO₂ - 748, CO - 2.2, NO_x - 0.38 and PAN - 0.17 (all values in tonnes).

Fig. 2.1 Summary diagrammatic representation of the effects of sulphur dioxide on plants

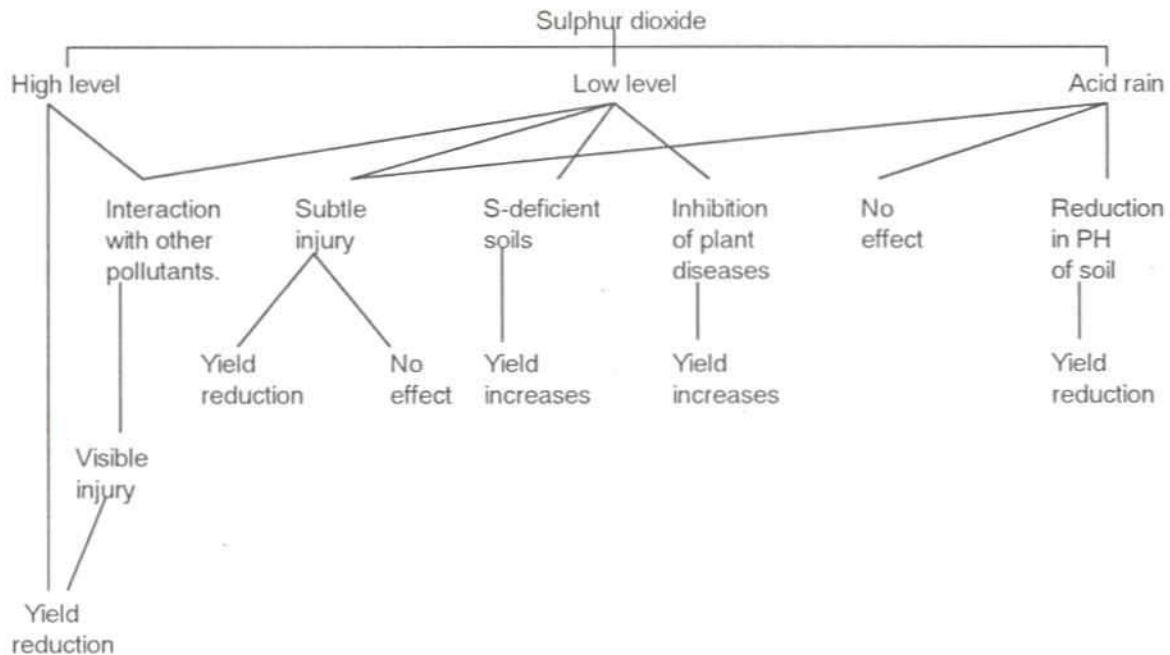


Table 2.1 Industrial sources of major air pollutants

S.No.	Pollutant	Sources
01	Sulphur dioxide (SO ₂)	Coal, fuel oil and petroleum combustion.
02	Nitrogen dioxide (NO ₂)	High temp. combustion of coal, oil, gas and gasoline in power plants and internal combustion engines.
03	Hydrogen fluoride (HF)	Phosphate rock processing, aluminium industry, iron smelting, brick and ceramic works, and fibreglass manufacturing.
04	Chlorine (Cl)	Leaks in chlorine storage tanks, hydrochloric acid mist.
05	Ammonia(NH ₃)	Leakages in fertilizer manufacturing factories, transfers and transport of the chemical.
06	Hydrogen sulphide (H ₂ S)	Decay and decomposition of organic wastes, dumps, sewage, etc.
07	Carbon oxides (CO and CO ₂)	Products of combustion of fuels- incomplete combustion/Organic respiration.
08	Ethylene (C ₂ H ₄)	Incomplete combustion of coal, gas, and oil for heating, and automobile and truck exhaust.
09	Particulates (SPM)	Combustion (esp. incomplete) processes, Fly ash, Thermal power plants, Cement factories, Automobiles, etc.
10 *	Ozone(O ₃)	Dissociation of NO ₂ (NO ₂ ---> NO+O) (O ₂ +O --> O ₃)
11 *	Peroxyacetyl	Ozonated olefin nitrate (PAN)
12 *	Smog	Combination of fine particulates and NO _x in air
13 *	Acid precipitates	Combination of NO ₂ and / or SO ₂ with water vapour in the atmosphere

(Source : Painter D.E. 1974, except for * No. 10-13).

Table 2.2 Quantities of SO₂ liberated during different types of industrial activities

Source	SO ₂ emission factor (in kg)
Combustion of coal	4.536 per 1000 kg coal (Variable).
Combustion of fuel oil	9.9 per 10,000 L oil (Variable).
Municipal incineration	0.544 - 0.907 per 1000 kg refuse.
Sulphuric acid manufacture	9.07 - 3.75 per 1000 kg 80% acid.
Cu smelting (Primary)	635.04 per 1000 kg conc. ore.
Pb smelting (Primary)	299.376 per 1000 kg conc. ore.
Pb smelting (Sec. cupola)	29.03 per 1000 kg metal changed.
Zn smelting (Primary)	494.424 per 1000 kg conc. ore.
Kraft mill recovery furnace	1.088 - 1.078 per 1000 kg air dry pulp.
Sulphite mill recovery furnace (assuming 90% recovery)	18.144 per 1000 kg air dry pulp.

(Source : Kumar and Prakash, 1978.)

Table 2.3 Amount of SO₂ emitted by burning different types of fuels

Fuel	SO ₂ emission in kg per tonne of fuel
Firewood	20
Coal	6 to 15.0
Oil	6 to 7.6
LPG	0.0002 to 0.008
Natural Gas	0.2
Petrol	5.4
Diesel	5 to 6

(Source : Kumar and Prakash, 1978.)

Table 2.4 Solubilities of pollutant gases in water

Pollutant	Solubility at 20°C (cm ³ gas ml ⁻¹ H ₂ O)
CO	0.02
NO	0.05
CO ₂	0.88
PAN	--
O ₃	0.26
NO ₂	Decomposes
Cl ₂	2.30
SO ₂	39.40
HF	446

(Source : Hill and Chamberlain, 1974.)

Table 2.5 Injury symptoms and pollution dose thresholds of tolerance by sensitive species of plants

S. No.	Pollutants	Threshold dose	Plant injury symptoms
1.	Sulphur dioxide	0.70 ppm ($1820 \mu\text{g m}^{-3}$) for 1 hr.; 0.18 ppm ($468 \mu\text{g m}^{-3}$) for 8 hr.; 0.008-0.017 ppm ($21/44 \mu\text{g m}^{-3}$) for growing season. (Linzon 1978)	Interveinal necrotic blotches. Red brown dieback or banding in pines.
2.	Nitrogen oxides	20 ppm ($38 \times 10^3 \mu\text{g m}^{-3}$) for 1 hr.; 1.6 - 2.6 ppm ($3000-5000 \mu\text{g m}^{-3}$) for 48 hr.; 1 ppm ($1900 \mu\text{g m}^{-3}$) for 100 hr.; (National Academy of Sciences, 1977)	Interveinal necrotic blotches similar to those by SO_2 . Red brown distal necrosis in pines.
3.	Fluoride	< 100 $\mu\text{g g}^{-1}$ fluoride (Weinstein 1977)	Tip and margin necrosis,
4.	Ammonia	55 ppm ($38 \times 10^3 \mu\text{g m}^{-3}$) for 1 hr.;	Interveinal necrotic blotches similar to those by SO_2 . Distal necrosis in pines.
5.	Chlorine	0.5 - 1.5 ppm ($1400 - 4530 \mu\text{g m}^{-3}$) for 0.5 - 3 hr.	Chlorosis, upper surface fleck similar to O_3 . Distal necrosis in pines.
6.	Ethylene	Variable, undetermined	Chlorosis, necrosis, abscission, Dwarfing, premature defoliation.
7.	Hydrogen sulphide	100 ppm ($14 \times 10^4 \mu\text{g m}^{-3}$) for 5 hr.; (U.S. Environ. Protection Agency 1976)	Interveinal necrotic blotches. Distal necrosis in pines.
8.	Trace metals	Variable, undetermined	Interveinal chlorosis, tip and margin necrosis, Distal necrosis.
9.	Ozone	0.20 - 0.30 ppm ($392 - 588 \mu\text{g m}^{-3}$) for 2-4 hr.; Some conifers 0.08 ppm ($157 \mu\text{g m}^{-3}$) for 12-13 hr. (National Academy of Sciences 1977b)	Upper surface flecks Distal necrosis and stunted needles in pines.
10.	Peroxy acetyl nitrate	0.20 - 0.80 ppm ($989-3958 \mu\text{g m}^{-3}$) for 8 hr. (Davis 1975)	Lower surface bronzing, Chlorosis, early senescence.
11.	Acid rain	pH < 3.0	Necrotic spots, Distal necrosis pines.

(Source : Smith W.H. 1981.)

Table 2.6 Compilation of research in India indicating sensitive and tolerant species, with reference to industrial pollutants

Name of Plant	Sensitive	Tolerant	Reference
<u>Mangifera indica</u>	Coal dust		
<u>Citrus lemon</u>		Coal dust	Rao, 1971
<u>Phaseolus aureus</u> (Green gram)	Petro cake		Prasad and Rao (1981)
<u>Zea mays</u>	Cement dust		Sree Rangaswamy et al, (1973)
<u>Syzygium cuminii</u>	Cement dust		Jafri et al, (1979)
<u>Psidium quyava</u>	Cement dust		Yunus and Ahmed (1980)
<u>Triticum aestivum</u>	Cement dust		Singh and Rao (1980 a)
<u>Calotropis procera</u>	Cement dust		Yusuf and Vyas (1982)
<u>Cassia fistula</u>	Cement dust		
<u>Dalbergia sissoo</u>	Cement dust		
<u>Withania somnifera</u>	Cement dust		
<u>Glycine max</u>	Cement dust		Singh and Rao (1978 a)
<u>Hordeum vulgare</u>		5% fly ash	Bhatia (1978)
<u>Portulaca sp.</u>			
<u>Triticum aestivum</u>	above 20% Fly ash		Pawar and Dubey (1982)
<u>Triticum aestivum</u>		6g/m ² /day fly ash	Dubey et al, (1982)
		4g/m ² /day fly ash	
<u>Dolichos lablab</u>		4g/m ² /day fly - ash	Pawar et al, (bean) (1983)
<u>Abelmoschus esculantus</u>	Cement and Coal dust	fly - ash	Pawar et al, (1982)
Var Pusa savani			
<u>Commelina benghalensis</u>	Air borne dust		Chaphekar et al, (1980)
<u>Brassica oleraceae</u>	Urban air		Garg and Varshney (1980)
<u>Chenopodium album</u>			
<u>Cicer arietinum</u>			
<u>Dolichos lablab</u>			
<u>Sonchus asper</u>			
<u>Withania somnifera</u>			
<u>Tabernaemontana coronaria</u>	Polluted environment		Srivastava et al, (1980)
<u>Calotropis procera</u>		Polluted conditions	Yunus and Ahmed(1981)

(Contd.....)

Table 2.6 (Contd.....)

Name of Plant	Sensitive	Tolerant	Reference
<u>Calotropis gigantea</u>	Polluted areas		Bhirava Murthy and Kumar (1983)
Baro paddy. Var. Ratna	Urban dust		Das and Pattanayak (1978)
<u>Mangifera indica</u>		Dust Collector	Shetye and
<u>Thespesia populnea</u> <u>Erythrina indica</u>	Poor dust Collector		Chaphekar (1980) -----
<u>Polyalthia longifolia</u> <u>Ficus benghalensis</u> <u>Ficus infectoria</u> <u>Ficus religiosa</u> <u>Mangifera indica</u> <u>Tectona grandis</u> <u>Polyalthia longifolia</u> <u>Shorea robusta</u> <u>Terminalia arjuna</u> <u>Cassia fistula</u> <u>Poinciana regia</u> <u>Sesbania sp.</u>	Poor dust Collector.	Dust Collector	Das 1981 and Das <i>et al.</i> (1981)
<u>Pithecolobium dulce</u> <u>Argyrea speciosa</u> <u>Leucaena leucocephala</u> <u>Melilotus alba</u>		Better dust collector.	Rao (1971)
Banana Crop.	Polluted area		Ghouse and Khan (1983)
<u>Lycopersicum esculentum</u>	SO ₂ and dust From brick Kiln		Bedi <i>et al.</i> (1982)
<u>Mangifera indica</u>	SO ₂		Bell and Bedi (1981)
<u>Helianthus annus</u> <u>Crotalaria juncea</u> <u>Commelina benghalensis</u> <u>Cyamopsis tetragonoloba</u> <u>Cicer arietinum</u>	To pollute areas		Rao 1972 Shetye 1979 Giridhar (an published data) Pawar and Dubey (1983) Chaphekar <i>et al.</i> (1980 a)
	Fly ash SO ₂		Dubey <i>et al.</i> (1982)

(Contd.....)

Table 2.6 (Contd.....)

Name of Plant	Sensitive	Tolerant	Reference
<u>Medicago sativa</u> (Alfa-alfa)	SO ₂		Singh and Rao (1979, 1980)
<u>Sorghum vulgare</u> var CSH - 1	SO ₂		Boralkar and Chaphekar (1978)
<u>Glycine max</u>	SO ₂		Pandey and Rao (1979). Prasad and Rao (1982)
<u>Phaseolus aureus</u>	SO ₂		Singh and Rao (1980)
<u>Arachis hypogea</u>	SO ₂		Mishra (1980)
<u>Dolichos lablab</u>	SO ₂		Banerjee and Chaphekar (1978)
<u>Phaseolus aureus</u> Var. Vaishakhee	SO ₂		Boralkar and Chaphekar (1980)
<u>Trigonella foenum- graecum</u>	SO ₂		Boralkar and Chaphekar (1983)
<u>Pisum sativum</u>	SO ₂		Varshney and Varshney (1978)
<u>Crossandra undulaefolia</u>	SO ₂		Chaphekar and Karbhari (1974)
<u>Mirabilis jalapa</u>			
<u>Amaranthus spinosus</u>	SO ₂		Boralkar and Chaphekar (1980)
<u>Spinacea olercea</u>			
<u>Raphanus sativus</u>	SO ₂		Banerjee and Chaphekar (1978)
<u>Commeling benghalensis</u>			
<u>Erythrina indica</u>			
Barley, Cotton, Wheat, Aster, Cosmos, Verbena, Zinnia, Sweet Pea, Ipomoea purpurea, 4 o'clock plant, Bean Beet, Carrot, Chilli, Pumpkin, Radish Bhendi, Sunflower etc.	SO ₂		Pandey and Vaidya (1979)
Most trees		SO ₂	Pandey and Vaidya (1979)
<u>Mangifera indica</u>	SO ₂		Chaphekar (1972)
<u>Terminalia catappa</u>			
<u>Malachra capitata</u> <u>Dahlia</u>			
<u>Croton</u> , <u>Plumeria</u>		SO ₂	Chaphekar (1972)
<u>Opuntia</u> , <u>Nerium</u>			
<u>Dahlia</u> , <u>Petunia</u> , <u>Alfalfa</u> , <u>cotton</u> <u>Barley</u>	SO ₂		Vaishnavi (1975)

(Contd.....)

Table 2.6 (Contd.....)

Name of Plant	Sensitive	Tolerant	Reference
<u>Spinacia oleracea</u>	Gasoline Vapour.		Prasad (1980)
<u>Abelmoschus esculantus</u> <u>Cyamopsis tetragonoloba</u> <u>Crotalaria juncea</u> <u>Trigonella foenum-graecum</u> <u>Nerium indicum</u>	Ammonia SO ₂		Chaphekar and Boralkar (1979) Varshney, (Unpublished) Meenakshy <u>et al</u> (1981)
<u>Cynodon dactylon</u>	HF		Varshney and Varshney (1981)
<u>Cicer arietinum</u> <u>Nasturtium indicum</u> <u>Petunia alba</u> <u>Tradescantia axillaris</u> <u>Madhuca indica</u>	SO ₂ SO ₂ , fly-ash		Agrawal M (1989)
<u>Cassia siamea</u> <u>Delonix regia</u> <u>Shorea robusta</u> <u>Acacia arabica</u>	-- " --		
<u>Acacia catechu</u> <u>Zizyphus sp.</u>		SO ₂ , fly-ash	
<u>Mangifera indica</u>		Dust	Agrawal & Khanam (1989)
<u>Ficus benghalensis</u> L <u>Ficus infectoria</u> Roxb <u>Holoptelia integrifolia</u> Planch <u>Ipomoea fistulosa</u> Mart ex choisy <u>Lagerstroemia</u> sp. <u>Nyctanthes arbortristis</u> L <u>Peltophorum pterocarpum</u> (DC) K.Heyne		Dust	Ahmad Yunus <u>et al</u> (1991)
<u>Tectona grandis</u> L <u>Terminalia arjuna</u> W & A <u>Thevetia nerifolia</u> Jass <u>Acacia arabica</u> Willd <u>Bougainvillea spectabilis</u> Willd <u>Hibiscus rosa sinensis</u> Willd <u>Morus alba</u>		Dust	Ahmad Yunus <u>et al</u> (1991)

(Contd.....)

Table 2.6 (Contd.....)

Name of Plant	Sensitive	Tolerant	Reference
<u>Nerium indicum</u> Mill <u>Thevetia nerifolia</u> juss <u>Dalbergia sissoo</u> Roxb		Cement dust	
<u>Azadirachta indica</u> A.Juss <u>Brassica campestris</u> L <u>Citrus aurantium</u> L <u>Delonix regia</u> Raffin <u>Syzygium cuminii</u> (L) skeel <u>Mangifera indica</u> L <u>Pisum sativum</u> L <u>Tabernaemontana coronaria</u> Willd <u>Triticum aestivum</u> L <u>Zizyphus mauritiana</u> Lamk <u>Helianthus annus</u> L	Cement dust		Pandey, Misra et al (1994)
<u>Opuntia monocantha</u> <u>Opuntia dillenii</u> <u>Kalanchoe marmorata</u> <u>Crassula</u> <u>Bryophyllum</u> <u>Aloe</u> <u>Bryophyllum tabiflorum</u> <u>Euphorbia cattamindoios</u>		fly ash SO ₂	Raza S.H., Shylaja G. (1992)
<u>Caesalpinia pulcherima</u> <u>Eugenia jambolana</u> <u>Polyalthia longifolia</u> <u>Pongamia pinnata</u> <u>Caesalpinia pulcherima</u> <u>Pithecolobium dulce</u> <u>Cassia fistula</u> <u>Pongamia globra</u> <u>Polyalthia longifolia</u>		SO ₂ SO ₂ SO ₂ SO ₂ Dust Dust	Murthy M.S.R. et al (1990) Raza S.H. et al (1991)
<u>Pithecolobium dulce</u> <u>Caesalpinia pulcherrima</u> <u>Polyalthia longifolia</u> <u>Pongamia pinnata</u>		SO ₂ SO ₂	Raza S.H. et al (1989)

Table 2.7 Absorption of SO₂ by seedlings fumigated at 1.0 ppm for 1 hour in a controlled chamber (27 ± 1°C, 51 ± 7 R.H., 1300 fc)

Species	SO ₂ uptake	
	mg SO ₂ dm ⁻² hr ⁻¹	mg SO ₂ g ⁻¹ hr ⁻¹
Red maple	0.088	0.260
White birch	0.086	0.268
Sweetgum	0.074	0.267
Firethorn	0.072	0.213
Privet	0.068	0.134
Rhododendron	0.056	0.079
White ash	0.046	0.118
Azalea	0.044	0.072

(Source : Roberts 1974.)

Table 2.8 Guesstimated gaseous pollutant flux rates for dry soil and vegetative surfaces

Pollutant	µg m ⁻² hr ⁻¹	
	Soil surface	Vegetative surface
CO	1.9 × 10 ⁴	2.6 × 10 ³
NO _x	2.0 × 10 ²	2.3 × 10 ³
O ₃	1.0 × 10 ⁹	6.2 × 10 ⁴
PAN	----	1.2 × 10 ³
SO ₂	7.7 × 10 ⁶	4.1 × 10 ⁴

(Source : US EPA 1976.)

CHAPTER-3

THEORETICAL MODELS FOR DEVELOPMENT OF GREEN BELT

Introduction

The air pollution emitted by industries settles on the ground and vegetation of surrounding area. The plants interact with both gaseous and particulate pollutants and to great extent absorb them and thus, remove them from the atmosphere. This pollution removal property of the plants has been known for a long time. For several years tree planting has been promoted by USSR scientists and city planners for the purpose of reducing ground level air pollution. Many scientists have also suggested the use of green belt, which is rows of trees, for reducing the pollution originating from industrial operations. (Kalyushnyi *et al.*, 1952; Flemming 1967; Hanson and Throne, 1970; Warren 1973; Ganguly, 1976).

The capability of plants to act as a sink for air contaminants has been addressed by a number of reviews. (USEPA, 1976; Smith and Dochinger 1976, Bennett and Hill 1975; Hill 1971; Environmental Health Science Centre 1975; Keller 1978). All these studies indicate that the surface of vegetation provides a major filtration and reaction surface to the atmosphere for removing pollutants from the atmosphere.

Mechanism of Deposition

Interaction of pollution with vegetation has always been expressed by a common parameter known as the deposition velocity of the pollutants. The concept of deposition velocity has also been widely used in agriculture to calculate the dose of fertilizer and pesticides for crop growth and its protection. The deposition velocity is defined as follows :

$$\text{Deposition Velocity (Vd)} = \frac{\text{Amount of pollutant deposited per unit area of surface per second}}{\text{Concentration of pollution per unit volume above surface}}$$

It has dimension of Ms^{-1} (see McMohan & Denison 1979 for values of Vd for commonly released pollutants).

Particulates are deposited on plant surface by three processes - sedimentation by the gravity action, impaction under the influence of eddy currents, and deposition under the influence of precipitation.

Sedimentation usually results in the deposition of the particles on the upper surfaces of the plant and is most important for large particles. Sedimentation velocity varies with particle density, shape etc. Impaction occurs when air flows past an obstacle and the air stream divides. The efficiency of collection via impaction increases with decreasing diameter of the

collection obstacle and increasing diameter of the particle. It has been suggested that impaction is the principal means of deposition if particle size is of the order of tens of micrometers (μm) or greater, obstacle size is of the order of centimeters or less, approach velocity is of the order of meters per second or more and the collecting surface is wet, sticky, hairy, or otherwise retentive. For particles of dimension 1-5 μm , impaction is not efficient and interception by fine hairs on vegetation is possibly the most efficient retentive mechanism. The efficiency of washout of particles by rain is high for particles approximately of 20-30 μm size. The capturing efficiency of rain drops falls off very sharply for particles of 5 μm or less.

The hypothesis that trees are important particulate sinks is supported by evidence obtained from studies dealing with diverse particulates including radioactive, trace element, pollen, spore, salt, precipitation dust and other unspecified particles. So far as gaseous pollutants are concerned, substantial evidence is available to support the fact that plants in general and trees in particular function as sinks for gaseous pollutants. The gaseous pollutants are transferred from the atmosphere to vegetation by the combined forces of diffusion and flowing air movement. Once in contact with the plants, gases may be bound or dissolved on exterior surfaces or taken up by the plants via stomata. If the surface of the plant is wet and if the gas is water soluble, the former process can be very important. When the plant is dry or in the case of gases with relatively low water solubilities, the latter mechanism is assumed to be most important. For example, hydrogen fluoride, sulphur dioxide, nitrogen dioxide and ozone which are soluble and reactive, are readily absorbed, while nitric oxide and carbon monoxide, which are very insoluble, are absorbed relatively slowly or not at all by vegetation. It should be noted that when vegetative surfaces are damp, the pollutant removal rate may increase up to ten fold. Under damp condition, the entire plant surface - leaves, twigs, branches, stems - is available for uptake of gaseous pollutant.

The interaction of these various sized particles and gaseous pollutants with exceedingly diverse vegetative surfaces under conditions of extremely variable microclimate and pollutant source characteristics suggests an enormously complex relationship. These studies have expressed uptake of pollution by plants in terms of deposition velocity. This concept though suitable for estimation of loss of pollutant over a vegetation surface, is hard to apply for a case when pollution travels horizontally through a canopy (e.g. through green belt). The mathematical models so far available in literature for green belt are applicable only for ground level air pollution source. The only theoretical model available for estimation of depletion of pollutants by green belt is developed by Kapoor and Gupta (1984). This model expresses pollution attenuation factor A_f of green belt in terms of different dimensions and characteristics of green belt under various meteorological conditions. The model is described in next section.

About the Model

Mathematical model for the estimation of pollution attenuation by a green belt exists only for a ground level pollution source. Such ground level releases can occur by break in storage vessels and under various conditions such as follows :

- (i) Fugitive emissions

- (ii) Elevated releases reaching ground level due to
- stack downwash due to low discharge velocity
 - effect of obstacles upstream
 - short stack near a long flat building
 - downwash in the wake of a cliff
 - fumigation conditions due to breaking up of ground based temperature inversion.

The green belt model introduces the concept of a pollution attenuation coefficient for estimating the removal of pollutant while passing through the green belt. The formulation of pollution attenuation coefficient makes use of parameters such as leaf area density of the tree plantation, deposition velocity of the pollutant on leaf surface and wind speed in the green belt. The model gives the dependence of the pollution attenuation factor A_f of a green belt on various physical parameters of the green belt such as its height, width, distance from the pollution source and on atmospheric stability conditions and hence, the model can be used to optimise the design of the green belt in obtaining the desired degree of attenuation of the pollution around an industry.

The application of model has been made for two different situations viz. a source oriented approach and a receptor oriented approach. In the former case, the model is applied for estimation of pollution attenuation factor of a green belt planted around a source i.e. an industrial establishment. In the latter case, the model has been applied in studying the pollution attenuation by planting green belt around a receptor, which needs to be protected from the effects of the pollution.

The details of the model, its application aspects including its limitations are given in following sections.

Development of the Model

Various field experiments carried out by Raynor *et al.*, (1974) at Brookhaven National Laboratory USA aiming to estimate the deposition of particulates by forest using pollens and spores have indicated that the mass flux of the pollutant decreases almost exponentially with travel distance within the forest. Chamberlain (1970) and Chadwick and Chamberlain (1970) also proposed exponential removal law for removal of pollutants. Hence considering the exponential law, if the mass flux of a pollutant which enters the green belt is Q_c , the mass flux Q_x at a travel distance X within the green belt is given by

$$Q_x = Q_c e^{-Kx} \quad (1)$$

Where, K = pollution attenuation coefficient, m^{-1} .

Because of the non-availability of experimentally measured values for the following relationship for K in terms of easily measurable parameters was proposed in the model.

$$K = K_p t V_d / U_c \quad (2)$$

Where V_d = dry deposition velocity of pollutant for vegetative canopy, ms^{-1}
 U_c = average wind speed through the green belt, ms^{-1}

P_t = average foliage surface area density of a single tree, of green belt m^2m^{-3}

$K = P_c / P_t$

P_c = average foliage surface area density of the green belt, m^2m^{-3}

The constant K depends on the spacing of the trees in the green belt and is introduced to consider the overall foliage surface area density. For an ideal green belt, the value of K will be unity when such a green belt has the same foliage surface area density as that of a single tree.

The above formulation of K as given in equation (2) has been tested by Kapoor and Gupta (1984) using experimental data and is discussed here. For this testing, it is necessary to demonstrate that the value of K as obtained by using equation (2) compares reasonably well with the value estimated using equation (1) for the same set of field measurements. The study conducted by Raynor et al., (1974) regarding the measurements of variation of mass flux of pollens (having size 20 μm) with distance provides such a comparison. The average value of K obtained from the experiments conducted by Raynor et al using equation (1) is $0.0187 + 0.0047 m^{-1}$ and for the same set of experiments, the value of K calculated by using equation (2) ranges between 0.0088 to $0.0181 m^{-1}$ which compare reasonably well.

Effectiveness of a green belt

A schematic diagram of the green belt around a pollution source i.e. an industry is given in Fig. 3.1.

The pollution attenuation factor A_f gives the effectiveness of a green belt in attenuating pollution. The attenuation factor A_f has been defined as the ratio of mass flux of pollutant reaching a given distance in the absence of green belt to the mass flux of pollutant reaching the same distance in the presence of the green belt. Mathematically,

$$A_f = \frac{Q_{WB}}{Q_B} \quad \text{----- (3)}$$

Where, Q_{WB} = Mass flux of pollutant reaching at distance in the absence of a green belt

Q_B = Mass flux of pollutant reaching at the same distance in the presence of the green belt

The value of pollution attenuation factor, A_f is calculated in the following five stages.

STAGE-1

Massflux reaching at the inner edge of the green belt

The depletion of pollutant, because of the dry deposition over the travel distance upto the inner edge (X_1) of the green belt and above it (X_2) is obtained using the source depletion model (Chamberlain, 1970). The mass flux Q_A reaching the location A (as per figure 3.1) can be evaluated by

$$QA = Q_0FD \text{ ----- (4)}$$

Where, Q_0 is the mass flux at the source, and, the FD is the deposition correction factor which is given by :

$$FD = \exp \left(-\frac{6z}{H} - \frac{V_d}{U} \right) \text{ ----- (5)}$$

- Where, H = release height
- $6z$ = Standard deviation of concentration distribution in vertical direction
- V_d = dry deposition velocity
- U = mean wind speed
- X = travel distance

Value of FD can be obtained either from equation (5) or from table no. 3.1 (reproduced from Hukkoo et al 1988); which gives the value of FDo for the ratio of $V_d/U = 0.01$ at various distances under different atmospheric stability conditions). The value of FD for any ratio of V_d/U is given by

$$FD = (FDo) 100^{V_d/U} \text{ ----- (6)}$$

The value of QA can thus be obtained with the help of equations (4) and (6).

STAGE-2 :

Fraction of mass flux QA entering the green belt

The material QA is divided into two parts, namely, Q_c which passes through the green belt and Q_{AA} which passes over it (see figure-3.1). The proportion in which QA is divided into these two parts depends upon the height of trees, distance X_1 and atmospheric conditions.

The calculation of Q_c involves the effective height h_e of the incident air steam. If the height of the green belt is h , then h_e is given by

$$U(z)dz = hU_c \text{ ----- (7)}$$

Where $U(z)$ is the wind speed at height Z profile outside the green belt and U_c is average wind speed through green belt. The methodology for calculation of h_e , is given by Kapoor and Gupta (1984) and values of h_e for different heights of trees under different atmospheric stability conditions reproduced from that work is given here in Table 3.2. The quantity Q_c is then evaluated as follows.

$$Q_c = QA \int_0^h C \frac{U(z)}{U_c} dz \text{ ----- (8)}$$

$C(X, 0, 0)$ the centre line ground level concentration at down wind travel distance X .

Where, concentration C is given by ----- (9)

Where, y and z are dispersion coefficients and are in fact the standard deviations of concentration distribution in crosswind and vertical directions respectively at down wind distance X . This is a standard atmospheric dispersion equation. More information on this and other atmospheric dispersion models can be obtained from Sutton, 1953; IAEA publications 1980; 1986. Equation (8) after substitution and carrying out the integration over y and z , can be written as,

$$Q_c = Q_A \text{ ----- (10)}$$

Where ----- (11)

The value of the mass flux which passes over the green belt, Q_{AA} can thus be obtained using the following relation

$$Q_{AA} = Q_A - Q_C \text{ ----- (12)}$$

Table 3.2 Values of h_e

Tree (m)	Values of h_e (m) for height Atmospheric stability condition					
	A	B	C	D	E	F
10	3.62	3.68	3.04	3.29	3.49	4.52
15	5.04	5.12	4.17	4.42	4.76	6.12
20	6.40	6.49	5.52	5.49	5.95	7.56
25	7.71	7.80	6.29	6.50	7.07	8.91
30	8.99	9.08	7.29	7.48	8.14	10.16

Stage-3

Mass flux Q_{BC} coming out of green belt

The material Q_c is depleted in the green belt according to the relation given in equation (1). Value of Q_c for the pollutant and applicable to the green belt can be obtained using equation (2).

Thus,

$$Q_{BC} = Q_c \exp (- X_2) \text{ ----- (13)}$$

Where X_2 is the width of the green belt. The amount of material Q_{AA} which passes over the green belt will also get depleted to mass flux Q_{BA} by loss of material at the top surface of the green belt. The value of Q_{BA} is evaluated for travel distance X_2 from (4) and (6) by replacing Q_0 by Q_{AA} .

Stage-4 :

Total mass flux Q_B reaching at the outer edge of the green belt

The total mass flux Q_B reaching at the outer edge of the green belt (location B) is thus given by

$$Q_B = Q_{BC} + Q_{BA} \text{ ----- (14)}$$

Stage-5 :

Calculation of attenuation factor, A_f

In the absence of a green belt, the mass flux Q_{WB} reaching the distance $X_1 + X_2$ is evaluated using equations (4) and (6). The attenuation factor A_f of the green belt at location B is then obtained using equation (3).

Combining all the five above stages and after doing the necessary mathematical simplifications, the pollution attenuation factor, A_f is finally given by,

$$FD(X_1+X_2) A_f = \text{-----(15)}$$

Where,

- FD (X_1+X_2) = deposition correction factor for travel over distance (X_1+X_2)
- FD (X_1) = deposition correction factor for travel over distance X_1
- FD(X_2) = deposition correction factor for travel over distance X_2

Other parameters have their usual significance as described earlier.

Optimization of Green Belt

In previous section, a model for the development of green belt around pollution sources for reducing pollution levels has been described which can be used for the optimization of the physical dimensions of the green belt. This optimization, methodology is further described below.

It may be reiterated that the model incorporates following parameters for the computation of pollution attenuation factor, A_f : (i) physical characteristics of the green belt, e.g., distance from the source, width, height and leaf surface area density; (ii) aerodynamic properties eg., wind speed through green belt and effective height of the incident air stream, (iii) deposition velocity of the pollutant, and (iv) atmospheric stability conditions. The estimated value of attenuation factor, A_f for different combinations of green belt parameters i.e. X_1, X_2, h, U under different atmospheric stability conditions can be used to optimise the design of the green belt. The parameters X_1, X_2 and are critical for optimisation. The choice of remaining parameters (h and U) is restricted and decided mostly by the local conditions. For example, it is preferable to have taller trees with high foliage density, but trees of height greater than 20 meters are not common at most sites.

In optimising the physical dimensions of green belt for a ground level source as described above, factors like; the variation in the density of tree plantation and interfacial mass exchange through upper boundary of green belt were not considered. Since, these factors also play important role in effectiveness of green belt, these are discussed in next section.

Effect of Density of Tree plantation

The effect of density of tree plantation on attenuation factor has been dealt in details by Gupta and Kapoor (1992). It has been found out that the value of attenuation factor increases with increase in the density of tree plantation [K of equation (2)] upto an optimum value of K but decreases thereafter for $X_2 = 4$ Km. However, this concept is true only when interfacial mass exchange of pollutants through upper boundary of the green belt is not considered.

The interfacial mass exchange of pollutant in vertical across upper boundary of green belt would modify source mass flux moving through and above it and would thus influence the value of A_f . Consideration of interfacial pollutant exchange results in net movement of material from higher pollution region to lower pollution region. Value of A_f reduces when pollution moves out of canopy region to the region above. Whereas, when pollution enters from above to within canopy region, A_f increases. Reduction in A_f is seen for all values of density of tree plantation (K) for $X_2 < 2$ Km and for $K < 0.7$ for $X_2 > 2$ Km. A small increase in A_f is seen for $K = 0.7$ for $X_2 > 2$ km. These studies help to optimise K for a green belt of given h and X_2 to obtain maximum A_f . Optimum value of K giving maximum A_f for different X_2 for with and without interfacial mass exchange is given in Table 3.3 (Gupta and Kapoor, 1992).

Table-3.3 Value of maximum A_f and optimum K with and without interfacial mass exchange for different widths of green belt for neutral stability condition (category 'D').

X_2 (m)	Without interfacial pollutant exchange		With interfacial pollutant exchange	
	Maximum A_f	Optimum K	Maximum A_f	Optimum K
500	2.17×10^1	0.9	1.87×10^1	0.9
1000	6.64×10^1	0.7	3.10×10^1	0.8
2000	2.13×10^2	0.6	3.84×10^1	0.7
3000	5.87×10^2	0.5	4.67×10^1	0.7
4000	1.46×10^3	0.4	5.67×10^1	0.7
5000	3.76×10^3	0.4	6.88×10^1	0.7

Effect of other parameters

As an illustrative example for optimisation, values of A_f are calculated for a few selected values of parameters and the results are discussed here. The calculations are performed for removal of particulate material by a green belt for $\lambda = 0.02\text{m}^{-1}$ and tree height varying from 10-30m. Amongst the other parameters, value of V_{dx_1} and V_{dx_2} are assumed to be equal and assigned a value of 0.0156ms^{-1} (which is the gravitational settling rate for 20 μm particle size). Similarly U_{x_1} and U_{x_2} are assumed to be the same as $U(10)$. The values of $U(10)$ & UC used in these calculations under different atmospheric stability conditions are given below.

Stability condition	:	A	B	C	D	E	F
$U(10)$:	2	2	4	5.5	3	2
UC	:	0.5	0.5	0.75	1.0	0.6	0.5

Variation of A_f with X_1 and X_2

For a fixed height of tree, the value of A_f is expected to increase with increase in X_2 and with decrease in X_1 . Though it is preferable to plant the green belt as close as possible to the pollution source (i.e, low value of X_1), practical considerations may not permit very low values of X_1 . Similarly for fixed value of X_1 and X_2 , the value of A_f is greater for taller trees. The variation of A_f with X_1 and X_2 and h under different atmospheric stability conditions is discussed below.

Unstable condition, A

The variation of A_f with X_1 for a fixed value of $X_2 = 500\text{m}$ and with X_2 for a fixed value of $X_1 = 50\text{m}$ for stability condition A are given in figures 3.2 and 3.3 respectively. It can be seen from figure 3.2 that the value of A_f is close to unity even for taller trees if $X_1 = 300\text{m}$ or more. Reducing the value of X_1 is of advantage only in the case of tall trees and a value of $A_f = 6$ is obtained for 30m tall tree if X_1 is kept at 50 m.

Figure 3.2 shows that the value of A_f remains constant beyond a certain value of X_2 depending on the height of trees. This suggests that increasing the value of X_2 more than 300m does not serve any useful purpose for stability condition A for $h = 10$ to 30 m.

Stable condition, F

Figures 3.4 and 3.5 which are similar to figure 3.1 and 3.2 present the variation of A_f in stability condition F. The value of A_f , as high as 10^4 , is attainable in this stability condition (see fig - 3.4) for trees of height 15m or more for $X_2 = 500\text{m}$ and $X_1 = 50\text{m}$. This figure also shows that if the tree height is more than 25m, the value of A_f is of the same order even if X_1 is increased to 100m. Figure 3.5 shows that the value of A_f increases with X_2 upto a certain distance and thereafter the increase in A_f is not significant. This feature of more or less constant value of A_f beyond a certain distance helps in estimating the optimum width of the green belt. For the conditions considered in this example, this distance is 500, 700 and 1700m for tree heights 10, 15, and 30 m respectively.

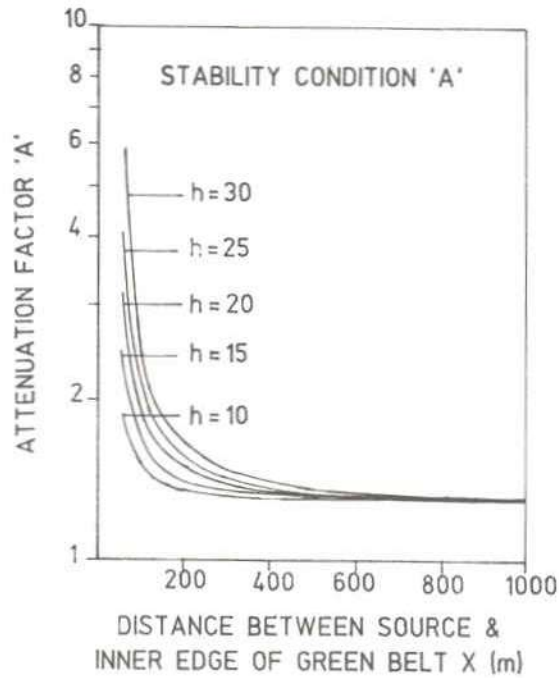


Fig. 3.2 Attenuation Factor as a Function of Distance Between the Source and Inner Edge of Green Belt and the Tree Height, for $X_1=500\text{m}$, $\lambda = 0.02\text{m}^{-1}$ and for Atmospheric Stability Condition A

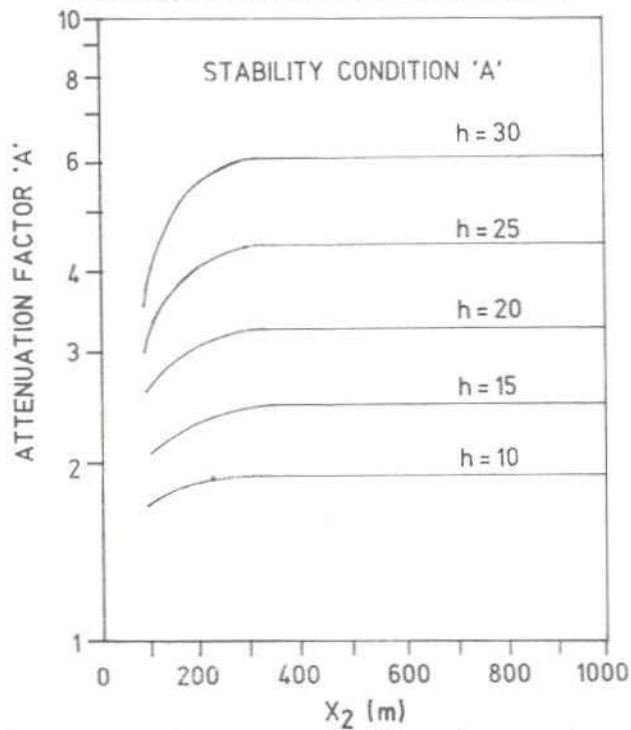


Fig. 3.3 Attenuation Factor as a Function of Width of Green Belt and the Tree Height, for $X_1=50\text{m}$, $\lambda = 0.02\text{m}^{-1}$ and for Atmospheric Stability Condition A

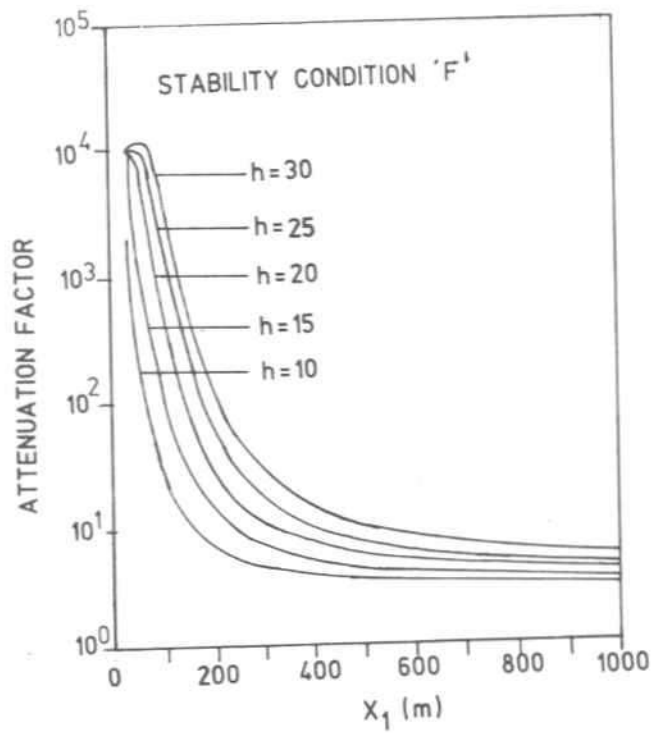


Fig. 3.4 For Atmospheric Stability Condition F

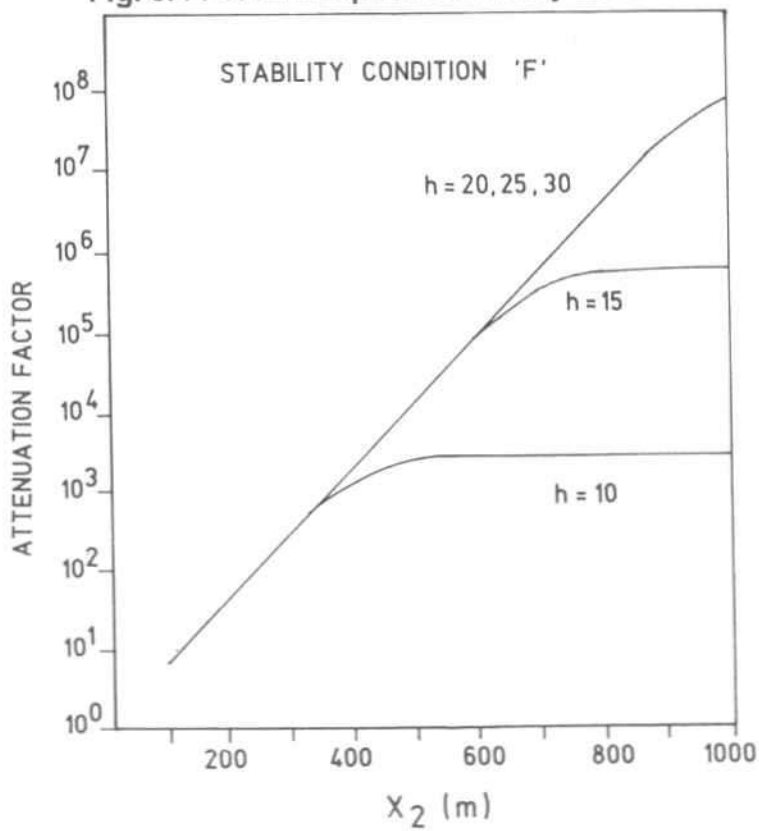


Fig. 3.5 For Atmospheric Stability Condition F

Variation in other Atmospheric stability conditions

The above discussion pertains to only two extreme atmospheric stability conditions. The values of A_f for intermediate stability conditions lie mostly in between the two extreme values (Table-3.4). It can be seen from this Table that, for 15m high trees, advantage gained by increasing the width of green belt from 500 to 1000m is not significant in all the stability conditions except for F where A_f of more than 10^4 is obtained for $X_1 = 50m$. However, if the tree height is increased to 30m, an attenuation factor of greater than 10^4 is possible in stability category E also for a green belt width of 1000m, whereas, in stability category D, the attenuation factor obtained is 600. This suggests that a green belt consisting of tall trees around an industry could provide significant attenuation factors for about 50% of the time in a year for the case considered here.

X_2 (m) (m)	h value of A_f for stability class					
	A	B	C	D	E	F
500	15	2.5	3.6	4.5	1.7×10^1	1.2×10^2 1.1×10^4
30	6.2	1.4×10^1	2.6×10^1	6.0×10^2	1.4×10^4	1.1×10^4
1000	15	2.5	3.6	4.5	1.7×10^1	1.2×10^2 5.9×10^5
30	6.2	1.5×10^1	2.6×10^1	6.0×10^2	1.1×10^5	8.2×10^7

Application of Green belt Model

The green belt model developed here is applied to two different cases for studying the usefulness of green belt in reducing the impact of pollution. Out of the two applications, one is a source oriented approach and the other is receptor oriented approach. In the source oriented approach, green belt of suitable dimension is planted around a source emitting pollution and studies are made to know the usefulness of green belt in reducing the effects of pollution for ground level releases. In the second case i.e., in the receptor oriented approach, green belt of suitable dimension is planted around an object which is getting deteriorated or likely to get deteriorated as a result of pollution in and around it and studies made to protect it against pollution. These two examples are dealt within a little more detail in the following paragraphs.

Source oriented approach

A nuclear power reactor surrounded by a suitably designed green belt provides an example of the source oriented approach.

Gupta and Kapoor (1985) analysed the consequences of a hypothetical reactor accident, in which a large, cold, ground level release of radioactive nuclides takes place in the presence of a suitably designed green belt around a nuclear power plant. The release of 54 radionuclides from a 1000MWe light water reactor was considered. These radionuclides fall into two main categories : particulates and noble gases. The deposition velocity on

vegetation for particulates was taken as 0.01 ms^{-1} and zero for noble gases (being inert in nature). The calculations considered the building wake effect (effect of stagnation of pollutants and subsequent dilution owing to alignment of surrounding structures which give rise to eddy currents) and radio - active decay as well as deposition of radionuclides in the green belt.

The radiological consequences were calculated in terms of early and continued mortalities. The radiation dose to four important body organs (viz. thyroid, lung, gastrointestinal tract, and bone marrow) of persons staying up to 100 kms from the reactor were calculated under different atmospheric stability categories. For calculation of early and continued mortality by the effect of radiation dose, the dose - mortality criteria of WASH 1400 (1975) were adopted.

The reactor accident consequences were calculated without a green belt and compared with the corresponding consequences when the reactor is surrounded by a 15m high green belt of 1500m width. The inner boundary of the green belt was taken as 50 m away from the reactor. Besides the decrease in mortality probability, the impact of green belt on reduction of other important consequences of lesser importance like relocation of population and banning of food produced in contaminated regions were also analysed. The analysis shows that, the benefits of developing a suitably designed green belt around nuclear power plants are as follows :-

- (i) The early and continued mortalities are practically eliminated beyond a distance of 3km.
- (ii) The relocation of population to protect it from long term external exposure from ground contamination may not be required.
- (iii) The supply of food from uncontaminated areas may be needed for populations living between 2 to 20 km only in the affected sector.

Since the siting requirements in many countries require exclusion distance ranging from 0.5 to 3 km from the reactor, it should be possible to develop a green belt around nuclear power plants that will substantially reduce the consequences of the accidents. The green belt would thus serve as another barrier between the nuclear power plant and the public and would strengthen the defense-in -depth philosophy adopted in the design of nuclear power plants. The assured availability of a suitably designed green belt throughout the year could also help in reducing the magnitude of emergency preparedness in the public domain.

Receptor oriented Approach

Mathematically both source and receptor oriented approach are the same, the only difference between the two is the manner in which the green belt is planted. In the source oriented approach, the green belt is planted around the pollution source, whereas in the receptor oriented approach the receptor is protected against pollution by planting a green belt around it. The case of protecting the Taj Mahal against air pollution by a green belt is presented here as an example of receptor oriented approach.

The value of the pollution attenuation factor, A_f is computed for different atmospheric

stability conditions, different heights, widths of the green belt and also for varying distances of green belt from the receptor. The results of the studies suggest that the green belt is more effective in attenuating pollution in stable atmospheric stability conditions and for smaller distance between source and green belt (X_1). Increasing the height of trees is of advantage in attenuating the pollution only for a smaller value of X_1 . Also, it is observed that increasing the width of green belt beyond 200m does not significantly increase the value of A_f , for the range of X_1 considered in the study. In general, the study indicates that, the value of A_f in the case of Taj Mahal is much smaller than that obtained by a source oriented approach. Significant values of A_f occur only for nearby ground level pollution sources and that also in stable atmospheric conditions.

Nomenclature

Symbol	Name	Unit
A_f	Pollution Attenuation Factor	Ratio
F_D	Deposition Correction Factor	Ratio
h	Physical height of green belt	m
h_e	Effective height of green belt	m
H	Pollution release height	m
K	Density of tree plantation in green belt	Ratio
Q	Mass flux of pollution	kg. S ⁻¹
U	Mean wind speed	mS ⁻¹
$U_{(z)}$	Wind speed at height Z	mS ⁻¹
U_c	Average wind speed through green belt	mS ⁻¹
V_d	Pollutants deposition velocity	mS ⁻¹
X	Travel distance	m
	Pollution Attenuation coefficient	m ⁻¹
P_c	Average foliage surface area density of the green belt	m ² m ⁻³
P_t	Average foliage surface area density of a single tree	m ² m ⁻³
	Standard deviation of concentration in cross-wind direction	m
	Standard deviation of concentration in vertical direction	m
$X(x,y,z)$	Concentration of pollutant at travel distance x, Crosswind distance y and height z	kg m ⁻³

CHAPTER – 4

AGRO-CLIMATIC ZONES OF INDIA

A country of subcontinental dimensions and varied features of land and rivers, is endowed with a large number of biogeographic zones. Though there were several attempts to classify Indian vegetation types, the most commonly used classification is that by Champion (1938) with modifications. Since the accent of the present effort is on cultivation of plants, rather than on the naturally growing vegetation types, a suitable scheme recognizing bio-climates along with soil types is necessary. Carter (1954) divided India into six climatic regions, from arid to perhumid, based on Thornthwaite's system of climate classification. Krishnan (1988) identified 40 soil climatic zones based on major soil types and moisture index. Planning Commission, Government of India, New Delhi (Alagh, 1990), have recommended a scheme for agro-climatic classification of the country.

According to this scheme, there are 15 agro-climatic regions (Fig.4.1). Each of these regions is further divided into 68 ub-zones, based on detailed characteristic features, such as natural resources, typologies (land productivity level, relative pressure on land and environmental factors) etc.

Subtypes presented in the Planning Commission document further describe ranges of rainfall (Fig. 4.2), general climatic conditions and soil types (Fig. 4.3) prevailing in these regions. The emphasis here is on the development of resources and their optimum utilization in a sustainable manner within the framework of resource constraints and potentials of each region.

Under National Agricultural Research Project (NARP), a 120 sub-zone map has been prepared, based primarily on rainfall, existing cropping pattern and administrative units. More recently, using parameters such as physiography, soils, bioclimates and length of growing period, an agro-ecological map of the country (Fig. 4.4.) has been prepared. This scheme recognizes 6 regions, which are further divided into 20 sub-regions.

A sophistication to agro-climatic classification for kharif crops has been devised by Chowdhery et al, (1993), employing principal component analysis to agro-climatic variables for delineating India into homogenous zones.

During the present work, the scheme suggested by the Planning Commission has been adopted. Appendix A gives the 15 agro-climatic zones and their 68 sub-zones, for which details such as annual rainfall, climate, soil types and revenue districts covered by them, are given.

It is expected that user of this report refers to Appendix A, for identifying and locating one's area of concern, before proceeding further to the list of plants to be chosen for plantation programme.



LEGEND

- | | |
|---------------------------|------------------------------|
| 1. WESTERN HIMALAYAN | 9. WESTERN PLATEAU - HILLS |
| 2. EASTERN HIMALAYAN | 10. SOUTHERN PLAREAU HILLS |
| 3. LOWER GANGETIC PLAINS | 11. EAST COST PLAINS - HILLS |
| 4. MIDDLE GANGETIC PLAINS | 12. WEST COST PLAINS - HILLS |
| 5. UPPER GANGETIC PLAINS | 13. GUJARAT PLAINS - HILLS |
| 6. TRANS GANGETIC PLAINS | 14. WESTERN DRY REGION |
| 7. EASTERN PLATEAU HILLS | 15. THE ISLANDS REGION |
| 8. CENTRAL PLATEAU HILLS | |

Fig. 4.1 Agro Climatic Zones

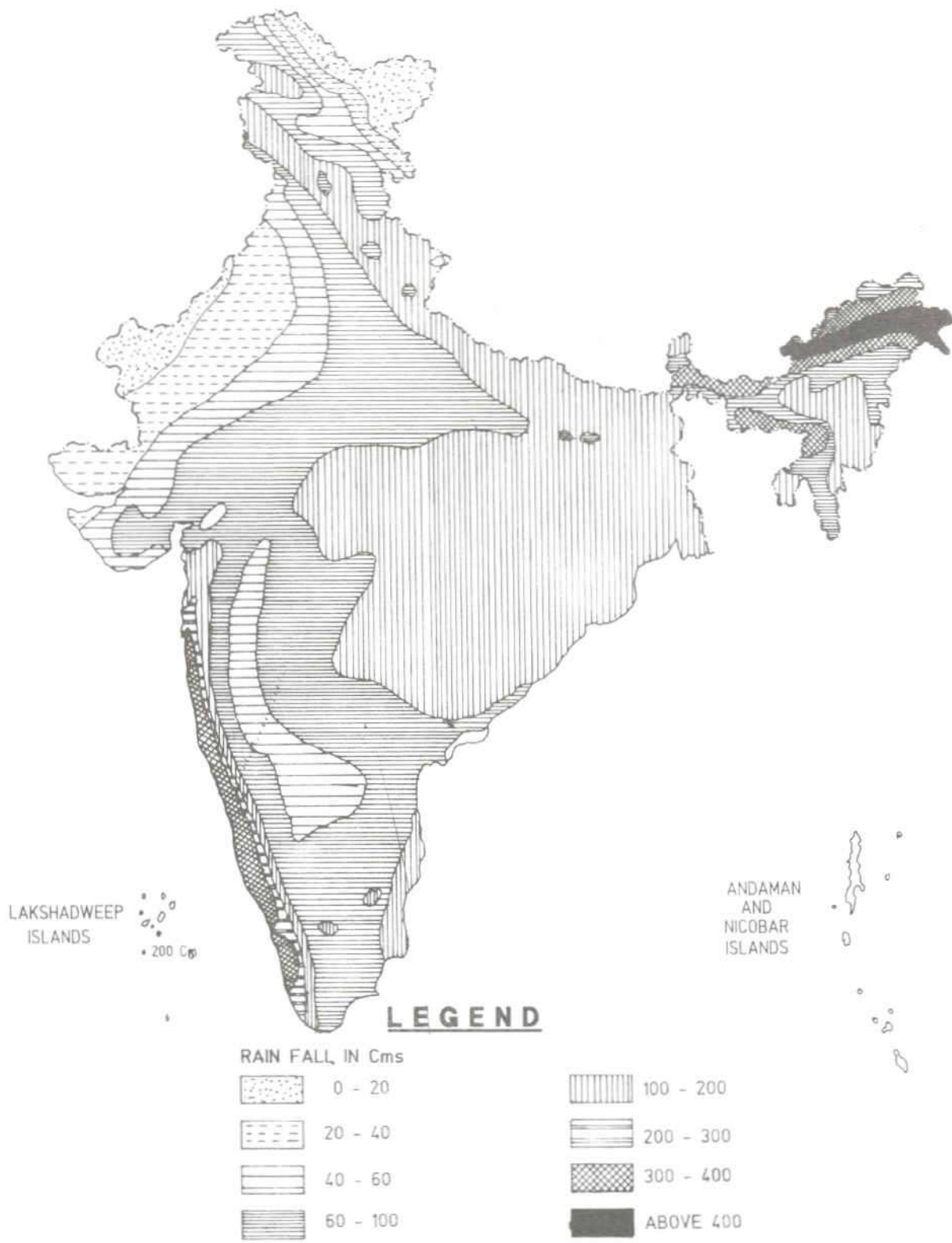


Fig. 4.2 Annual Rainfall

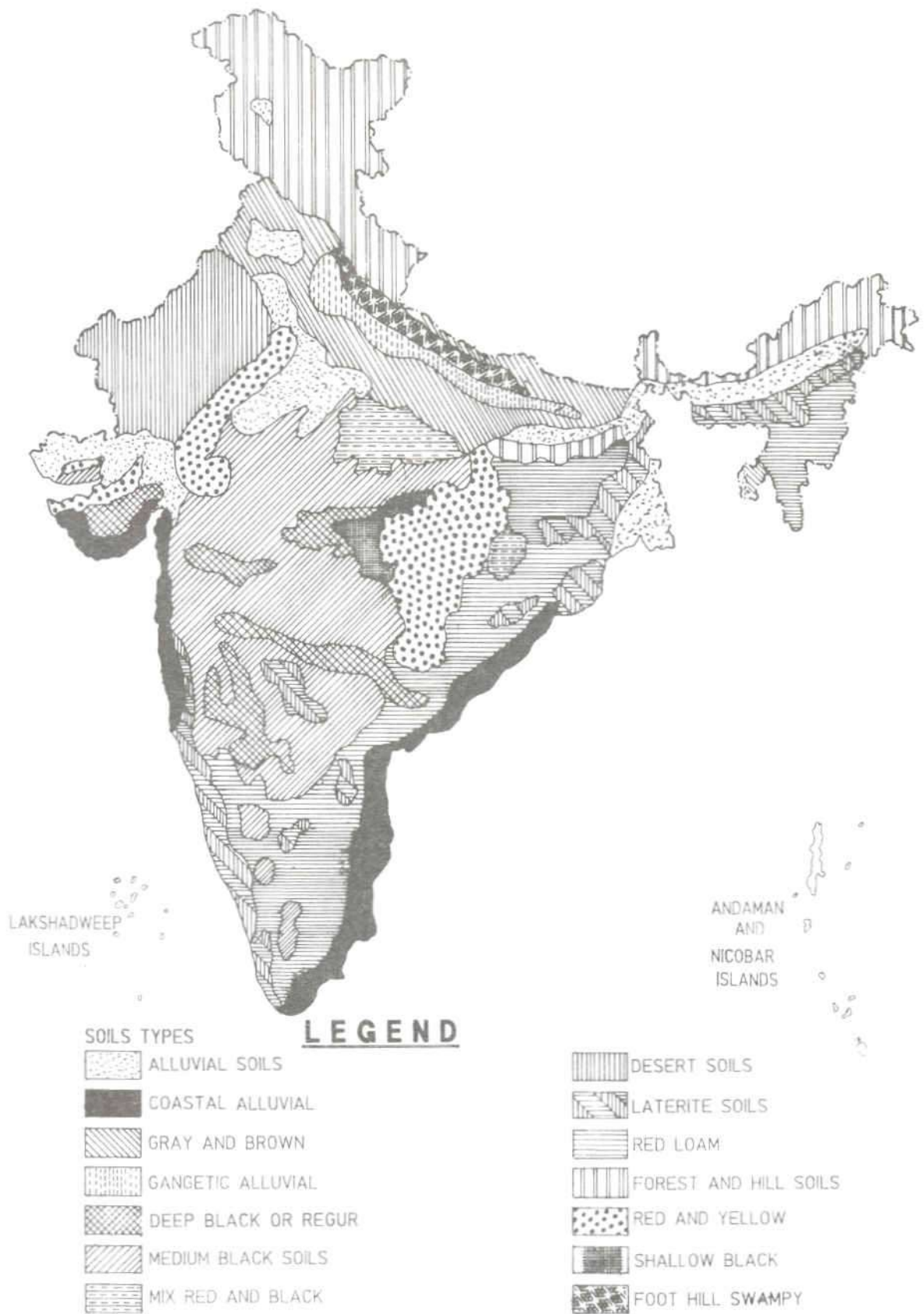


Fig. 4.3 Soils

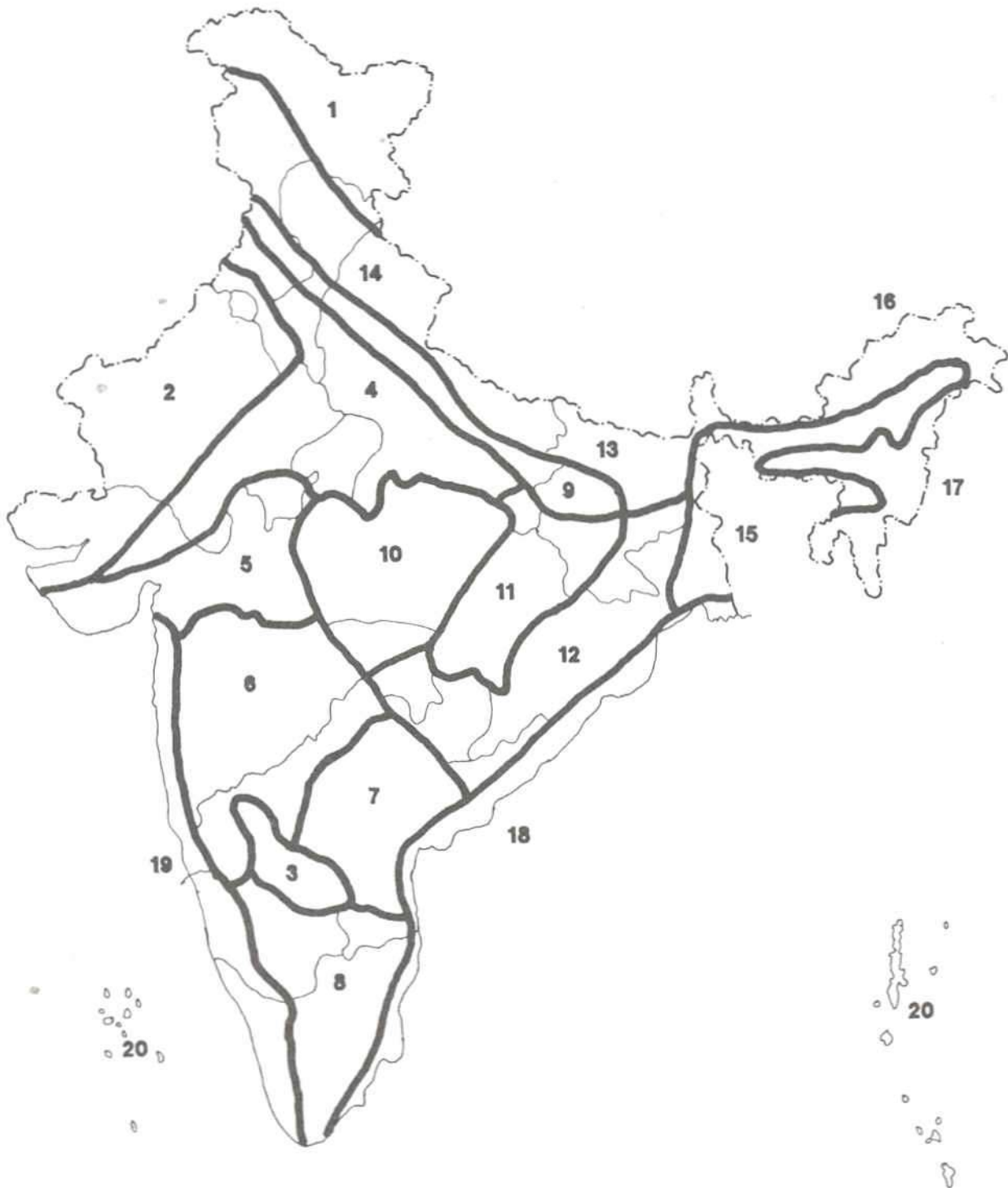


Fig. 4.4 Agro-Economical Regions

CHAPTER - 5

SELECTION OF PLANTS FOR GREEN BELTS

Discussion in earlier chapters indicate the nature of plant-air pollutant interactions and sensitivity indicated by plants. It also brings out the limitations under which plants are to function as scavengers of air pollutants. Other limitations for growing plants are the climatic conditions and soil characters. Of these, the latter get modified when plants are cultivated and grown under care, e.g. A standard horticultural practice involves planting of saplings in pits of substantial dimensions, i.e. 1m x 1m x 1m for big trees and almost half of these dimensions for smaller trees and shrubs. The pits are then filled with earth, sand, silt and manure in pre-determined proportions. Saplings planted in such pits are watered liberally. The growing plants are then cared for the first three years, or for at least two years under favourable conditions of climate and drainage. Nutrients in pits are supplemented and the juveniles provided protection. Hence, it is safe to assume that trees and bushes grown as green belt components in areas under human control, will have overcome the limitations imposed by soil characters to a great extent. Limitations imposed by climatic conditions on the other hand, cannot be overcome and hence will have to be taken into account while selecting species for plantation in different bio-climatic conditions.

While making choice of plant species for cultivation in green belts, weightage has to be given to the natural factor of bio-climate. It is also presumed that the selected plants will be grown as per normal horticultural (or forestry) practice given above and authorities responsible for plantation, will also make adequate provisions for watering and protection of the saplings.

For effective removal of pollutants, it is necessary that (1) plants grow under conditions of adequate nutritional supply (for health and vigour of growth), (2) absence of water stress (to maintain openness of stomatal apertures and form of epidermal structures), and (3) are well-exposed to atmospheric conditions of light and breeze (i.e. away from engineering structures hindering free flow of air) to maintain free interaction with gases.

Characters of plants including shapes of crowns (Fig.5-1) considered necessary for effecting absorption of pollutant gases and removal of dust particles are as follows :

For absorption of gases

- 1) Tolerance towards pollutants in question, at concentrations, that are not too high to be instantaneously lethal),
- 2) Longer duration of foliage,
- 3) Freely exposed foliage, through
 - a. Adequate height of crown,
 - b. Openness of foliage in canopy,
 - c. Big leaves (long and broad laminar surfaces),

- d. Large number of stomatal apertures,
- e. Stomata well-exposed (in level with the general epidermal surface).

For removal of suspended particulate matter

- 1. Height and spread of crown,
- 2. Leaves supported on firm petioles,
- 3. Abundance of surfaces on bark and foliage, through
 - a. Roughness of bark,
 - b. Epidermal outgrowths on petioles,
 - c. Abundance of axillary hairs,
 - d. Hairs or scales on laminar surfaces,
 - e. Stomata protected (by wax, arches/rings, hairs, etc.).

Note : All tolerant plants are not necessarily good for green belts. e.g. Xerophytes with sunken stomata can withstand pollution by avoidance but are poor absorbers of pollutants due to low gaseous exchange capacity.

It is unrealistic to expect, barring exceptions, that atmosphere in an industrial area will constitute only one species of air pollutant. More commonly, one comes across several pollutants, especially SO₂, NO₂ and oxidants, and SPM and also HF in the same region. It will hence be advisable to choose for cultivation of a green belt anywhere, plant species capable of sorption of chemicals as well as dust pollutants. Combined efficiency of a variety of species should contribute to reach the goals of green belts.

Models for Attenuation Coefficients given in chapter Three provide guidelines for positioning of plants with reference to particulate emission source at ground level. Width of the belt as presented by the model, may prove difficult for many industries to attain, for one or more reasons. Hence, it becomes necessary to decide to have green belts in places available around the industry (source-oriented plantation) as well as around habitats (receptor-oriented plantation). Lists of plants given in Appendix-C should be seen from this angle for selection of species combinations, in conformity with bioclimatic attributes of respective regions.

Plantation along Roadsides

Automobiles may be considered as ground level, mobile sources of pollution of both types - gaseous as well as particulate. Components of green belts on roadsides hence, should be both absorbers of gases as well as of dust particles, including even lead particulates. Sorption of the latter type has been estimated by Joshi (1990) who found high levels of lead sorption on ornamentals cultivated in traffic islands. Choice of plants for roadside (and traffic island) plantations may be for containment of pollution and for formation of a screen between traffic and roadside residences. This choice of plants should include shrubs of height 1 to 1.5 m and tree of 3 to 5 m height. The intermixing of trees and shrubs should be such that the foliage area density in vertical is almost uniform. A green belt of such a design and having a width of 30 to 50 m will give a pollution attenuation factor of 2 to 100 for unsuitable to plants atmospheric conditions. Thus medium-sized and small

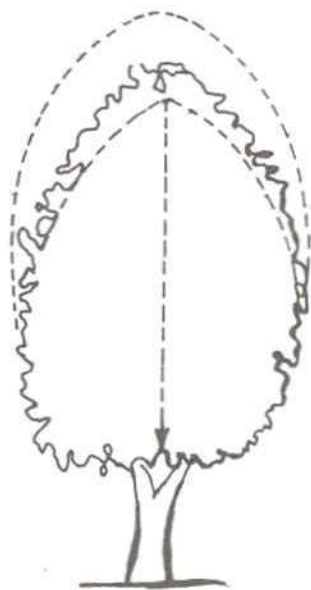
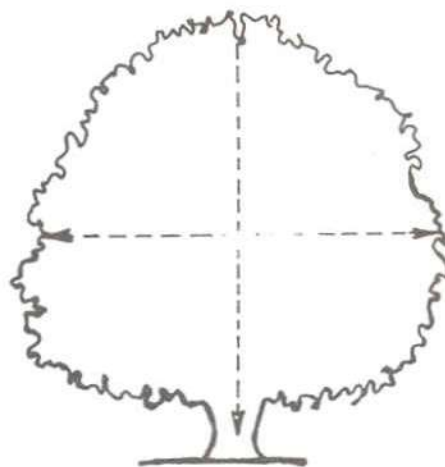
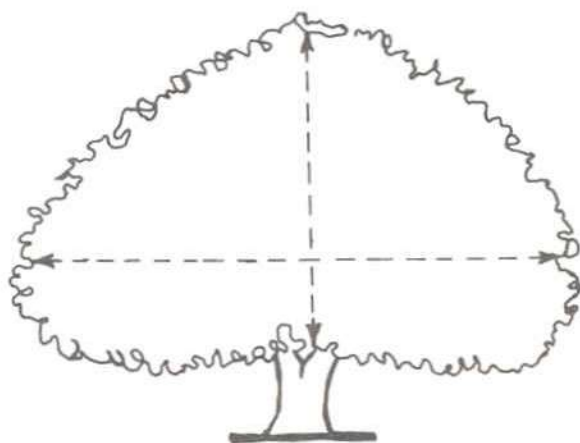
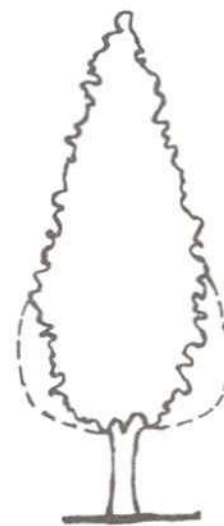
trees alternating with shrubs, aimed at sorption of particulates and gases, will be suitable here. Since safety of traffic is a major consideration, shrubs in traffic islands and along road-dividers will have to be short enough to be below the eye-level of motorists. An ideal design for roadside green belt is presented in Fig.5.2. Still, it is necessary to emphasize that each traffic island has its own character and needs to be studied separately for designing its green belt.

A comprehensive list of plants recommended for green belts in the country is presented in Appendix-B. The list consists of latin and common names of plants, natural order to which they belong and a number of relevant characteristic features, viz. tolerance or otherwise towards air pollution, habit, growth rate, flowering phenology, crown shape and approximate surface area, etc.

The list is not complete in itself. Several more species could be added to it. Criteria for inclusion of species in this list include availability, knowledge about their horticultural aspects, particularly propagation methods and growth rates and (sometimes) observed or reported information about their tolerance to air pollution. Numerous species, indigenous to certain regions, may also be included wherever possible. In extreme areas (e.g. where stresses due to water, salinity, salt-sprays, etc. are acute) only tolerant species should be chosen. Appendix C provides lists of plants recommended for cultivation in the six agro-climatic zones and their subzones.

The shapes given here are for convenience only. Many crown shapes range between those identified following, viz. Oblong-Round, Round-Spreading, Conical-Oblong, etc. Some shapes also change with age or environmental stresses.

Fig.5.1 TREE CANOPY SHAPES

**OBLONG****ROUND****SPREADING****CONICAL**

The shapes given here are for convenience only. Many crown shapes range between those identified following, viz. Oblong-Round, Round-Spreading, Conical-Oblong, etc. Some shapes also change with age or environmental stresses.

FIG. 5.1 TREE CANOPY SHAPES

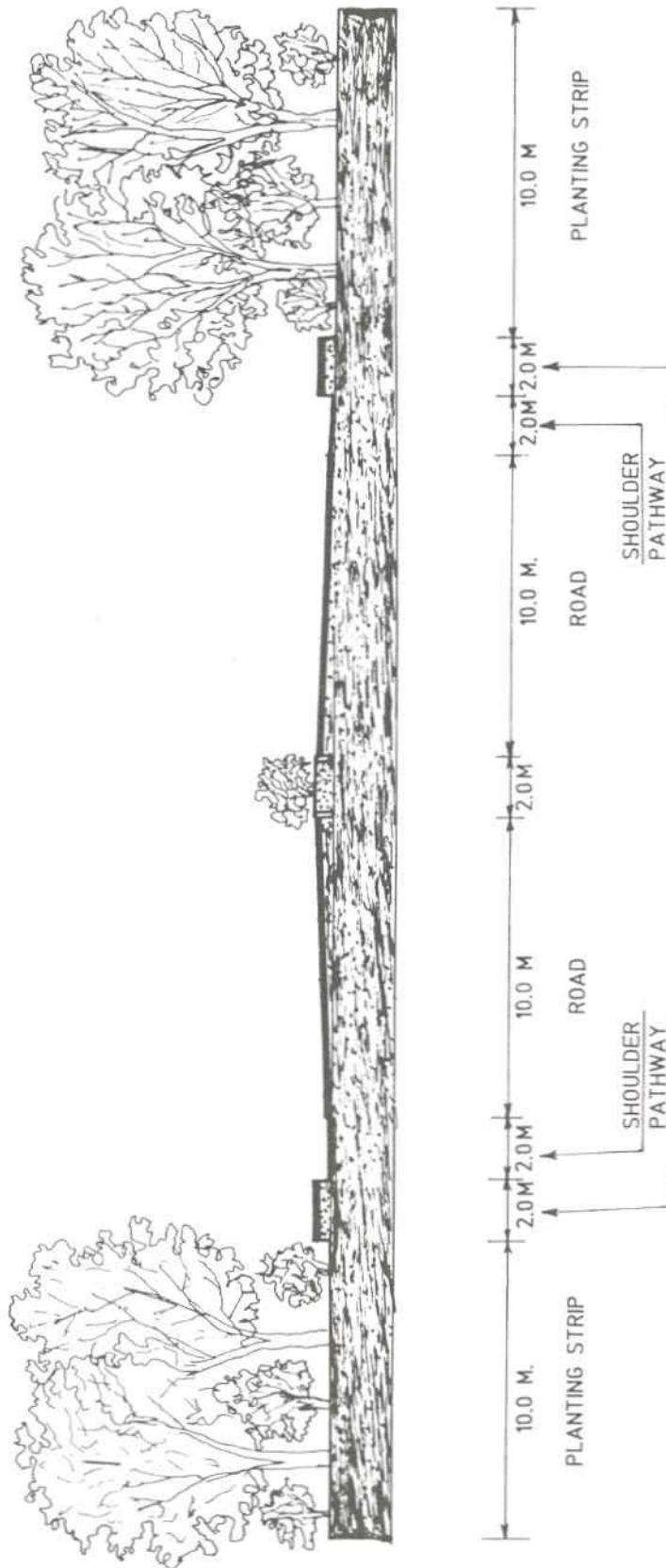


FIG. 5.2 TYPICAL ROAD -SIDE PLANTATION

CHAPTER - 6

STABILIZATION OF FLY - ASH WITH PLANTS**Introduction**

Of all the sources of non-muscular energy, coal is the most abundant one (Tandon, 1989). Total stocks of coal in India are 1,70,460.54 million tons of which 49,376.28 million tons are proven ones. Compared to oil and natural gas reserves (16,000 mt potential), coal stocks are more long-lasting and hence more reliable for exploitation. Hydropower is clean but creates other environmental problems through construction of large impoundments. Moreover, most of the hydropower potential in India has already been harnessed, leaving very little scope for further expansion to meet increasing demands of times. Nuclear power potential is vast. Presently meeting only a fraction of countries energy needs. Energy from fusion may provide an answer, when it becomes available on commercial scale, at the required magnitude. By all accounts then, we have to resort to coal for energy production till other power sources can be harnessed satisfactorily.

Environmental hazards of utilization of coal

Of all the fossil fuels, coal is the dirtiest one. All the way - from coal mine to ash dumps, this fuel poses environmental hazards in one or another form. Acidic drainage from coal mines and pit-head dumps are reported repeatedly by several workers (Bradshaw and Chadwick, 1980). Fugitive dust escaping along coal transportation channels, from pit-heads to power plants and at the time of loading - unloading operations has also been observed (Rao, 1971). Once at power plants, every stage of coal utilization creates a different environmental hazard.

Coal arriving in power plant premises is tipped from railway wagons or from conveyors. The tipping and storage areas are the ones where fugitive coal-dust escapes in the immediate neighbourhood, especially when these operations take place in the open, under dry-weather conditions.

Crushing of coal and conveyance of fine coal to furnaces is the next stage of fugitive dust emission. Combustion of coal for energy production then takes place, where generation of ash and pollutant gases takes place. A substantial amount of energy also escapes at the same time. Under the present technological scenario, a large proportion of all the three are captured and sought to be nullified, detoxified or ameliorated, from environmental point of view. Considering the magnitude of energy production however, even small proportion of the pollutant output proves to be a major environmental hazard. e.g. A 500 MW TPP using Indian coal (0.5% S, 40% mineral matter) generates 3537 tons of ash, 76 tons of SO₂, every day of its full capacity working. Pollution abatement measures of good capacities (99.8% in respect of dust capture) still permit around 884 g SO₂ and 66 g dust to emit from the high stack, every second. Ash captured before emission from stacks is deposited in pits, valleys or even on flat grounds. It finds its way in air by wind erosion and in water bodies by surface run off. Where deposited, the land by itself is unfit for any primary production process.

Covering of ash dumps

The large proportion of ash (40-47% in Indian coals) is conveyed to deposition areas in pipelines in the form of slurry. Receiving grounds are valleys, flat-lands or pits dug for the purpose. On decantation, or after infiltration of water into the ground, the ash stands exposed to elements - winds and rains. Ash gets blown on winds to get deposited downwind on croplands or on other types of vegetation, smother plants and affects yields (Rao, 1971; Bradshaw and Chadwick, 1980). Ash carried by run-off water forms sediments in nearby waterways causing turbidity problems for aquatic organisms, reduces water quality for drinking or even for irrigation. Cases of accumulation of toxic heavy metals in sediments of rivers are also reported (Evans and Geisey, 1979). Stabilization of ash deposits, hence, is always an urgent necessity.

Examples of successful stabilization of ash dumps and covering the same with plants can be cited (Bradshaw and Chadwick, 1980). Use of stabilized grounds formed by ash deposits for agricultural production has also been done.

The picture in India however, is far from encouraging so far. Though attempts appear to have been made for covering ash by plants, failure of the same was seen in the form of 2-3 year old plants getting chlorotic, bronzed or copper coloured and eventually dyeing. In one reasonably successful operation, where a variety of trees grew successfully for 5-6 years without soil amendments (as reported by the staff), two drawbacks were observed - i) the tall trees (about 4-5 m in height) had started lodging and ii) ash between tree bases had blown away. It is hence necessary to emphasize that a holistic approach to the problem of ash stabilization is desirable. Location of ash dump 'vis a vis' other land-uses in the vicinity, landscaping of the dump, stabilization, detoxification and utilization of the ground created for productive and other purposes should be planned meticulously and simultaneously. The planning process obviously should involve many disciplines. The following suggestions are a part of the planning operation, with a stress on plantation. The suggestions are based on i) experience of countries where productive lands have been formed after ash deposition and ii) working with much more toxic and hazardous tailings with comparable physical properties, from zinc-lead, mines (Chaphekar 1989).

Suggested procedure for Plantation

Fly ash is deficient in plant nutrients like nitrogen and sometimes phosphorus and other minerals and contains toxic metals like copper, cadmium, cobalt, chromium, manganese, molybdenum, nickel, lead, zinc and boron (Tables 6.1 and 6.2). Amendment of ash with nutrients and agents to arrest toxicants are essential for covering it with plants. Some suitable and inexpensive soil additives are given in Table 6.3, along with their properties. Nutrient contents of some commonly used organic manures are given in Table 6.4.

Mixing of farmyard manure (FYM) in 1:4 proportion should serve well as was found with zinc mine tailings (Chaphekar, *et al.*, 1986). For growing grasses, this mix need be in the top soil (upto 15 cm) only, while for tree saplings, pits of suitable dimensions (60x60x60 or 90x90x90 cm) are required with similar mixtures. Watering regimes depend upon local climatic conditions, though in initial stages regular watering - daily for grass and 2-3 times a week for trees is a must.

Nothing compares favourably with the capacity of carpet forming grasses in holding soil in its place, e.g. *Cynodon dactylon* has conservation value index (CVI) of 94% (Ambasht, 1970). Cultivation of grasses with spreading habit stabilizes the ash surface effectively. Grasses with high turnover rate of shoots contribute substantially to the organic enrichment of the otherwise nutrient-poor silty ash. Weathered ash is reported to be substantially less toxic than the freshly deposited ash (Bradshaw & Chedwick, 1980). Cultivation of herbaceous legumes enriches the substratum with nitrogen. The stabilized ash then forms suitable ground for other planned utilities like woodland, fuel or fruit-yielding trees, etc. Tables 6.5 (Jha & Singh, 1994) and 6.6 give lists of plants considered suitable for growing on ash dumps for their stabilization. The plants listed are grasses, legumes and MPTs (multi-purpose trees) forming a comprehensive agroforestry system. Possibilities for development of different amenities are numerous, including parks for recreational or educational purposes. Testing of edible parts of plants for toxic heavy metal contents would help decision-making for deriving agricultural yield from stabilized ash dumps. Experience derived after practicing stabilization efforts along suggested lines, would prove valuable as guidelines for further efforts.

Precautions

There are several variables in the environment and the types in inputs leading to pollution stress. Major variation is in the set of biogeographical conditions - especially climate and topography, as a result of which corresponding modifications in planting strategies become necessary. A large variety of local (climatically adapted) plant species need to be tried in different regions of the country. In case of failure of any of the species to respond as expected, a thorough investigation (even post-mortem) into the causes of failures, is called for. Such investigations provide guidelines for corrective measures and modifications in plans.

Another important aspect of ameliorative action is evaluation of action taken. Minor drawbacks in execution of plans tend to get amplified with passage of time. Continuous monitoring of plant growth, immediate replacement of casualties, supplementation of nutrients, rescheduling of watering regimes, etc. are important.

Table 6.1 Chemical Composition of Fly-ash

Element	Concentration (Values in %)	Element	Concentration (Values in ppm)
Si	51.94	Co	21
Na	0.49	Ni	86
K	0.60	Cu	68
Mg	0.29	Mo	50
Ca	1.38	Zn	72
Fe	6.13	Cd	5
Al	23.94	As	36
P	0.22		

(Source : D.N.Rao, M.Agrawal, J.Singh, 1990)

Table 6.2 Concentration of Elements in Typical Indian Coal And Fly-Ash Samples

Elements	Concentration in ppm	
	Coal	Fly Ash
Na	300	1300
K	2075	18275
La	47.6	238
Ce	30.2	145
Hg	11.0	48
Pb	1.8	8.1
Th	5.3	25
Cr	62.8	404
Hf	7.1	32.6
Sc	22.9	106
Zn	540	2027
Fe	20890	106670
Ta	1.5	5.1
Co	33.4	128
Eu	1.0	5.6
Sm	0.065	2.29
Au	0.14	0.69

(Source : M.H.Fulekar & J.M.Dave, 1990)

Table 6.3 Soil additives and their properties

Material	pH	Durability	C:N	Application to soil tons ha ⁻¹		
				(a)	(b)	(c)
Hay	5.5	1 season	25:1	2	3	4
Manure	6.6	6-12 months	25:1	15	30	40
Sawdust	3.5-7.0	3-5 years	200:1 to 500:1	1	5	10
Leaves (composted)	6.5	1 season	40:1	3	4	5
Refuse	7.5	1 season	45:1 to 55:1	20	-	-
Compost	8.5					

(a) While seeding, (b) for erosion control, (c) around already established plants.

(Source : Bradshaw and Chadwick, 1980)

Table 6.4 Nutrient contents of some types of organic manures

Manure type	Nutrient contents %			Organic matter %
	N	P	K	
Farm yard manure	0.62	0.13	0.49	24
Pig slurry	0.21	0.10	0.18	5
Poultry manure	2.30	0.90	0.65	65
Sewage sludge	1.82	0.43	0.46	39
Mushroom compost	2.80	0.20	0.80	65
Domestic refuse	0.50	0.20	0.30	65
Straw	0.48	1.62	0.85	95

(Source ; Juwarkar. *et al.*, 1989).

Table 6.5 Suggested Multi-Purpose Trees (MPTs) Suitable for Revegetation of Mine Spoils and Degraded Habitats

Acacia catechu
Acacia nilotica
Acacia tortilis
Albizia lebbek
Albizia procera
Azadirachta indica
Casuarina equisetifolia
Dalbergia sissoo
Dendrocalamus strictus
Dichrostachys cinerea
Gmelina arborea
Holarrhena antidysenterica
Holoptelia integrifolia
Leucaena leucocephala
Madhuca indica
Melia azaderach
Phyllanthus emblica
Pongamia pinnata
Prosopis cineraria
Sesbania aegyptiaca
Shorea robusta
Syzygium cumini
Tamarindus indica
Tectona grandis
Terminalia arjuna
Terminalia bellerica
Zizyphus mauritiana

Adapted from (A.K. Jha & J.S.Singh, 1994)

Table 6.6 List of Grasses, Legumes And Multi-purpose Trees (MPTs) Suggested For Cultivation for Stabilization of Fly-Ash

Grasses

Bothriochloa intermedia
 Bothriochloa pertus
 Brachiaria mutica
 Cenchrus setigerus
 Chloris gayana
 Chrysopogon fulvus
 Cynodon dactylon
 Echinochloa colona
 Eragrostis cynosuroides
 Heteropogon contortus
 Paspalidium geminatum
 Sacharum bengalense
 Sehima nervosum
 Sporobolus airoides
 Sporobolus coromendelines

Herbaceous Legumes

Cajanus cajan
 Crotalaria juncea
 Crotalaria burhia
 Desmodium triflorum
 Medicago sativa
 Phaseolus mungo
 Stylosanthes hamata

Trees

Acacia albida
 Acacia auriculiformis
 Acacia catechu
 Acacia holosericea
 Acacia nilotica
 Acacia senegal
 Albizia amara
 Albizia lebbeck
 Azadirachta indica
 Dalbergia sissoo
 Eucalyptus hybrid
 Erythrina variegata
 Gliricidia sepium
 Grewia tenax
 Hardwickia binata
 Leucaena latisiliqua
 Pithecellobium dulce
 Zizyphus nummularia

(Source : A.K. Jha & J.S. Singh, 1994)

Bioclimatic Zones of India Inclusive of Soil Types and Revenue Districts
I. Western Himalayan Region

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	High altitude temperate	165	Humid to cold arid	Hill soil mountain meadow, skeletal Tarai.	Chilas, Gilgit, Gilgit Wazarat, Jammu, Kashmir. North (Baramula) Kashmir South (Anantnag, Pulwama, Srinagar, Badgam) Kathua, Ladakh (Kargil, Ladakh.) Mirpar, Muzaffarabad (kupwara.) Poonch, Riasi (Rajauri) Tribal territory. Udhampur (Udhampur Doda) (J and K)
2.	Hill temperate	2000	Humid	Brown Hill	Bilaspur, chamba Hamirpur, Kangra, kinnaur, Kullu, Lahul and spiti Mandi, shimla sirmour, solan, Una (H.P)
3	Valley temperate	400	sub Humid	sub Mountain, Mountain, Meadu, Skeletal	Chamoil, Dehra Dun Garhwal, Tehri Garhwal Pithoragarh, Almora, Nainital, Uttarkashi
4.	Sub-tropical	1030	Semi-arid to humid	Alluvial (Recent) Brown Hills	

II. Eastern Himalayan Region

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	Himalayan Hills	2641	Perhumid to humid	Brown Hills	Darjeeling (W.B.) East sikkim, North Sikkim, South sikkim, West sikkim.
2.	NE, Hills	3528	Per humid to humid	Red sandy Laterite	Karbi Anglong, North Cachar Hills (Assam) Dibang valley, East Kameng. East Siang, Lohit. Lower Subansiri Tirap, Upper Subansiri, West Kameng (Tawang), West Siang (Ar.P) East Garo Hills. East Khasi Hills, Jaintia Hills, West Garo Hills, West Khasi Hills (Meghalaya(Kohima, Mok's kohung. Mon, Phek, Tuensong, Wokha, Zunhebota (Nagaland)
3.	Southern Hill	2052	Per humid to humid	Acidic soil	Bishnupur (Central Manipur) Churachandpur (South Manipur) Imphal (Central Manipur) Senapati (North Manipur) Tamenglong (West Manipur) Chandel (Tengnoupal) Thoubal (Central Manipur) Ukhrul (East Manipur) North Tripura, South Tripura, West Tripura, Aizwal. Chhingtupui Lunmglei (Mizoram)

(Contd.....)

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
4.	Lower	1840	Per humid to humid	Alluvial Red loamy	Barpeta Dhubri, Darrang, Goalpara, Kaprup (Nalbari), Kokrajhar (Nagoan), Sonitpur Nowgong (Assam)
5.	Upper	2809	Humid to per Humid	Alluvial Red Loamy	Dibrugarh, Karbi Anglong, Jorhat, Karimgani, Lakhimpur, Sibsagar (Golaghat), Cachar (Silchar, Pragiyotishpur) (Assam), Jalpaiguti Koch Bihar (W.B.)

III. Lower Gangetic Plains (West Bengal)

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	Barind Plains	1587	Moist sub humid and sry sub humid	Red and yellow allwvial	Mallah West Dinajpur
2.	Central Alluvial Plains	1449	Moist sub humid to dry sub humid	Red and yellow Deltaic Alluvium, Red Loamy	Barddhaman Haora, Hugli Medinipur (E&W) Murshidabad, Nadia
3.	Alluvial Coastal Saline Plains	1607	Dry sub humid to moist sub humid	Red and yellow deltaic Alluvial	Calcutta, Twenty Four Paragans (North and South)
4.	Rarh Plains	1302	Moist sub humid to Dry sub humid	Red and yellow red loamy	Bankura Birbham.

IV. Middle Gangetic Plains

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	North West Alluvial	1211	Moist sub humid to dry sub humid	Alluvial calcarious	Azamgarh, Bahraich, Ballia Basti, Faizabad Gazipur, Gonda, Gorakhpur, Jaunpur. Mirzapur, Deoria, Varanasi (U.P.)
2.	North East Alluvial	1470	Dry Sub humid to Moist sub humid	Alluvial tatai	Aurangabad, Begusarai Bhagalpur, Bhojpur, Darbhanga, Gaya, Gopalganj, Katihar Khagaria, Madhepura, Mudhubani, Munger, Muzzaffarpur, Nalanda, Nawada, Poschim Champaran, Patna, Purba Champaran, Purnia, Rohtas, Saharsa, amsatipur, Saran, Sitamarhi, Siwan. Vaishali (Bihar)

V. Upper Gangetic Plainns (Uttar Pradesh)

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	Central Plains	979	Dry sub humid to semi arid	Alluvial	Allahabad, Bara banki, Fatehpur, Hardoi, Kheri Lucknow, Pilibhit, Rae Bareli, Sitapur, Sultanpur, Unnao, Partapgarh
2.	North Western Plains	907	Dry sub humid to semi arid	Alluvial tarai	Bareilly, Bijmor Bulandshahar, Gaziabad, Meerut, Moradabad, Muzaffarnagar, Rampur, Saharanpur, Shahjahanpur
3.	South Western Plains	721	Semi arid	Alluvial	Agra, Aligarh, Badam Etah, Etawah, Farukhabad, Kanpur (Rural), Kanpur (Urban) Manipur, Mathura

VI. Trans Gangetic Plains

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	Foot hills of Shivalik and Himalayas	890	Semi-arid to dry sub-humid	Alluvial (Recent) Calcareous	Gurdaspur, Hoshiarpur Rupnagar (Punjab) Ambala, Chandigarh (Haryana)
2.	Plains	561	Semi arid to dry sub humid	Alluvial (Recent) Calcareous	Amritsar, Jalandhar Kapurthala, Ludhiana, Patiala (Punjab), Faribdabad, Gurgaon, Jind, Karnal, Kurukshetra, Rohtak, Sonapat (Haryana) Delhi
3.	Scarce Rainfall arid zone	360	Arid and Extreme arid	Calcareous Sierozemic Alluvial (Recent) Desert	Bathinda, Faridkot, Ferozpur, Sangrur (Punjab), Bhiwani, Hisar, Mahendragarh Sirsa (Haryana) Ganganagar (Rajasthan)

VII. Eastern Plateau and Hills

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	Eastern Plain	1271	Dry sub humid	Medium to deep black red and yellow	Bolanagar, Dhenkanal Sambalpur (Orissa) Balaghat, Bilaspur, Durg, Raipur, Raj Nandgaon (M.P.) Bhandara, Chandrapur Garchiroli (Maharashtra)
2.	Eastern Highland	1436	Moist sub humid to dry sub-humid	Red sandy, Red and Yellow	Koönjhar, Mayurbhanj Sundargarh (Orissa) Rajgarh, Surguja, Shahdol (M.P.)
3.	North Central Plateau	1296	Moist sub humid to dry sub-humid	Red sandy Red and Yellow	Deogarh, Dhanbad, Giridih, Godda, Hazaribag, Sahibganj, Santhal Pargana (Dumka) (Bihar)
4.	Eastern Plateau	1369	Moist sub humid to dry sub humid	Red and Yellow, Red loamy	Puruliya (W.B.) Lahardaga, Palamau Ranchi, Singhbhum (Bihar)
5.	Tribal	1338	Moist sub humid to dry sub humid	Red sandy Red and Yellow, Red loamy	Kalahandi, Koraput Phulbani (Orissa) Bastar (M.P.)

VIII. Central Plateau and Hills

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	Bundelkhand	780	Dry sub humid to dry arid	Mixed red and black	Banda, Jalaun, Jhansi, Lalitpur, Hamirpur(U.R.)
2.	Bundelkhand (M.P.)	700	Dry sub humid to semi arid	Mixed red and black	Chhatarpur, Datia, Tikamgarh (M.P.)
3.	North Hills	1570	Moist sub humid to dry sub humid	Red and Yellow	Mandla (M.P.)
4.	Kymore Plateau and Satpura Hills	1100	Dry sub humid	Red & Yellow Medium black	Jabalpur, Panna, Rewa, Satna, Seoni, Sidhi (M.P.)
5.	Vindhya Plateau	1130	Dry sub humid	Medium black	Bhopal, Damoh, Raisen, Sagar, Sehore, Vidisha (M.P.)
6.	Satpura	1220	Dry sub humid	Shallow black Mixed Red and black	Chhindwara, Betul (M.P.)
7.	Central Narmada vally	1300	Dry sub humid	Deep black skeletal	Hoshangabad, Narsimhapur (M.P.)
8.	Gird	670	Semi arid (half drier)	Medium black, Alluvial	Bhind, Guna, Gwalior, Morena (M.P.)
9.	South eastern Plains	760	Semi arid (half drier and water half)	Medium black	Bundi, Kota (Rajasthan)
10.	Southern Plains	760	Semi arid (Water half)	Medium red and grey, brown	Banswara, Dungarpur (Rajasthan)
11.	Transitional Plains	490	Semi arid to arid	Desert soil Grey brown	Pali, Sirohi (Rajasthan)
12.	Southern Plains Aravalli Hills	500	Semi arid (Water Half)	Red and Yellow Grey brown	Bhilwara, Chandigarh, Udaipur (Rajasthan)

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
13.	Semi-arid Eastern Plains	500	Semi arid (drier half)	Alluvial	Ajmet, Jaipur, Tonk (Rajasthan)
14.	Flood Prone Eastern Plains	500	Semi arid (Drier half)	Alluvial (Recent)	Alwar, Bharatpur, Sawai Madhopur, Dhaulpur (Rajasthan)

IX. Western Plateau and Hills

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	Hill zone	988	Semi-arid	Medium to deep black Shallow red Red loamy	Kalhapur, Nasik, Pune, Satara (Maharashtra) Jhabua (M.P.)
2.	Scarcity zone	602	Semi-arid	Medium black, deep black	Ahmednagar, Dhule, Sangli, Sholapur (Maharashtra)
3.	Plateau zone North	874	Semi-arid (Eetter half)	Medium black, deep black, Mixed red & black Shallow red	Akola, Amaravati, Aurangabad, Beed, Buldana, Jalgaon, Jalana, Latur, Osmanabad, Parbhani (Maharashtra) Dewas, Dhar, East Nimar, Indore, Mandsaur, Rajgarh, Ratlam, Shajapur, Ujjain, West Nimar (M.P.) Jhalawar (Rajasthan)
4.	Plateau zone South	1040	Semi-arid to dry sub humid	Medium black, Shallow, black	Nagpur, Nanded, Warsha, Yavatma (Maharashtra)

X. Southern Plateau and Hills Region

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	Sub zone-1	769	Semi-arid & arid	Medium black, Laterite deep black, Red loamy	Belgaum, Ballary, Bidar, Bijapur, Dharwad, Gulbarga, Raichur (Karnataka)
2.	Sub zone-2	677	Semi-arid	Red loamy medium black, Red sandy, coastal alluvium, laterite	Anantpur, Chittor, Cuddapah, Kurnool (A.P.) Banglore, Chitradurga, Kolar, Tumkur (Karnataka)
3.	Sub zone-3	725	Semi-arid & arid	Red sandy, Medium to deeo black	Hyderabad, Mahbubnagar, Nalgonda, Rangareddi (A.P.)
4.	Sub zone-4	1001	Semi-arid (Wetter half)	Deep black, Medium black	Adilabad, Karimnagar, Khammam, Medak, Nizamabad, Warangal (A.P.)
5.	Sub zone-5	865	Semi-arid	Red loamy, Red sandy	Mandya, Mysore (Karnataka) Dharmapuri (Tamilnadu) Hasan (Karnataka)
6.	Sub zone-6	841	Semi-arid to dry sub humid	Mixed red & black red loamy, Deltaic alluvium	Coimbatore, Madurai (Anna) Tiruchirapalli, Periyar, Pudukkotai (Tamil Nadu)

XI. East Coast Plains and Hills Region

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	North Orissa Coast	1287	Moist sub humid	Deltaic alluvial, Coastal alluvial Laterite, Red Loamy	Baleshwar, Cuttack Puri (Orissa)
2.	North coastal Andhra	1128	Dry sub humid	Red loamy Laterite, Medium black, red sandy, coastal alluvial	Srikakulam, Vishakhapatnam, Vizianagaram (A.P.)
3.	South coastal Andhra	996	Semi-arid	Deltaic, Alluvium Deep black Red sandy Red and black	East Godavari, Guntur, Krishna, Prakasam, West Godavari (A.P.) Yanam (Pondicherry)
4.	North coastal Tamil Nadu	1036	Semi-arid	Red loamy Red sandy, coastal alluvium	Nellore (A.P.) Chengalpattu, Madras, North Arcot, South Arcot (Tamil Nadu) Pondicherry)
5.	Tenjavur	1113	Semi-arid to dry sub humid	Deltaic alluvium Red loamy	Thanjavur (Tamil) Karaikal (Pondicherry)
6.	South coastal	780	Semi-arid (drier half)	Mixed Red & black coastal Alluvium	Karmarajar, Ramanathapuram Tirunelveli, P. Muthurama Lingam (Ramnathapuram) (Tamil Nadu)

XII. West Coast Plains and Ghat Region

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	Coastal Hilly	3640	Per humid & humid	Laterite, Red, loamy Coastal	Uttarkannada (Karnataka) Greater Bombay, Ratnagiri Raigad (Kolaba) Sindhudurg Thane (Maharashtra) Goa
2.	Coastal Midland	3127	Dry sub humid & per humid	Red loamy, Coastal alluvium laterite	Alleppy, Cannanore, Ernakulam Kasargood, Kozhikode, Malappuram Quilion, Trichur, Trivandrum (Kerala) Kanniyakumari (Tamil Nadu) Dakshin Kannada (Karnataka)
3.	Midland	2727	Per humid	Laterite Coastal Alluvium	Kottayam, Palghat, Pathanamittitta (Kerala)
4.	Hilly	2226	Per humid	Red loamy, Mixed Red & black	Iddukki, Wayanad (Kerala), Chikmaglur Kodagur (coorg) Shimoga (karnataka) Nilgiri (Tamil Nadu)

XIII. Gujarat Plains and Hill Regions

S. No.	Sub Zone	Rainfall (mm)	Climate	Soils	Districts
1.	South Gujarat	1793	Semi-arid to dry sub humid	Deep black coastal alluvium	The Dangs, Valsad (Gujarat) Daman Dadra & Nagar Haveli
2.	South Gujarat	974	Semi arid to dry sub humid	Deep black coastal alluvium	Bharuch, Surat (Gujarat)
3.	Middle Gujarat	904	Semi arid	Medium black	Kheda, Ranch – Mahals Vadodara (Gujarat)
4.	North Gujarat	735	Arid to semi arid	Grey brown deltaic alluvium	Ahmedabad, Banaskantha, Mahesana, Sabarkantha (Gujarat)
5.	North West Arid	340	Arid to semi arid	Grey brown deltaic alluvium	Kachchh (Gujarat)
6.	North Sourashtra	537	Dry sub humid	Coastal alluvium Medium black	Amreli, Bhavnagar, Jamnagar, Rajkot, Surendranagar (Gujarat)
7.	South Saurashtra	844	Dry sub humid	Coastal alluvium Medium black	Junagadh

XIV. Western Dry Regions

S. No.	Sub Zone	Rainfal (mm)	Climate	Soils	Districts
1.	Western Dry	395	Arid to extremely arid	Desert soil, Grey Brown	Barmer, Bikaner, Churu, Jaisalmer, Jalor, Jhunjhunu, Jodhpur, Nagaur, Sikar (Rajasthan)

XV. The Island Regions

Andaman, Nicobar & Lakshadweep

(1)	(2)
1. Andaman	1. Laksjadweep
2. Nicobar	

APPENDIX-B

This Appendix consists of names of plants recommended for Green Belts. Abbreviations and order of presentation used in this Appendix are as follows :

- | | | |
|--------|---|---|
| No. | - | Serial number in the list, starting with first letter of the generic name. |
| | - | Latin name of the plant. |
| Fam. | - | Family. |
| C.N. | - | Common and vernacular name in different languages of India, Viz.
Beng - Bengali, Guj. - Gujrati,
Mar. - Marathi, Hin. - Hindi....etc. |
| S/T | - | Sensitive/Tolerant, (to air pollution) |
| HA | - | Habit. |
| HT | - | Height. |
| GR | - | Growth rate. |
| R | - | Regeneration. |
| E/D | - | Evergreen/Deciduous. |
| DF | - | Duration of foliage. |
| Flo.S. | - | Flowering season. |
| CSA | - | Crown surface area (estimated). |
| CS | - | Crown shape. |
| LA | - | Leaf area. |
| SI | - | Stomatal index. |

No. A1 Abutilon indicum Linn.

- Fam. - Malvaceae
 C.N. - Country mallow; Beng. Jhampi; Guj. Khapat;
 Hin. - Kanghi; Kan - Srimudrigida; Mal. Jhonkaped;
 Mar - Chakrabhenda; Oriya - Nakochono;
 Tam - Thuttli; Tel - Botlabenda, Tuttilibenda;
 Assam - Jhapa; Goa - Petari.
- S/T - T
 HA - Shrub
 HT - 5m
 GR - Quick growing
 R - Through Seeds.
 E/D - Deciduous.
 Flos - Most of the year.
 CS - Oblong.

No. A2 Acacia auriculiformis A. cunn.

- Fam - Mimoseae
 C.N. - Australian Wattle, Beng - Akashmone.
 S/T. - T
 HA - Tree.
 HT - 16 m.
 GR - Quick growing.
 R - By seeds.
 E/D - Evergreen
 Flo.S. - June - Jan.
 CSA - 8548.22 m²
 CS - Oblong
 LA - .140.50 cm²
 SI - 10.9

- No. A3 Acacia catechu, Willd
 Fam - Mimoseae
 C.N. - The cutch tree. Sonkhairi, Sans - Khadira,
 Hin - Khair; Beng - Kuth; Tam - Karangalli,
 Tel - Khadiramamu.
 S/T - T
 HA - Shrub
 HT - 3m
 GR - Quick growing
 R - By seeds.
 E/D - Evergreen.
 Flo.S. - May - August
 CSA - 108.42 m²
 CS - Oblong.
 LA - 109.98 cm²
 SI - 8.24
- No. A4 Acacia dealbata Link.
 Fam - Mimoseae
 C.N. - Silver wattle.
 S/T - T
 HA - Tree
 HT - 15m
 GR - Quick growing
 R - By seeds
 E/D - Evergreen.
 Flo.S. - April - June
- No. A5 Acacia farnesiana Willd
 Fam - Mimoseae
 C.N. - The cassia flower.
 Hindi - Gandh - babul, Beng - Guya babula,
 Sans - Arimaedah; Mar - Deobabal,

Tam - Kasturivel; Tel - Kasturitungma.

S/T - T
 HA - Tree.
 HT - 5m.
 GR - Quick growing.
 R - By seeds.
 E/D - Evergreen
 Flo.S. - Aug - Mar.

No. A6 Acacia ferruginea DC

Fam - Mimoseae
 C.N. - Safed khair.
 Sans - Somasara; Tam - Velvelam; Tel - Ansandra.
 S/T - T
 HA - Tree.
 HT - 3-4m.
 GR - Quick growing.
 R - By seeds
 E/D - Evergreen
 Flo.S. - Jan - Feb.

No. A7 Acacia leucophloea Willd.

Fam - Mimoseae
 C.N. - Distiller's acacia; Beng - Safed babul
 Eng - White babool; Guj. Haribaval;
 Hindi - Safed babul; Kan - Bilijal;
 Mal - Pattacharayamaram; M.P - Vilayati babul;
 Mar - Hewar; Raj - Arunj; Sans - Arimedah;
 Tam - Velvayalam; Tel - Tellatumma.
 S/T - T
 HA - Shrub.
 HT - 3 m
 GR - Quick growing

R - By seeds.
 E/D - Deciduous
 Flo.S. - Jan.-Feb.
 CSA - 8281.4 m²
 CS - Oblong
 LA - 132.52 cm²
 SI - 12.01

No. A8 Acacia mearnsii de Wild.
 Fam - Mimoseae.
 C.N. - Black wattle, Tam - Chavukku
 S/T - T
 HA - Tree
 HT - 20m
 GR - Quick growing.
 R - By seeds, Root suckers.
 E/D - Evergreen
 CS - Spreading.

No. A9 Acacia mellifera (Vahl) Beth.
 Fam - Mimoseae
 S/T - T
 HA - Tree
 HT - 8 -10m
 GR - Quick growing
 R - By seeds
 E/D - Deciduous
 Flo.S. - Twice in an year

No. A10 Acacia nilotica (Linn) Willd.
 Fam - Mimoseae
 C.N. - Indian Gum - Arabic tree, Beng, Hindi, Punjab and
 M.P - Babul; Eng - Babul; Guj - Baval;

Bihar - Babule; Kan - Karijauli, Mal - Karivelan,
 Mar - Vedibabul; Oriya - Baubra;
 Sans - Barburah, Vavari; Tam - Karuvelamaram;
 Tel - Nallatumma.

S/T - T
 HA - Tree
 HT - 8m
 GR - Quick growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - Aug - Jan.
 CSA - 8293.74 m²
 CS - Spreading.
 LA - 135.70 cm²
 SI - 11.23

No. A11 Acacia pennata Willd

Fam - Mimoseae
 C.N. - Hin - Biswal; Kumaon - Agla; Beng - Kuchui;
 Sans - Ari; Tam - Indu; Tel - Karusikaya.
 S/T - T
 HA - Shrub
 HT - 8m
 GR - Quick growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - June - Aug.
 CS - Round

No. A12 Acacia polyacantha Willd.

Fam - Mimoseae
 S/T - T
 HA - Tree

HT - 10m
 GR - Quick growing
 R - By seeds
 E/D - Semi - deciduous.
 Flo.S. - May - June, Oct - Nov.
 CS - Flat crown

No. A13 Acacia senegal Willd.

Fam - Mimoseae
 C.N. - Sans - Svetakhadira; Rajasthan - Kumta
 S/T - T
 HA - Tree
 HT - 5m
 GR - Quick growing
 R - By seeds.
 E/D - Deciduous
 Flo.S. - Aug - Mid Sept, Nov. - Mar.
 CS - Feathery spreading crown

No. A14 Acacia sinuata (Lour) Merrill

Fam - Mimoseae
 C.N. - Beng - Banritha; Guj and Mar - Shikakai;
 Hin - Kochi; Kan - Sige; Mal - Chikaka;
 Tam - Shikakai; Tel Sikaayai.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Quick growing.
 R - By seeds.

No. A15 Acacia tortilis Hayne

Fam - Mimoseae
 C.N. - The Umbrella thorn tree.

S/T - T
 HA - Tree
 HT - 8m
 GR - Quick growing.
 R - By seeds.
 E/D - Evergreen

No. A16 Acer campbellii Hook F. and Thoms.

Fam - Aceraceae.
 C.N. - Himalayan maple. Beng - Kabashi Lepcha - Daom,
 Yatlikung.
 S/T - S
 HA - Tree
 HT - 12m
 GR - Quick growing.
 R - By seeds.
 E/D - Deciduous.
 CS - Spreading

No. A17 Acer negundo Linn

Fam - Aceraceae
 C.N. - Ash - leaved maple, Boxeldes.
 S/T - S
 HA - Tree
 HT - 12m
 GR - Quick growing
 R - By seeds.
 E/D - Deciduous.
 CS - Spreading

No. A18 Achras sapota Linn

Fam - Sapotaceae.
 C.N. - Sapota; Tam - Shimai - elluppai Mar - Chikoo

S/T	-	T
HA	-	Tree.
HT	-	10m
GR	-	Slow growing during early stages.
R	-	Grafting.
E/D	-	Evergreen
Flo.S.	-	Round the year in coastal districts. Sept. - Dec. in other areas.
CSA	-	309.021 m ²
CS	-	Spreading.
LA	-	108.02 cm ²
SI	-	25.78

No. A19 Actinodaphne angustifolia Nees.

Fam	-	Lauraceae.
C.N.	-	Mar - Pisa; Mal - Malavirinya, Tam - Tali
S/T	-	T
HA	-	Tree
HT	-	13m
GR	-	Slow
R	-	By seeds
E/D	-	Evergreen.
Flo.S.	-	May - June, Nov.
CS	-	Round

No. A20 Adenanthera pavonina Linn.

Fam		Mimoseae
C.N.		Coral - or red wood. Beng - Rakta Kambal; Guj - Badigumehi; Kan and Mal - Manjadi; Mar.- Thorligunji; Oriya - Girid; Sans - Kunchandana; Tam - Anaikundumani, Tel - Bandiguruvenda.
S/T	-	T

HA - Tree
 HT - 20m
 GR - Quick growing
 R - By seeds
 E/D - Deciduous
 Flo.S. - Mar - Aug.
 CS - Spreading

No. A21 Adina cordifolia Roxb.

Fam - Rubiaceae.
 C.N. - Sans - Dharakadamba; Hindi - Haldu; Beng - Keli,
 Kadam; Tam and Mal - Manja, Kadamba;
 Tel - Pasupa - Kadamba
 S/T - T
 HA - Tree
 HT - 20m
 GR - Slow growing
 R - By seeds.
 E/D - Deciduous
 Flo.S. - June - Sept.
 CSA - 148, 490.1 m²
 CS - Oblong / Round.
 LA. - 268.54 cm²
 SI - 29.63

No. A22 Aegle marmelos (Linn) Correa.

Fam - Rutaceae.
 C.N. - Beal tree, Holy fruit tree;
 Beng, Hindi, Mar and Assam - Bael; Guj - Bili;
 Kan - Bilva; Mal - Koovalam, Kukamla.
 Oriya - Belo; San - Bilva, vilvah; Tam - Vilvam,
 Kuvilam; Tel - Maaredu, Urdu - Bel.
 S/T - T

HA	-	Tree
HT	-	12m
GR	-	Slow growing
R	-	By seeds, root cuttings.
E/D	-	Evergreen
Flo.S.	-	May - July
CSA	-	26547.19 m ²
CS	-	Oblong
LA	-	57.72 cm ²
SI	-	24.08

No. A23 Aesculus indica Hook

Fam	-	Sapindaceae
C.N.	-	Himalayan chestnut, Indian Horse - chestnut; Hindi - Bankhar; Jaunsar Pu; Kashmir - Hanedun; Kumaun - Pangar; Punjab - Bankhar.
S/T	-	S
HA	-	Tree
HT	-	20m
GR	-	Quick growing
R	-	By seeds, root suckers.
E/D	-	Deciduous
Flo.S.	-	Apr - June.
CS	-	Spreading

No. A24 Ailanthus altissima (Mill) Swingle

Fam	-	Simarubaceae.
C.N.	-	Ailanto
S/T	-	T
HA	-	Tree
HT	-	12m
GR	-	Quick growing
R	-	By seeds.

C/D - Deciduous
 Flo.S. - Sept - Nov.
 CS - Spreading

No. A25 Ailanthus excelsa Roxb.

Fam - Simarubaceae.
 C.N. - Tree of Heaven. Mar. Maharuk Guj, Hindi,
 Mar Maharakha, Kan - Hemaraheeramara,
 Mal - Mattipongilyam, Oriya - Mahala,
 Sans - Madala arala; Tam - Perumarautta,
 Tel - Peddamaanu.
 S/T - T
 HA - Tree
 HT - 20m
 GR - Quick growing
 R - By seeds. shoot, root cuttings.
 E/D - Deciduous.
 Flo.S. - Feb - March
 CSA - 152, 481.2 m²
 CS - Round
 LA - 167.47 cm²
 SI - 13.01

No. A26 Alangium chinense (Lour) Harms

Fam - Alangiaceae.
 C.N. - Beng - Bonipodo; Assam - Bhelu; Garo - Phagrany;
 HP and Punjab - Budanar; Kashmir - Prot;
 Khasi - Dieng - Mylliatlap; Kumaun - Garh.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By seeds
 E/D - Deciduous.

- No. A27 Albizia amara Boiv
 Fam - Mimoseae
 C.N. - Mar - Tugli Lalai; Sans - Krishna sirisha;
 Tam - Turinjl; Tel - Sigara.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By seeds, Root suckers
 E/D - Deciduous
 Flo.S. - April - June
 CS - Spreading
- No. A28 Albizia chinensis (Osbeck) Merrill
 Fam - Mimoseae
 C.N. - Beng - Chakua, Assam - Saukoroi, Hindi - Siran;
 Garo - Beolphiu; Kan - Kalbage; Khasi - Dieng -
 phyneat; Mal - Pottavaga; Mar - Laeli;
 Tam - Pilivagei; Telkondachigera
 S/T - T
 HA - Tree
 HT - 10-12m
 GR - Quick growing
 R - By seeds
 E/D - Deciduous
 Flo.S. - April - June.
 CS - Spreading flat topped
- No. A29 Albizia lebbeck Benth
 Fam - Mimoseae.
 C.N. - The Siris tree. Beng - Sirish; Guj - Pilosarasio;
 Hindi - Siris, Kan - Bagemara; Mal - Vag.
 Nenmenivaka, Vaka; Mar. Sirisha; Sans - Srisah,

Bhandi; Tam - Vakai, Vagei Tel - Dirisana, Sirisha;
Trade - Kokko

S/T - T
HA - Tree
HT - 20m
GR - Quick growing
R - By seeds
E/D - Deciduous
Flo.S. - April - May
CAS - 62,509.32 m²
CS - Round / spreading.
LA - 272.51 cm²
SI - 19.72

No. A30 Albizia moluccana Mig.

Fam - Mimoseae.
C.N. - White popinae, Lead tree, Guj - Lasobaval;
Hindi - Subabul, Vilaitibaral;
Mal - Takarannimaram; Oriya - Rajokasundari;
Tam - Nattuccavundal; Tel - Kaniti.

S/T - T
HA - Tree
HT - 15m
GR - Quick growing
R - By seeds
E/D - Evergreen
Flo.S. - July - Oct.
CS - Oblong

No. A31 Albizia odoratissima Benth.

Fam - Mimoseae.
C.N. - Black siris; Beng - Kakur siris; Hin - Kala siris;
Mar - Chikunda; Sans - Svetashirisha;

Tam - Karuvagei; Tel - Chinduga.
 S/T - T
 HA - Tree
 HT - 18m
 GR - Quick growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - April - June.
 CS - Oblong

No. A32 Albizia procera Benth

Fam - Mimoseae
 C.N. - White siris, Beng - Korai; Assam - Korai Cachar -
 Jigring - bon - phayng; Kan - Bellate;
 Mal - Karunth - agara; Mar - Kinhai;
 Tam - Kondavagei; Tel - Tellachinduga
 S/T - T
 HA - Tree
 HT - 20m
 GR - Quick growing
 R - By seeds
 E/D - Deciduous
 Flo.S. - June - Sept.
 CSA - 28471.26 m²
 CS - Round / Oblong
 LA - 286.74 cm²
 SI - 20.21

No. A33 Aleurites fordii Hemsl

Fam - Euphorbiaceae.
 C.N. - Tungoil tree
 S/T - T
 HA - Tree

HT - 8m
 GR - Quick growing
 R - By seeds
 E/D - Deciduous
 Flo.S. - April - June.
 CS - Round

No. A34 Alnus nepalensis D. Don

Fam - Betulaceae.
 C.N. - Indian or Nepalese Alder. Hin - Uits; Aru.P. - Udis;
 Chamba - Piak; Kumaun - Udish Lepcha - Koyal;
 Punjab - Koe.
 HA - Tree
 HT - 20 m
 GR - Quick growing
 R - By seeds
 E/D - Deciduous
 Flo.S. - Sept - Nov.

No. A35 Alnus nitida Endl

Fam - Betulaceae
 C.N. - The west - Himalayan Alder; Kashmir - Seril;
 Punjab - Sharol; U.P. Kunis.
 HA - Tree
 HT - 20m
 GR - Quick growing after 1st year.
 R - By seeds
 E/D - Deciduous
 Flo.S. - August - October

No. A36 Alstonia scholaris (Linn.) R. Br.

Fam - Apocynaceae.
 C.N. - Eng - Devil tree, shaitan wood, Hindi - Chattiyar

saittan kajat; Mal - Elilampala, Yaksippala, Pala, Daiva ppala; Mar - Satvin; Sans - Saptapamah, Saptachadah; Tam - Elilappalai, Palai

S/T	-	T
HA	-	Tree
HT	-	15m
Gr	-	Quick growing
R	-	By seeds
E/D	-	Evergreen
Flo.S.	-	Dec - Mar.
CSA	-	241,680.5 m ²
CS	-	Round
LA	-	52.31 cm ²
SI	-	15.23

No. A37 Anona squamosa Linn.

Fam - Anonaceae.
 C.N. - Custard apple, Sugar apple, Sweet sop.;
 Assam - Atakatal;
 Beng, Guj, Mar and Hindi - Seetaphal, Sharifa;
 Kan - Seethaphala; Mal - Sitappalam, Attaccakka;
 Oriya - Seethaapholo; Punjab - Sharifa;
 Sans - Seetaaphalam; Tam - Atta, Sitappalam
 Tel - Seetaaphalam.

S/T	-	T
HA	-	Small tree
HT	-	10m
GR	-	Fast growing
R	-	By seeds, Grafting, Budding
E/D	-	Evergreen
Flo.S.	-	March - July extended upto sept.
CSA	-	2178.21 m ²
CS	-	Round.

LA - 53.86 cm²

SI - 26.19

No. A38 Anona reticulata Linn.

Fam - Anonaceae.

C.N. - Bullock's Heart; Beng and Hindi - Luvuni, nona;
Goa and Kokan - Anona;
Guj and Mar - Raamaphal;
Kan - Raamaphala; Mal - Raamappazham;
Oriya - Raamaphala; Sans - Lavani, Raamaphalam;
Tam - Manilvatta, raamsita; Tel - Raamaphalamu.

S/T - T

HA - Tree

HT - 10m

GR - Fast growing

R - By seeds

E/D - Evergreen

Flo.S. - June.

CSA - 2017.44 m²

CS - Round

LA - 50.91 cm²

SI - 17.24

No. A39 Anogeissus latifolia Wall.

Fam - Combretaceae.

C.N. - Axlewood, Button tree; Guj - Dhavdo;
Hindi - Dhaura; Kan - Bejjalu;
Mal - Maruka- njiram; Mar - Dabria;
Oriya - Dohu; Tam. Vekaynaga; Tel - Chirumaanu,
tellamaddi, Bihar - Bhanji; U.P., N.W. Himal - Bakli

S/T - T

HA - Tree

GR - Slow growing

R - By seeds,, Root suckers
 E/D - Evergreen
 Flo.S. - May - July
 CSA - 67542.82 m²
 CS - Round / oblong
 LA - 140.23 cm²
 SI - 18.72

No. A40 Anthocephalus chinensis (Lamk.)

Fam - Rubiaceae.
 C.N. - Mar, Hin, Sans - Kadamba; Beng - Kadam;
 Tam - Vellai - cadama; Tel - Kadambama.
 S/T - T
 HA - Tree
 HT - 20m
 GR - Quick growing
 R - By seeds.
 E/D - Deciduous
 Flo.S. - Nov - Feb.
 CSA - 52,233.5 m²
 CS - Spreading
 LA - 106.72 cm²
 SI - 19.63

No. A41 Aphanamixis polystachya (Wall) Parker.

Fam - Meliaceae.
 C.N. - Rohituka tree; Hin - Harin - hara;
 Mal - Cemmaram; Sans - Rohitakah;
 Tam - Malampuluvan, Semmaram;
 Beng - Tiktaraj, Pittaraj, Tel - Chawamanu.
 S/T - T
 HA - Tree
 HT - 13m

GR - Slow growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - July.
 CSA - 10826.95 m²
 CS - Oblong / Round
 LA - 1566.4 cm²
 SI - 18.14

No. A42 Artocarpus heterophyllus Lamk.

Fam - Urticaceae.
 C.N. - Jack fruit tree, Hin - Kathal, Cakki; Mar - Phannas;
 Mal - Palavu; Sana - Panasah; Tam - Pila, Palavu.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Slow growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - Nov. - Jan.
 CSA - 196,419.1 m²
 CS - Oblong
 LA - 106.86 cm²
 SI - 19.05

No. A43 Artocarpus lacucha Buch

Fam - Urticaceae.
 C.N. - ~~Monkey Jack~~. Hindi Beng - Dahua;
 Mar - Wotomba; Sans - Lakucha; Tam - Ilagusam;
 Tel - Kammaregu.
 S/T - T
 HA - Tree
 HT - 18m

GR	-	Quick growing
R	-	By seeds.
E/D	-	Deciduous
Flo.S.	-	Mar - April
CSA	-	2113.20 m ²
CS	-	Spreading / Round
LA	-	104.32 cm ²
SI	-	18.95

No. A44 Azadirachta indica A. Juss.

Fam	-	Meliaceae.
C.N.	-	Indian Lilac, Neem tree, Margosa tree; Beng and Hin - Nim; Guj - Limbado; Kan - Bevinamara; Mal - Veppu, Aruveppa; Mar - Limba; Oriya - Nimba; Tam - Veppam; Tel - Veepachettu.
S/T	-	T
HA	-	Tree
HT	-	20 m
GR	-	Quick growth after 1st season
R	-	By seeds
E/D	-	Evergreen
Flo.S.	-	Jan - March, Aug. - Sept.
CSA	-	300,445.3 m ²
CS	-	Spreading.
LA	-	83.89 cm ²
SI	-	29.2

No. B1 Balanites roxburghii Planch

Fam	-	Balanitaceae.
C.N.	-	Desert - Date; Beng. Hingol; Guj - Ingoriyo; Hin and Mar - Hingan; Kan - Ingalore, Mal - Nanjunta;

Oriya - Ingudihala, Sans - Angavruksha;
 Tam - Nanjundan; Tel - Gara; Raj - Hingorni

S/T - T
 HA - Tree
 HT - 9m
 GR - Quick growing
 R - By seeds.
 E/D - Evergreen
 Flo.S. - April - June.
 CS - Spreading

No. B2 Bambusa arundinacia (Retz) Roxb

Fam - Poaceae
 C.N. - Thorny Bamboo; Beng - Bans; Guj - Wans;
 Hin - Kantabans; Kan - Andebiduru; Mal - Illi;
 Mar - Bambu; Oriya - Bendo; Sans - Bahupallava
 vansa; Tam - Mullumungil; Tel - Mullabongu;
 Assam - Banha; H.P. Kallabans; Jammu - Lambert;
 Kashmir - Billawar; Punjab - Magar bang.

S/T - T
 HA - Shrub.
 HT - 20m
 GR - Quick growing
 R - By cuttings.
 E/D - Deciduous.
 CS - Oblong.

No. B3 Bambusa vulgaris Schrad.

Fam - Poaceae
 C.N. - The Golden bamboo; Beng - bans; Mar - Kalaka;
 Oriya - Sundragai; Tam & Mal - Ponungile.
 S/T - T
 HA - Shrub/tall perennial grasses.

HT - 15m
 GR - Quick growing
 R - Cutting.
 E/D - Deciduous.

No. B4 Barringtonia acutangula (L) Gaertn.

Fam - Barringtoniaceae.
 C.N. - Indian Oak. Assam - Kanapa; Beng, Hin - Hijal;
 Guj-Samudraphal; Kan - Holekauva;
 Mal - Attampu, Attupelu, Mar - Dattephal;
 Oriya - Hinjolo; Tam - Adampa, samuttirappalam;
 Tel - Kanapachettu; Sans - Samudraphalah.
 S/T - T
 HA - Tree
 HT - 9-12 m
 GR - Quick growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - March - May, Sept - Oct.
 CS - Spreading

No. B5 Barringtonia racemosa Roxb

Fam - Barringtoniaceae.
 C.N. - Beng - Samudraphal; Hin - Ijjut;
 Kan - Kanaginetere; Mal - Katampu; Mar - Nivar;
 Tam - Arattam; Tel - Kanapa.
 S/T - T
 HA - Tree.
 HT - 6-8m
 GR - Fast growing.
 R - By seeds.
 E/D - Evergreen
 Flo.S. - Throughout the year.

No. B6 Bauhinia acuminata Linn.

Fam - Caesalpinaceae.
 C.N. - Kanchan
 S/T - T
 HA - Shrub.
 HT - 3m
 GR - Quick growing
 R - By seeds.
 E/D - Deciduous
 Flo.S. - June
 CSA - 109.8 m²
 CS - Oblong / Round.
 LA - 69.46 cm²
 SI - 22.31

No. B7 Bauhinia purpurea Linn.

Fam - Caesalpinaceae
 C.N. - Butterfly tree, Mountain ebony. Beng - Dev
 kanchan; Hin - Khairwal; Kan - Baswanapada;
 Mal - Chuvanna - Mandaram,
 Mar- Rakta Kaanchan; Tam - Mandari;
 Tel - Kaanchanamu.
 S/T - T
 HA - Tree
 HT - 7 m
 GR - Quick growing
 R - Through seeds
 E/D - Deciduous
 Flo.S. - Sept - Nov.
 CSA - 625.2 m²
 CS - Oblong
 LA - 107.3 cm²
 SI - 23.58

- No. B8 Bauhinia racemosa Lamk.
- Fam - Caesalpinaceae
- C.N. - Beng - Banraj; Guj - Asundro; Hin - Astha;
 Kan - Banne; Mal - Kotapuli; Mar - Apta;
 Oriya - Omboroda; Sans - Swetakanchanamu;
 Tam - Araivattatthi; Tel - Ari; Punjab - Kosundra.
- S/T - T
- HA - Small tree
- HT - 5m
- GR - Quick growing
- R - By seeds
- E/D - Deciduous
- Flo.S. - Mar - June
- CSA - 136.9 m²
- CS - Oblong
- LA - 73.4 cm²
- SI - 25.68.

- No. B9 Bauhinia semla Wanderlin
- Fam - Caesalpinaceae
- C.N. - Hin - Semla; Mar - Koilar; Tel - Nirpa. H.P. - Karalla;
 Punjab - Kural.
- ST - T
- HA - Tree
- HT - 10m
- GR - Quick growing
- R - By seeds
- E/D - Deciduous
- Flo.S - Sept - Nov.
- CS - Round.

- No. B10 Bauhinia varigata Linn.
- Fam - Caesalpinaceae.

- C.N. - Buddhist bauhinia, Mountain Ebony,
 Beng - Raktakanchan; Guj - kovindara;
 Hin - Kachnar; Kan - Arisinatige;
 Mal - Mandaram, Konnu, Malayakatti;
 Mar - Kanchan, Sans - Kovidarah;
 Tam - Shemmandarai; Tel - Devakanchanamu.
- S/T - T
 HA - Tree
 HT - 5m
 GR - Quick growing
 R - By seeds
 E/D - Deciduous
 Flo.S. - Nov.
 CSA - 1769.52 m²
 CS - Oblong
 LA - 53.2 cm²
 SI - 27.41

No. B11 Betula alnoides Buch-Ham.

- Fam - Betulaceae
 C.N. - Indian birch. Nagabirch. Beng - Holosunli;
 Guj - Bhojpatra; Hin - Bhujpatra;
 Sans - Bhurja patram; Tel - Bhojapatramu;
 Urdu - Bhurjapatra; Assam - Dieng - ling;
 Garhwal - Sauer; Kumaun - Banutis;
 Nagaland Teri-ching's; Punjab - Shagru.
- S/T - S
 HA - Tree
 HT - 15m
 GR - Quick growing after 1st yr.
 R - By seeds, cutting.
 E/D - Deciduous (Winter)

Flo.S. - Nov. - Jan.
CS - Oblong

No. B12 Bischofia javanica Blume.

Fam - Bischofiaceae.
C.N. - Bishopwood; Beng - kainjal; Hin - Paniala;
Kan - Gobranerale; Mal - Nira; Mar - Boke;
Oriya - Dingiri; Tam - Thondi; Tel - Nalupumusti;
Andaman - Ye - badauka; Assam - Urian;
Megh - Deing. Soh - Tug.
ST - T
HA - Tree
HT - 15m
GR - Quick growing
R - By seeds, cuttings.
E/D - Semi - deciduous.
Flo.S. - April - Sept
CS - Oblong.

No. B13 Bougainvillea spectabilis Willd.

Fam - Nyctaginaceae.
C.N. - Bougainvillea
S/T - T
HA - Shrub
HT - 8m
GR - Quick growing
R - By cutting
E/D - Evergreen
Flo.S. - Throughout the year.
CSA - 939.25 m²
CS - Oblong / Round.
LA - 33.15 cm²
SI - 32.53

- No. B14 Bridelia squamosa Lamk.
 Fam - Euphorbiaceae
 C.N. - Hin - Khaja; Beng - Geio, Kantakoi;
 Mal - Mukkayini; Mar - Asanai;
 Sans - Mahavira; Tam - Mullavengai;
 Tel - Bontha-yepi.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By seeds, Root suckers.
 E/D - Deciduous.
 Flo.S.- May - Oct.
 CSA - 58,432.1 m²
 CS - Spreading
 LA - 168.09 cm²
 SI - 25.1

- No. B15 Broussonetia papyrifera L. Nerit
 Fam - Moraceae
 C.N. - Paper mulberrys, Hin - Jangli toot;
 Kan - Kaagaduppunaeralae.
 S/T - T
 HA - Tree
 HT - 12m
 GR - Quick growing
 R - By seeds, cuttings, air-layering.
 E/D - Deciduous
 Flo.S. - Aug - Nov.
 CS - Oblong.

- No. B16 Buchanania lanzan Spreng.
 Fam - Anacardiaceae.

C.N.	-	Almondette tree. Beng - chironji; Guj and Mar - Charoli; Hin - Achar; Kan - Murkali; Mal-Mungapera; Oriya - Charu; Sans - Priyalam; Tam - Morala; Tel - Mortichettu or Saara.
S/T	-	T
HA	-	Tree
HT	-	13m
GR	-	Quick growing
R	-	By seeds, root suckers.
E/D	-	Evergreen
Flo.S.	-	Jan - Mar.
CS	-	Round.

No. B17 Butea monosperma Lamk.

Fam	-	Fabaceae
C.N.	-	Flame of the forest; Beng. Mal, Mar - Palas; Guj - Khakharo; Hin - Kashmir. Dhak ; Kan - Muttuga; Oriya - Porasu; Punjab -chichra; Sans - Palaasa; Tam - Tarasa; Tel - Mooduga, Palaasamu.
S/T	-	T
HA	-	Tree
HT	-	10m
GR	-	Slow growing
R	-	By seeds
E/D	-	Deciduous.
Flo.S.	-	Jan - April
CSA	-	38,592.1 m ²
CS	-	Oblong / Ovoid
LA	-	448.6 cm ²
SI	-	29.43

- No. C1 Caesalpinia pulcherrima (L) Swartz.
- Fam - Cesalpinaceae.
- C.N. - White gold mohur; Kan - Kempukenijiga;
Mar - Sankasura; Tam - Vadanarayana;
Tel - Sankesula, Vatanarayana.
- S/T - T
- HT - 4m
- GR - Quick growing
- R - By seeds, cuttings.
- E/D - Evergreen.
- Flo.S. - Throughout the year.
- CSA - 639.32 m²
- CS - Spreading.
- LA - 246.4 cm²
- SI - 29.09

- No. C2 Callistemon citrinus (Curtis) stapf.
- Fam - Myrtaceae
- C.N. - Bottle brush, scarlet bottle brush.
- S/T - T
- HA - Small tree
- HT - 5m
- GR - Slow growing
- R - By seeds, cuttings
- E/D - Evergreen
- Flo.S. - Throughout the year esp. April.
- CSA - 45,997.2 m²
- CS - Conical
- LA - 214.01 cm²
- SI - 127.49

- No. C3 Calophyllum inophyllum Linn
- Fam - Clusiaceae

C.N.	-	Alexandrian laurel, Beng and Hin - Sultanachampa; Guj - Udi; Kan - Honne; Mal - Punnai; Mar - Surangi; Oriya - Poonang, Sans - Punnagah; Tam - Punnai, Punnagam; Tel - Ponnachettu.
S/T	-	T
HA	-	Tree
HT	-	18m
GR	-	Slow growing
R	-	By seeds.
E/D	-	Evergreen
Flo.S.	-	Dec - Jan.
CSA	-	21,426.3 m ²
CS	-	Round / spreading
LA	-	130.51 cm ²
SI	-	28.43

No. C4 Calotropis gigantea R.Br (Linn)

Fam	-	Asclepiadaceae
C.N.	-	Gigantic swallow wort; Beng - Akand; Mar - Rui; Mal - Erukku; Tam - Erukkam; Tel - Peddajilleedu
S/T	-	T
HA	-	Shrub
HT	-	5m
GR	-	Quick growing
R	-	By seeds, cuttings
E/D	-	Evergreen
Flo.S.	-	Feb - July
CSA	-	47.5 m ²
CS	-	Oblong / Round
LA	-	48.58 cm ²
SI	-	9.93

- No. C5 Calotropis procera (R.Br) Ait.
 Fam - Asclepiadaceae.
 C.N. - Swallow wort; Hin - Akada, Mar - Mandare, Rui;
 Oriya - Orkho; Sans - Alkarka; Tam - Velleruku;
 Tel - Chinnajilleedu.
 S/T - T
 HA - Shrub
 HT - 6m
 GR - Quick growing
 R - By seeds, cutting
 E/D - Evergreen
 Flo.S. - December
 CSA - 87.7 m²
 CS - Oblong / Round
 LA - 50.06 cm²
 SI - 10.32
- No. C6 Carissa spinarum Linn.
 Fam - Apocynaceae
 C.N. - Hin - Karaunda; Mar - Karwand; Oriya - Anka;
 Tam - chiru; Tel - Kalivi; Kashmir - Garunda;
 Punjab - Janglikarunda
 S/T - T
 HA - Shrub
 HT - 3m
 GR - Quick growing
 R - By seeds, root suekers.
 E/D - Evergreen
 Flo.S. - Mar - May
 CS - Round
- No. C7 Cassia fistula Linn
 Fam - Caesalpinaceae.

- C.N. - Golden showers, Indian laburnum; Beng and
Hin, Jammu - Amaltas; Guj, Mar - Garmala,
Bahwa; Kan - Aragenia; Mal - Svarnaviram;
Oriya - Sunari; Punjab - Alash; San - Saraphala;
Tam - Arakkuvadam;
Tel - Reelachettu, VKoolaponna
- S/T - T
- HA - Tree
- HT - 12m
- GR - Quick growing
- R - By seeds, suckers
- E/D - Deciduous
- Flo.S. - March - May
- CSA - 2957.11 m²
- CS - Round
- LA - 130.51 cm²
- SI - 20.4

- No. C8 Cassia javanica Linn.
- Fam - Caesalpinaceae.
- S/T - T
- HA - Tree
- HT - 12m
- GR - Quick growing
- R - Through seeds.
- E/D - Deciduous
- Flo.S. - May - June
- CS - Round

- No. C9 Cassia pumila Lamk.
- Fam - Caesalpinaceae.
- C.N. - Yellow Cassia; Mar - Sarmal; Tel - Nallajiluga;
Kan - Nelatogache.

S/T - T
 HA - Tree
 HT - 10-12m
 GR - Quick growing
 R - By seeds
 E/D - Evergreen
 CSA - 13,273.7 m²
 CS - Round
 LA - 118.47 cm²
 SI - 19.84

No. C10 Cassia renigera Wall ex. Benth.

Fam - Caesalpinaceae
 C.N. - Pink Cassia
 S/T - T
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By seeds
 E/D - Deciduous
 Flo.S. - May - June
 CSA - 9,432 m²
 CS - Round / spreading
 LA - 115.2 cm²
 SI - 17.21

No. C11 Cassia siamea Lamk.

Fam - Caesalpinaceae.
 C.N. - Iron wood tree; Beng - Minjri; Guj - Kaisid;
 Kan - Hiretangad, Mar - Kassod, Tam - Manja-
 Konnai; Tel - Seematangeedu.
 S/T - T
 HA - Tree

HT - 10-12m
 GR - Fast growing
 R - By seeds.
 E/D - Evergreen
 Flo.S. - Aug - May.
 CSA - 3927.36 m²
 CS - Oblong
 LA - 138.32 cm²
 SI - 21.2

No. C12 Casuarina equisetifolia Linn.

Fam - Casuarinaceae
 C.N. - Australian or Whistling pine; Beng - Jau;
 Guj and Hin - Jangli saru; Kan - Chabaku;
 Mal - Chavukku; Mar - Suru; Tam - Savukku;
 Tel - Saravi Sarugudu.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - Feb - April, Sept - Oct
 CS - Oblong

No. C13 Ceiba pentandra (Linn) Gaertn.

Fam - Bombacaceae
 C.N. - Kapok
 S/T - T
 HA - Tree
 HT - 15m
 GR - Quick growing
 R - By seeds

E/D - Deciduous
 Flo.S. - March - July
 CSA - 3126.98 m²
 CS - Oblong
 LA - 135.07 cm²
 SI - 18.21

No. C14 Celtis australis Linn

Fam - Ulmaceae.
 C.N. - European Nettle tree; Assam - Mohita;
 Cachar - Bonridu; Kashmir - Brimij, Khasi -
 Dieng - soh - thang - chi; Punjab - Batkar.
 S/T - T
 HA - Tree
 HT - 12m
 GR - Quick growing
 R - By seeds, stump - planting.
 E/D - Deciduous

No. C15 Citrus aurantium Linn

Fam - Rutaceae
 C.N. - Beng - Nebu; H - Limu - Niba, Khatta;
 Mal - Karna; Tel - Mallikanarangi; Tam - Narattai
 S/T - T
 HA - Tree
 HT - 5m
 GR - Quick growing
 R - By cutting, Grafting
 E/D - Evergreen
 Flo.S. - Sept - Nov
 CSA - 494.9 m²
 CS - Round / Oblong
 LA - 20.23 cm²
 SI - 35.81

No. C16 Citrus limon (Linn) Burm

Fam	-	Rutaceae
C.N.	-	Lime of India. (Limbu.); Beng - Bara nebu, Gora nebu; Hin - Bara nimbu. Pahari nimbu; Sans - Mala nimbu; Tam - Periya; Yelumichai; Tel - Bijapuram.
S/T	-	T
HA	-	Shrub
HT	-	3m
GR	-	Slow growing
R	-	By cutting, Grafting
E/D	-	Evergreen
Flo.S.	-	Nov - Jan
CSA	-	583.72 m ²
CS	-	Oblong
LA	-	18.55cm ²
SI	-	32.5

No. C17 Clerodendrum inerme (Linn) Gaertn.

Fam	-	Verbenaceae
C.N.	-	Beng - Banjai, Hin - Vanjai; Kan - Kundali; Mal - Cheruchinna, Mar - Vanajai; Kadumendi; Tam - Pinarichangan-guppi; Tel - Etipshinika.
S/T	-	T
HA	-	Shrub
HT	-	5m
GR	-	Quick growing
R	-	By seeds, cutting
E/D	-	Evergreen
Flo.S.	-	Nov - Jan.
CSA	-	723.43 m ²
CS	-	Round
LA	-	42.34 cm ²
SI	-	18.02

No. C18 Clerodendrum infortunatum Linn (auct), Wight.

Fam	-	Verbenaceae
C.N.	-	Hin and Beng - Bhant, San - Bhantaka; Tam -Perugilai; Tel - Gurrapukattiyaku; Mal - Peruku.
S/T	-	T
HA	-	Shrub
HT	-	3-4m
GR	-	Quick growing
R	-	By seeds, cutting
E/D	-	Evergreen
Flo.S.	-	Oct - Jan
CSA	-	854 m ²
CS	-	Round
LA	-	47.9 cm ²
SI	-	19.07

No. C19 Cocos nucifera Linn

Fam	-	Arecaceae
C.N.	-	Coconut tree; Beng - Dab, Narikel; Hin -Nariyal; Mal - Narikelam; Mar - Naral; Sans - Narikela; Tam - Tenkai; Tel - Narikelamu.
S/T	-	T
HA	-	Tree
HT	-	10-15m
GR	-	Slow growing
R	-	By seeds
E/D	-	Evergreen
Flo.S.	-	Throughout the year
CSA	-	109,347.4 m ²
CS	-	Round
LA	-	1635 cm ² per leaflet
SI	-	9.31

No. C20 Cordia dichotoma Forst

- Fam - Cordiaceae
 C.N. - Seb estan fruit tree. Beng - Bahubara;
 Guj- Bargunda; Hin - Chota - losora;
 Kan - Chikka challe; Mal - Cheruviri;
 Tam - Naruvili; Tel - Chinn - anakkeru.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Quick growing after 1st yr.
 R - By seeds, stem cutting
 E/D - Evergreen
 Flo.S. - March - April
 CS - Round / Oblong

No. C21 Coriaria nepalensis Wall

- Fam - Coriaceae
 C.N. - Mussorie berry tree; Hin - Masuri;
 Kashmir - Balel
 S/T - S
 HA - Shrub
 HT - 5m
 GR - Quick growing
 R - By seeds.
 E/D - Deciduous
 CS - Round

No. C22 Corylus colurna Linn

- Fam - Betulaeae
 C.N. - Turkish Hazel, Hin- Sharoli; Kashmir - Virin;
 Kumaun - Bhotia, badam; Punjab - Thangi
 S/T - S
 HA - Tree

HT - 10m
 GR - Quick growing
 R - By seeds
 E/D - Deciduous

No. D1 Dalbergia latifolia Roxb.

Fam - Fabaceae.
 C.N. - Black wood, Indian Rose wood. Beng - Sitsal;
 Guj, Hin and Mar - Shisham; Kan - Bite;
 Mal and Tam - Itti; Oriya - Sisua;
 Tel - Irugudu, cittegi.
 S/T - T
 HA - Tree
 HT - 20m
 GR - Quick growing
 R - By seeds, stem, root cuttings.
 E/D - Semideciduous
 Flo.S. - August - Sept
 CSA - 21,723.2 m²
 CS - Round
 LA - 187.9 cm²
 SI - 10.12

No. D2 Dalbergia sisoo Roxb.

Fam - Fabaceae.
 C.N. - Sissoo; Beng, Mar. Oriya and Assam - Sissu;
 Guj - Sisam; Hin - Shisham; Kan - Agar;u;
 Mal -Iruvil; Tam - Sissuitti; Tel - Errasissoo;
 Punjab - Tali.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Moderate during 1st yr. and rapid afterwards.

R - By seeds, Root and Stem cuttings.
 E/D - Evergreen
 Flo.S. - March - April - June
 CSA - 5,848.5 m²
 CSA - Round
 LA - 190.84 cm²
 SI - 18.72

No. D3 Delonix regia (Bojer) Rafin.

Fam - Caesalpinaceae.
 C.N. - Flameboyant, Flametree, Gulmohur;
 Tam - Mayarum; Tel - Seemasantkesula.
 S/T - S
 HA - Tree
 HT - 15m
 GR - Quick growing
 R - By seeds, cuttings
 E/D - Deciduous
 Flo.S. - Aprill - June
 CSA - 44,209.23 m²
 CS - Spreading / Flat topped.
 LA - 358.32 cm²
 SI - 14.38

No. D4 Dendrocalamus strictus Nees

Fam - Poaceae
 C.N. - Solid Bamboo; Beng - Karail; Guj - Nakorvans;
 Hin - Banskaban; Kan - Kiribiduru;
 Mal & Tam - Kalmungil; Mar - Bhariyel;
 Oriya - Saliabanso; San - Vansha;
 Tel - Saadharanapurveduru.
 S/T - T
 HA - Shrub / tall perennial grass.

HT - 12m
 GR - Quick growing
 R - By seeds, stem, rhizome cutting, layering
 E/D - Deciduous

No. D5 Derris indica (Lam.) Bennett.

Fam - Fabaceae.
 C.N. - Pongam - Oil Tree, Karanj, Indian Beech;
 Assam - Karchaw; Beng, Guj, Hin, Kumoun,
 Mar & Punjab - Karanja; Kan - Honge;
 Mal - Pungu. Oriya - Karanjo;
 Tam - Ponga, Pongam;
 Tel - Gaanugachettu, Punguchettu.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By seeds.
 E/D - Evergreen
 Flo.S. - April - June
 CSA - 6,278.1m²
 CS - Round
 LA - 79.6cm²
 SI - 25.20

No. D6 Diospyros melanoxylon Roxb.

Fam - Ebenaceae.
 C.N. - Ebony, Coromandel Ebony - Persimmon.
 Beng - Kend; Guj - Tamrag;
 Hin and Mar - Tendu; Kan - Abanasi;
 Mal - Kari; Oriya - Kendu; Tam - Karai;
 Tel - Tumki.
 S/T - T

HA - Tree
 HT - 10m
 GR - Slow growing
 R - By seeds, root suckers.
 E/D - Deciduous
 Flo.S. - Feb - April
 CSA - 324,355.2m²
 CS - Oblong
 LA - 167.78 cm²
 SI - 17.89

No. D7 Dryptes roxburghii (Wall)

Fam - Euphorbiaceae.
 C.N. - Putranjiva. Sans, Hin and Beng - Putranjiva;
 Pun - Jiyaputra; Kan - Putrajiva;
 Mal - Pongalam; Tam - Karupali; Tel - Kudurujiivi
 S/T - T
 HA - Tree
 HT - 15m
 GR - Slow growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - Mar - May
 CSA - 3445.32 m²
 CS - Round
 LA - 144.37 cm²
 SI - 19.81

No. D8 Duranta repens L

Fam - Verbenaceae.
 S/T - T
 HA - Shrub
 HT - 3m

GR	-	Quick growing
R	-	By seeds
E/D	-	Evergreen
Flo.S.	-	Throughout the year
CSA	-	60.47 m ²
CS	-	Spreading
LA	-	62.7 cm ²
SI	-	21.5

No. E1 Emblica officinalis Gaertn.

Fam	-	Euphorbiaceae.
C.N.	-	Gooseberry, Emblic myrobalan. Beng and Hin - Amla; Guj - Amali; Kan - Amalaka, nelli; Mal and Tam - Nelli; Mar - Awala; San - Amalaka; Tel - Amalakama, raatausirika
S/T	-	T
HA	-	Tree
HT	-	5m
GR	-	Quick growing
R	-	By seeds, cutting. Budding, inarching.
E/D	-	Deciduous
Flo.S.	-	June - July also in Feb, Mar - May.
CSA	-	17,381.2 m ²
CS	-	Oblong
LA	-	140.64 cm ²
SI	-	11.62

No. E2 Embryopteris peregrina Gaertn.

Fam	-	Ebenaceae.
S/T	-	T
HA	-	Tree
HT	-	10m

GR - Quick growing
 R - By seeds
 E/D - Deciduous
 Flo.S. - Mar - May
 CSA - 28,609.1 m²
 CS - Spreading
 LA - 84.07 cm²
 SI - 12.84

No. E3 Erythrina variegata Linn

Fam - Fabaceae.
 C.N. - Indian coral tree; Beng - Palita mandar;
 Guj - Bangaro; Hin - Dadap; Kan - Harivana
 Mal and Tam - Kalyanamurkku;
 Mar - Mandar, Pangara;
 San - Mandara; Tel - Baadita, Moduga.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By seeds, stem cuttings
 E/D - Deciduous
 Flo.S. - Feb - May
 CSA - 22,903.7 m²
 CS - Oblong
 LA - 168.94 cm²
 SI - 31.76

No. E4 Eucalyptus citriodora Hook.

Fam - Myrtaceae
 C.N. - Lemon scented gum
 S/T - T
 HA - Tree

HT - 20m
 GR - Quick growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - Feb - April. Oct - Dec.
 CSA - 52,447.63 m²
 CS - Conical
 LA - 48.37 cm²
 SI - 12.0

No. E5 Eucalyptus hybrid

Fam - Myrtaceae
 C.N. - Mysore gum
 S/T - T
 HA - Tree
 HT - 20m
 GR - Quick growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - Feb. - April., Oct. - Dec.
 CSA - 50,047.33 m²
 CS - Conical
 LA - 50.37 cm²
 SI - 12.91

No. E6 Exbucklandia populnea (R.Br) R.W.Br.

Fam - Hamamelidaceae
 C.N. - Beng - Bipli; Khasi - Dieng - doh; Trade - Pipli.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Slow growing
 R - By seeds

E/D - Evergreen
 Flo.S. - Nov. - Dec.
 CS - Round

- No. F1 Ficus benghalensis Linn
 Fam - Moraceae
 C.N. - Banyan Tree, Beng - Bar; Guj - Vad;
 Hin - Bargad; Kan - Ala; Mal - Ala, Vatam;
 Mar - Vad; Sans - Bahupada; Tam - Al;
 Tel - Peddamarri
 S/T - T
 HA - Tree
 HT - 20m
 GR - Quick growing
 R - By cutting, seeds
 E/D - Evergreen
 Flo.S. - April - June
 CSA - 2,36,493.67 m²
 CS - Spreading
 LA - 119.10 cm²
 SI - 21.72
- No. F2 Ficus benjamina Linn
 Fam - Moraceae
 C.N. - Assam - Chilubor; Beng - Pakur; Mar - Pimpri;
 Tam - Putrajivi
 S/T - T
 HA - Tree
 HT - 12m
 GR - Quick growing
 R - By seeds, cutting
 E/D - Evergreen
 Flo.S. - Sept - Nov

CSA - 87,326.12 m²
 CS - Spreading
 LA - 29.27 cm²
 SI - 18.62

No. F3 Ficus elastica Roxb
 Fam - Moraceae
 C.N. - Indian Rubber tree
 S/T - T
 HA - Tree (Epiphytic)
 HT - 12m
 GR - Quick growing
 R - By cutting
 E/D - Evergreen
 CSA - 6028.18 m²
 CS - Spreading / Round
 LA - 94.20 cm²
 SI - 19.43

No. F4 Ficus gibbosa Blume
 Fam - Moraceae
 C.N. - Mar - Datir; Garhwal - Chanchri;
 Sans - Udumbber; Tam - Iradgam;
 Tel - Tella - barinika; Orissa - Korotosani
 S/T - T
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By cuttings, seeds
 E/D - Evergreen
 Flo.S. - April - May
 CSA - 223,45.4 m²
 CS - Spreading

LA - 40.1 cm²
 SI - 19.81

No. F5 Ficus glomerata Roxb
 Fam - Moraceae
 C.N. - Beng - Dumur; Hin - Gular; Kan, Mal,
 Tam - Athi; Mar - Umbar; Oriya - Dimra;
 Tel - Atti, medichettu.
 S/T - T
 HA - Tree
 HT - 15m
 GR - Quick growing
 R - By seeds, cutting
 E/D - Deciduous
 Flo.S. - Aug - Oct, Dec - Feb
 CSA - 2,18,769.8 m²
 CS - Spreading
 LA - 47.28 cm²
 SI - 13.58

No. F6 Ficus hispida (L.) F.
 Fam - Moraceae
 C.N. - Kala - umbar, Beng - Kakdumur;
 Assam - Khoskadumar; Hin - Konea dumbar;
 Punjab - Rumbal; Sans - Kakadumbura;
 Tam and Mal - Peyatti; Tel - Vettiyati.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By seeds, cuttings
 E/D - Evergreen
 Flo.S. - April - July

CSA - 46942.02 m²
 CS - Spreading
 LA - 45.23 cm²
 SI - 17.21

No. F7 Ficus religiosa Linn

Fam - Moraceae
 C.N. - Peepal tree; Beng and San - Ashtthwa;
 Guj - Pipro; Hin - Pipal; Kan - Arali Ashwatha;
 Mar - Pimpala; Tam - Arasu; Tel - Ashavathamu,
 Raavichettu
 S/T - T
 HA - Tree
 HT - 20m
 GR - Grows slow in early stages later grows fast
 R - Through seeds, cutting.
 E/D - Evergreen
 Flo.S. - Jan. - May.
 CSA - 1,44,868 7 m²
 CS - Round/Oblong.
 LA - 114.15 cm²
 SI - 18.70

No. F8 Ficus semicordata Buch Ham.

Fam - Moraceae
 C.N. - Beng - Jagya Dumur; Hin - Jahephali;
 Kan - Gargasa; Mal - Perina; Mar - Porodumer;
 Tam - Taradi; Tel - Bommamarri.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Quick growing.
 R - Through seeds.

E/D - Evergreen.
 Flo.S. - Throughout the year.
 CSA - 52,809.61 m²
 CS - Round
 LA - 84.50 cm²
 SI - 17.38

No. F9 Ficus virens Ait

Fam - Moraceae
 C.N. - Hin and Punjab - Pilkhan; Ben - Pakar;
 Mal - Pepar, Mar - Pipli; Sans - Plaksha;
 Tam - Kurugu; Tel- Badiju
 S/T - T
 HA - Tree
 HT - 10m
 GR - Grows slowly in early stages later grows fast
 R - By seeds, cutting
 E/D - Evergreen
 Flo.S. - Jan - May
 CSA - 1,97, 838.2 m²
 CS - Oblong
 LA - 43.3 cm²
 SI - 15.91

No. G1 Garcinia indica Chosis.

Fam - Guttiferaceae
 C.N. - Hin and Mar - Kokam; Mal - Punampuli;
 Tam - Murgal
 S/T - T
 HA - Tree
 HT - 8m
 GR - Slow growing (1 st yr).
 R - Through seeds

E/D - Evergreen
 Flo.S. - Nov - Feb
 CSA - 210.748 m²
 CS - Oblong
 LA - 82.1 cm²
 SI - 22.03

No. G2 Garcinia talbotii Raizada.

Fam - Guttiferaceae
 S/T - T
 HA - Tree
 HT - 7m
 GR - Slow growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - Nov.
 CSA - 193.02 m²
 CS - Round
 LA - 78.9 cm²
 SI - 21.7

No. G3 Gardenia jasminoides Eills.

Fam - Rubiaceae
 C.N. - Sans - Anant. Gandharaj. Tam - Karinga
 S/T - T
 HA - Tree
 HT - 5m
 GR - Quick growing
 R - By seeds, stem cutting
 E/D - Evergreen
 Flo.S. - April - Aug extended upto Sept.
 CSA - 265.87 m²
 CS - Oblong

LA - 57.51 cm²
 SI - 19.21

No. G4 Gardenia resinifera Roth

Fam - Rubiaceae
 C.N. - Hin and Mar - Dikamali; Sans - Jantuka;
 Tam - Tikkamalli; Tel - Erubikki
 S/T - T
 HA - Tree
 HT - 5m
 GR - Quick growing
 R - By seeds, cutting
 E/D - Deciduous
 Flo.S. - Mar - June
 CSA - 572.36 m²
 CS - Oblong
 LA - 61.17 cm²
 SI - 19.73

No. G5 Gliricidia sepium (Jacq) Kunth ex Walp.

Fam - Fabaceae
 C.N. - Mother - of - cocoa, Mexican lilac.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By seeds and large cutting
 E/D - Deciduous
 Flo.S. - Jan - March
 CSA - 13412.6 m²
 CS - Oblong / Round
 LA - 136.46 cm²
 SI - 12.79

- No. G6 Grevillea robusta A. cunn
 Fam - Proteaceae.
 C.N. - Silvery or silky oak, Tam - Savukkamaram
 S/T - T
 HA - Tree
 HT - 20m
 GR - Quick growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - Feb - April
 CS - Oblong
- No. G7 Grewia elastica Royle.
 Fam - Tiliaceae
 C.N. - Beng - Dhamni; Hin and Punjab - Dhaman;
 Oriya - Mirgi chara; Mal - Satachi;
 Mar - Dhaman; Tam - Tarra; Tel - Charachi;
 Sans. - Dharmana.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By seeds
 E/D - Deciduous
 Flo.S. - May - Aug
 CS - Round
- No. G8 Grewia subinequalis DC.
 Fam - Tiliaceae.
 C.N. - Beng, Guj Hin, Mar and Punjab. Phalsa;
 Kan - Bhuttiyadippe; Oriya - Pharasakoli;
 Tam- Palisa; Tel - Nallajana.
 S/T - T

HA - Shrub.
 HT - 7m
 GR - Quick growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - Apr - June
 CS - Round

No. G9 Guazma ulmifolia Lamk.

Fam - Sterculiaceae
 C.N. - San, Tam, Tel and Mal - Rudraksha,
 Hin - Rudraki, Beng - Rudrakya;
 Mar - Rudraksh.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - Mar - August.
 CSA - 30279.8 m²
 CS - Round / Spreading
 LA - 85.21 cm²
 SI - 13.31

No. H1 Hamelia patens Jacq.

Fam - Rubiaceae
 C.N. - Scarlet bush
 S/T - T
 HA - Shrub
 HT - 3m
 GR - Quick growing
 R - By seeds, cuttings

E/D - Evergreen
 Flo.S. - Oct - Jan
 CSA - 824.06 m²
 CS - Round
 LA - 47.2 cm²
 SI - 19.07

No. H2 Heterophragma roxburghii DC.

Fam - Bignoniaceae
 C.N. - Mar, Guj, M.P. - Warras; Kan - Bechadi;
 Tel - Barukoligottu.
 S/T - T
 HA - Tree
 HT - 18m
 GR - Quick growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - Feb - April
 CSA - 155217.7 m²
 CS - Round / Oblong
 LA - 34.7 cm²
 SI - 14.2

No. H3 Hibiscus rosa-sinensis Linn

Fam - Malvaceae
 C.N. - Jasud. Chinese Hibiscus; Sans and Beng - Joba;
 Hin - Jasum; Mar - Jasavanda;
 Tam - Sapattuppu; Tel - Dasanamu.
 S/T - T
 HA - Shrub
 HT - 3m
 GR - Quick growing
 R - By cutting

E/D - Evergreen
 Flo.S. - Throughout the year
 CSA - 61.47 m²
 CS - Round / Oblong
 LA - 44.7 cm²
 SI - 23.32

No. H4 Hippophae rhamnoides Linn

Fam - Elaeagnaceae
 C.N. - Common seabuckthorn;
 Ladakh and H.P. - Sirma;
 Punjab - Kalabisa, Serma; U.P. - Chuma.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By seed, stem cuttings, suckers
 E/D - Deciduous
 Flo.S. - Mar - May

No. H5 Holoptelia integrifolia, (Roxb) DC.

Fam - Ulmaceae
 C.N. - Indian Elm. Kanju; Guj - Khanjho; Hin and
 Kumaun - Kanju; Kan - Thavasai; Mal - Aval;
 Oriya - Dauranja; Sans - Chirabilva;
 Tam - Ayal; Tel - Thapass; M.P - Karanjalam;
 Punjab - Rajain. Mar - Papdi
 S/T - T
 HA - Tree
 GR - Quick growing
 R - By seeds, stem cutting
 E/D - Deciduous
 Flo.S. - Feb - April

CSA - 29443.5 m²
 CS - Oblong
 LA - 67.30 cm²
 SI - 31.03

No. 11 Ixora arborea Roxb

Fam - Rubiaceae
 S/T - T
 HA - Tree
 HT - 6m
 GR - Quick growing
 R - By cutting
 E/D - Evergreen
 Flo.S. - Throughout the year
 CSA - 57.04 m²
 CS - Oblong to spreading
 LA - 54.2 cm²
 SI - 17.3

No. 12 Ixora chinensis

Fam - Rubiaceae
 S/T - T
 HA - Shrub
 HT - 6m
 GR - Quick growing
 R - By cutting
 E/D - Evergreen
 Flo.S. - March
 CS - Oblong

No. 13 Ixora coccinea L

Fam - Rubiaceae
 C.N. - Beng and Hin - Rangan. Mar - Pendgul;

Sans - Bandhuka; Tam - Vedji; Tel - Koranam,
Tachi; Mal - Tech

S/T	-	T
HA	-	Tree
HT	-	6m
GR	-	Quick growing
R	-	By cutting
E/D	-	Evergreen
Flo.S.	-	Throughout the year
CSA	-	183.26 m ²
CS	-	Oblong
LA	-	69.70 cm ²
SI	-	23.30

No. 14. Ixora rosea

Fam	-	Rubiaceae
S/T	-	T
HA	-	Tree
HT	-	6m
GR	-	Quick growing
R	-	By cutting
E/D	-	Evergreen
Flo.S.	-	More or less throughout the yr.
CSA	-	296.03 m ²
CS	-	Oblong
LA	-	62.21 cm ²
SI	-	20.30

No. 15. Ixora undulata

Fam	-	Rubiaceae
S/T	-	T
HA	-	Tree
HT	-	6m

GR - Quick growing
 R - By cutting
 E/D - Evergreen
 Flo.S. - March - April
 CS - Oblong

No. J1 Jacaranda mimosaeifolia D.Don.

Fam - Caesalpinaceae
 C.N. - Nil - gulmohur
 S/T - S
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By seeds
 E/D - Deciduous
 Flo.S. - March - April
 CSA - 7148.54 m²
 CS - Round
 LA - 46.4 cm²
 SI - 19.0

No. J2 Juniperus communis

Fam - Pinaceae
 C.N. - Common juniper; Beng - Havasha;
 Hin - Aaraar; Mar - Hosha; Kumaun - Chichia;
 Punjab and Kashmir - Betar.
 S/T - S
 HA - Shrub
 HT - 10m
 GR - Quick growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - March - April
 CS - Round / Oblong

No. K1 Kigelia africana Lamk
 Fam - Bignoniaceae
 C.N. - Sausage tree
 S/T - T
 HA - Small tree
 HT - 10m
 GR - Quick growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - Mar - June
 CSA - 58432.21 m²
 CS - Round / Oblong
 LA - 267.6 cm²
 SI - 12.90

No. L1 Lagerstroemia parviflora Roxb
 Fam - Lythraceae
 C.N. - Beng and Hin - Phurush; Mar - Dhayti;
 Tam - Tindiyam; Tel - Chinagoranta.
 S/T - T
 HA - Tall tree
 HT - 20m
 GR - Quick growing
 R - By seeds
 E/D - Deciduous
 Flo.S. - June
 CSA - 67051.42 m²
 CS - Round / Oblong
 LA - 84.12 cm²
 SI - 17.01

No. L2 Lagerstroemia speciosa (Linn)
 Fam - Lythraceae

C.N.	-	Queen crape Myrtle. Beng and Hin - Punjab Jarool; Kan - Holedasavala; Mal - Manimaruthu; Mar -Taman; Oriya - Patoli; Tam - Kadali; Tel - Varagoogu.
S/T	-	T
HA	-	Tree
HT	-	10m
GR	-	Quick growing
R	-	By seeds
E/D	-	Evergreen
Flo.S.	-	April - June
CSA	-	72569.31 m ²
CS	-	Oblong
LA	-	87.62 cm ²
SI	-	13.9

No. L3 Lantana camara Linn.

Fam	-	Verbenaceae
C.N.	-	Lantana, Wildsage; Kan - Natahugide; Mal - Arippu; Mar - Ghaneri, Chadurang; Tam - Unniced; Tel - Puulikampa; M.P. - Raimuniya.
S/T	-	T
HA	-	Shrub
HT	-	3m
GR	-	Quick growing
R	-	By seeds, cutting
E/D	-	Evergreen
Flo.S.	-	Throughout the year
CSA	-	324.58 m ²
CS	-	Spreading
LA	-	48.69 cm ²
SI	-	12.13

- No. L4 Lawsonia inermis Linn
- Fam - Lythraceae
- C.N. - Henna; Beng - Mehedi; Guj - Medi; Hin, Mar
and Punjab - Mehndi; Kan - Mayilanchi,goranta;
Mal - Mailanchi; Oriya - Benjat,
Sans - Mendika; Tam - Marithondi;
Tel - Gorinta; Kashmir -Mohuz.
- S/T - T
- HA - Shrub
- HT - 5m
- GR - Quick growing
- R - By seed and cutting
- E/D - Evergreen
- Flo.S. - April - July
- CSA - 71.85 m²
- CS - Round
- LA - 77.8 cm²
- SI - 17.0

- No. M1 Madhuca butyracea Macb
- Fam - Sapotaceae
- C.N. - The Indian butter - Tree; Beng - Gophal;
Hin - Phulwara, Chiura
- S/T - T
- HA - Tree
- HT - 15m
- GR - Quick growing
- R - By seeds
- B/D - Deciduous
- Flo.S. - June - July
- CS - Spreading

No. M2 Madhuca longifolia (Koen)

- Fam - Sapotaceae
 C.N. - The Butter tree; Beng Hin and Mar - Mahwa,
 Guj - Mahuda; Kan - Hippe; Mal - Ilupu,
 Poonam; Oriya - Mahula; Tam - Illupei;
 Tel - Ippa.
 S/T - T
 HA - Tree
 HT - 15m
 GR - Quick growing
 R - By seeds
 E/D - Deciduous
 Flo.S. - Feb - April
 CSA - 30,463.7 m²
 CS - Round / Oblong
 LA - 86.96 cm²
 SI - 22.18

No. M3 Mallotus philippensis (Lour) Muell, Arg.

- Fam - Euphorbiaceae
 C.N. - Hin and Bengal - Kamala, Kamila,
 Assam - Puddum; Mal - Tavitu, Mar - Kamala,
 Shendri; Tam - Kamala; Tel - Sinduri;
 Sans - Rechanaka.
 S/T - T
 HA - Tree
 HT - 12m
 GR - Slow growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - Nov - Jan
 CSA - 30497.8 m²
 CS - Oblong / Round

LA - 58.3 cm²
 SI - 19.0

No. M4 Mammea suriga (Buch - Ham. ex. Roxb.)

Fam - Guttifer aceae
 C.N. - Hin and Beng - Nagkesar; Kan - Surungi;
 Mar - Suringi; Mal - Surampunna;
 Tam - Surabunnai; Tel - Surampunnagamu;
 Sans - Punnag.
 S/T - T
 HA - Tree
 HT - 18m
 GR - Quick growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - Feb - Mar
 CSA - 27,865.1 m²
 CS - Spreading
 LA - 46.83 cm²
 SI - 20.1

No. M5 Mangifera indica Linn

Fam - Anacardiaceae
 C.N. - The mango tree, Beng and Hin - Am;
 Guj - Amri; Kan - Maavu; Mal - Aamram,
 maavu; Mar - Amba; Tam - Maanga, Maavu;
 Tel - Maamidichettu, Maavi.
 S/T - S
 HA - Tree
 HT - 15m
 GR - Quick growing after 1 st year
 R - By seeds, transplanting, grafting, budding, air
 lalyering, root cutting and marcotting.

E/D - Evergreen
 Flo.S. - South India - Jan - Mar;
 North India - Feb. - Apr.
 CSA - 69,004.67 m²
 CS - Round / Oblong
 LA - 85.27 cm²
 SI - 30.77

No. M6 Melaleuca leucadendron Linn

Fam - Myrtaceae
 C.N. - Cajaput tree; Beng, Hin Mar - Cajaputte,
 Tam - Kaiyappudai
 S/T - T
 HA - Tree
 GR - Quick growing
 R - By seeds, cuttings
 E/D - Evergreen
 Flo.S. - Sept - Nov
 CSA - 21,435.38 m²
 CS - Oblong
 LA - 83.57 cm²
 SI - 18.67

No. M7 Melia azadirach Linn

Fam - Meliaceae
 C.N. - The Persian lilac, Beng - Mahanim;
 Guj - Bakamlimbodo; Hin - Bakain;
 Kan - Arebvu, Hutchuburi; Mal - Karin, Vembu;
 Mar - Pejri; Tam - Malaivembu;
 Tel - Turakaveepa, Verriveepa.
 S/T - T
 HA - Tree
 HT - 20m

GR - Quick growing
 R - By seeds, stem, root, cutting, root sucker.
 E/D - Evergreen
 Flo.S. - March - May
 CSA - 38964.16 m²
 CS - Oblong
 LA - 83.79 cm²
 SI - (23.53) 23.53

No. M8 Milletia peguensis Ali

Fam - Fabaceae
 S/T - T
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By seeds.
 E/D - Evergreen
 Flo.S. - Aug. - Oct.
 CSA - 42311.52 m²
 CS - Round/oblong
 LA - 167.2 cm²
 SI - 12.2

No. M9 Millingtonia hortensis L.f.

Fam - Bignoniaceae
 C.N. - Indian cork - tree, Buch.
 S/T - S
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By seeds, cutting
 E/D - Evergreen
 Flo.S. - Oct. - Dec.

CSA - 22439.17m²
 CS - Oblong / Round
 LA - 139.2 cm²
 SI - 18.11

No. M10 Mimusops elengi Linn

Fam - Sapotaceae
 C.N. - Bakuli; Hin and Beng - Bakul; Mar - Borsati;
 Sans - Bakula; Punjab - Maulsari;
 Tam - Magilam; Tel - Vakulamu.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By seeds
 E/D - Evergreen
 Flo.S. - Jan. - Mar.
 CSA - 13,385.2 m²
 CS - Oblong / Round
 LA - 105.11 cm²
 SI - 22.31

No. M11 Mimusops hexandra Roxb.

Fam - Sapotaceae
 C.N. - Beng - Khirkhejur; Hin - Khirni; Mar - Rajan;
 Sans - Rajadani; Mals, Tam, and Tel - Pala.
 S/T - T
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By cutting
 E/D - Evergreen
 Flo.S. - Sept. - Nov.

CSA - 4063.1 m²
 CS - Oblong / Round
 LA - 89.32 cm²
 SI - 20.4

No. M12 Moringa oleifera Lamk.

Fam - Moringaceae
 C.N. - Drumstick tree, Horse Radish tree. Beng, Hin, Oriya, Assam and Punjab - Sajina; Guj - Midho saragavo; Kan - Nugge; Mal - Moringa; Mar - Shevga; Sans - Shobhanjana; Tam - Murugai, Tel - Mulaga.
 S/T - S
 HA - Tree
 HT - 10m
 GR - Quick growing
 R - By seeds, cutting
 E/D - Deciduous
 Flo.S. - Jan. - Apr.
 CSA - 23450.1 m²
 CS - Oblong
 LA - 14730 cm²
 SI - 28.2

No. M13 Morus alba Linn.

Fam - Moraceae.
 C.N. - Tuti. Mulberry - Beng, Hin, Mar - Kashmir and Punjab - Tut. Guj - Shetur; Kan - Hipnerle; Oriya - Tuto; Tam - Masukette; Tel - Reshmechettu, Pippalipanduchettu.
 S/T - S
 HA - Tree
 HT - 8m

GR	-	Quick growing
R	-	By seeds, cutting, grafting, budding
E/D	-	Evergreen
Flo.S.	-	Feb. - June.
CSA	-	1047.62 m ²
CS	-	Oblong
LA	-	285.3 cm ²
SI	-	17.4

No. M14 Murraya paniculata Linn

Fam	-	Rutaceae.
C.N.	-	Beng - Kamini; Hin - Marchula; M.P. and Guj - Chulajuti; Kan - Pandry, Tam - Simaikkonji; Tel - Nagagolunga.
S/T	-	T
HA	-	Shrub
HT	-	5m
GR	-	Quick growing
R	-	By seeds, cutting
E/D	-	Evergreen
Flo.S.	-	June. - Oct.
CSA	-	1354.61m ²
CS	-	Round
LA	-	35.3cm ²
SI	-	10.31

No. N1 Nerium indicum Mill.

Fam	-	Apocynaceae
C.N.	-	Pink oleander; Hin and Punjab - Kaner; Beng - Karabi; Mal - Karaviram; Mar - Kanhera; Tam, Tel- Karaviram
S/T	-	T
HA	-	Shrub

HT - 5m
 GR - Quick growing
 R - By cutting
 E/D - Evergreen
 Flo.S. - Throughout the year
 CSA - 5747.63 m²
 CS - Oblong / Round
 LA - 32.62 cm²
 SI - 15.7

No. N2 Nyctanthus arbor-tristis Linn

Fam - Oleaceae
 C.N. - Hin, Beng and Punjab -Harsinghar;
 Guj - Harsingara; Mar - Parijatak;
 Mal - Mannapu; San - Sephalika;
 Tam - Pavala - malligai; Tel - Sepali.
 S/T - T
 HA - Shrub
 HT - 5m
 GR - Quick growing
 R - By seeds, cutting
 E/D - Deciduous
 Flo.S. - More or less throughout the year
 CSA - 546.3 m²
 CS - Oblong / Round
 LA - 88.1 cm²
 SI - 14.73

No. O1 Ouginia oojeinensis (Roxb). Hochr.

Fam - Fabaceae
 C.N. - Beng - Tinis; Guj - Tanach; Hin - Sandan;
 Kan - Kari - Honne; Mal - Malavanna;
 Mar - Kalaphulas; Oriya - Banjan;

Tam - Narivengai; Tel - Tellamoduga;
M.P. - Tinsa; Bihar - Ruta; Trade - Sandan.

S/T - T
HA - Tree
HT - 12m
GR - Quick growing
R - By seeds, Root cutting
E/D - Deciduous
Flo.S. - Feb. - March

No. P1 Peltophorum pterocarpum (DC) Backer.

Fam - Caesalpinaceae.
C.N. - Copper pod tree.
S/T - T
HA - Tall tree
GR - Quick growing
R - By seeds.
E/D - Evergreen.
Flo.S.- May - Sept
CSA - 231045.3 m²
CS - Oblong/Round.
LA - 370.7 cm²
SI - 16.68

No. P2 Phoenix sylvestris (L) Roxb.

Fam - Arecaceae.
C.N. - The Wild datepalm; Beng & Hin - Khajur.
Guj - Kharak; Kan - Ichalu; Mar - Shindi;
Oriya - Khajuri; Tam - Icham; Tel - Peddaetta.
S/T - T
HA - Tree
HT - 10m
GR - Slow growing

R - By seeds.
 E/D - Evergreen.
 Flo.S.- Jan. - Feb.
 CSA - 546.1 m²
 CS - Round.
 LA - 411.32 cm²
 SI - 12.4

No. P3 Phyllanthus acidus (L)

Fam - Euphorbiaceae.
 C.N. - Country gooseberry; Beng - Hariphal, Noari;
 Hin - Harfarauri; Guj., M.P. - Harparawari;
 Tam - Kadalai; Tel - Sanagalu; Sans - Chanaka.
 S/T - T
 HA - Tree
 HT - 8 m
 GR - Quick growing
 R - By seeds, Cutting, Budding.
 E/D - Deciduous.
 Flo.S.- Feb. - May.
 CSA - 5647.5 m²
 CS - Oblong.
 LA - 543.03 cm²
 SI - 11.78

No. P4 Pinus khasiana

Fam - Pinaceae.
 C.N. - Khasipine.
 S/T - S
 HA - Tree
 HT - 10m
 GR - Slow growing
 R - By seeds.

E/D - Evergreen.
 Flo.S.- May - June, Sept. - Oct.
 CS - Round.

No. P5 Pinus roxburghii
 Fam - Pinaceae.
 C.N. - Hin - Chilgoza; N.W.H.P. - Chiri.
 S/T - S
 HA - Tree
 HT - 10m
 GR - Slow growing
 R - By seeds.
 E/D - Evergreen.
 Flo.S. - May - June, Sept. - Oct.
 CS - Round.

No. P6 Pinus wallichiana A.B.Jackson
 Fam - Pinaceae.
 C.N. - Chir pine.
 S/T - S
 HA - Tree
 HT - 12m
 GR - Slow growing
 R - By seeds.
 E/D - Evergreen.
 Flo.S. - May - June, Sept. - Oct.
 CS - Round.

No. P7 Pithecellobium ducle (Roxb.) Benth
 Fam - Mimosaceae.
 C.N. - Manila tamarind, Madras thorn;
 Beng - Dekhani babul, Hin - Vilayatimili;
 Jungle jalebi; Kan - Kottampuli;

	Mal - Korukkapuli; Mar - Vilayati chinot;
	Tam - Kodukkaapuli; Tel - Seema chinta.
S/T	- T
HA	- Tree
HT	- 8 m
GR	- Quick growing
R	- By seeds, Branch cutting.
E/D	- Evergreen.
Flo.S.	- Jan. - Feb.
CSA	- 2564.75 m ²
CS	- Oblong.
LA	- 182.6 cm ²
SI	- 11.78

No. P8 Poinciana pulcherrima Linn (R. Grah.)

Fam	- Caesalpinaceae.
C.N.	- Beng - Krishnachura; Hin - Guletura;
	Guj - Sandhesharo; Mar. - Shankasur; Sanse
	& Tel - Ratnagandhi; Mal. - Settimandaram;
	Tam - Mayuram; Tel - Ratnagandhi.
S/T	- T
HA	- Shrub
HT	- 3 m
GR	- Quick growing
R	- By cutting.
E/D	- Evergreen.
Flo.S.	- Oct. - Jan.
CSA	- 8034.67 m ²
CS	- Oblong.
LA	- 214.01 cm ²
SI	- 13.4

No. P9 Polyalthia longifolia (Sonn.) Th
 Fam - Anonaceae.
 C.N. - Hin & Beng - Devdaru; Guj - Asupala;
 Mar - Ashok; Kan - Putrajivi; Mal - Ashokam;
 Tam - Asogam; Tel - Asokamu.
 S/T - S
 HA - Tree
 HT - 15 or 5 m
 GR - Quick growing
 R - Through seeds (fresh).
 E/D - Evergreen.
 Flo.S.- April - June.
 CSA - 10,976.62 m² rounded crown.
 CS - Conical or Rounded
 LA - 55.06 cm²
 SI - 22.27

No. P10 Populus alba Linn
 Fam - Salicaceae.
 C.N. - White poplar; N.W. Himal - Chitta bagnu;
 Jangli frast. Kashmir - Fras.
 S/T - S
 HA - Tree
 HT - 15 m
 GR - Quick growing
 R - By seeds, stem, root cutting, root sucker.
 E/D - Deciduous.
 CS - Oblong.

No. P11 Populus ciliata Wall.
 Fam - Salicaceae.
 C.N. - Himalayan poplar; Beng - Bangikat;
 Jaunsar - biaoan, piplas, kumaun; Syan;

- N.W.H.P. - Bagnuchelum, tilaunja.
- S/T - S
- HA - Tree
- HT - 20 m
- GR - Quick growing
- R - By seeds, stem, root cutting, root sucker.
- E/D - Deciduous.
- CS - Oblong.

No. P12 Populus deltoides Bartr.

- Fam - Salicaceae.
- C.N. - Caroline poplar, Eastern cottonwood Necklace polar.
- S/T - S
- HA - Tree
- HT - 20 m
- GR - Quick growing
- R - By seeds, stem, root cutting, root sucker.
- E/D - Deciduous.
- CS - Oblong.

No. P13 Populus euphratica Olivier

- Fam - Salicaceae.
- C.N. - Indian poplar. Punjab & N.W.H.P-Bahan, bhan; Ladakh - Hotung, hondung.
- S/T - S
- HA - Tree
- HT - 10 m
- GR - Quick growing
- R - By seeds, stem, root cutting, root sucker.
- E/D - Deciduous.
- CS - Oblong.

- No. P14 Populus nigra Linn
 Fam - Salicaceae.
 C.N. - Lombardy - poplar; N.W.H.P. - Frast.
 S/T - S
 HA - Tree
 HT - 20 m
 GR - Quick growing
 R - By seeds, stem, root cutting, root sucker.
 E/D - Deciduous.
 CS - Conical.
- No. P15 Prosopis chilensis (Molina) stuntz.
 Fam - Mimos eae.
 C.N. - Mesquite; Guj - Gandaa babul, Pardesi babul;
 Hin - Vilayati kikkar; Vilayati babul, Kabuli
 kikkar.
 S/T - T
 HA - Tree
 HT - 10 m
 GR - Quick growing
 R - By seeds, root suckers.
 E/D - Evergreen.
 Flo.S.- Dec. - April.
 CSA - 7950.68 m²
 CS - Spreading.
 LA - 51.05 cm²
 SI - 19.23
- No. P16 Prosopis cineraria Linn.
 Fam - Mimos eae.
 C.N. - Beng & Oriya - Shami; Hin - Khejri;
 Guj - Sami, Khijado; Kan - Banni;
 Mal - Parampu, Tamba; Mar - Shami;

Tam - Perumbay, Jambu; Tel - Jammichettu.

S/T - T
 HA - Tree
 HT - 12 m
 GR - Quick growing
 R - By seeds, root suckers.
 E/D - Evergreen.
 Flo.S. - Dec. - April.
 CSA - 13,430.6 m²
 CS - Spreading.
 LA - 54.23 cm²
 SI - 18.1

No. P17 Prosopis pallida (H & B ex Willd)

Fam - Mimos eae.
 S/T - T
 HA - Tree
 HT - 10 m
 GR - Quick growing
 R - By seeds, root suckers.
 E/D - Evergreen.
 Flo S. - Dec. - April.
 CS - Spreading.

No. P18 Prosopis stephaniana Kunth.

Fam - Mimos eae.
 S/T - T
 HA - Shrub
 HT - 5 m
 GR - Quick growing
 R - By seeds, root suckers.
 E/D - Evergreen.
 Flo.S. - Dec. - Feb.
 CS - Spreading.

No. P19 Prosopis tamarugo FiPhil.

Fam - Mimos eae.
 S/T - T
 HA - Tree
 HT - 13 m
 GR - Quick growing
 R - By seeds, root suckers.
 E/D - Evergreen.
 Flo.S. - Dec. - April.
 CS - Spreading.

No. P20 Psidium guayava Linn.

Fam - Myrtaceae.
 C.N. - Guava tree. Beng - Peyara;
 Hin & Punjab - Amrud; Guj - Perala;
 Sans - Mansala; Tam, Mal - Koyya;
 Tel - Goyya; Mar - Peru
 S/T - T
 HA - Tree
 HT - 5 m
 GR - Quick growing
 R - By cutting, seeds, Budding, Grafting.
 E/D - Evergreen.
 CSA - 9,243.1 m²
 CS - Oblong.
 LA - 53.66 cm²
 SI - 28.38

No. P21 Pterygota alata var. irregularis (W.W.Smith)

Fam - Sterculiaceae
 C.N. - Assam - Tula; Kan - Bekaro, Mal - Porutonti;
 Tam - Kodiattondi.
 S/T - T

HA	-	Tree
HT	-	15 m
GR	-	Quick growing
R	-	By seeds, cuttings.
E/D	-	Semi deciduous.
Flo.S.	-	Mar. - April.
CSA	-	179,320.8 m ²
CS	-	Rround/Oblong
LA	-	189.4 cm ²
SI	-	22.04
CS	-	Rround/Oblong
LA	-	189.4 cm ²
SI	-	22.04

No. Q1 Quercus palustris

Fam	-	Fagaceae.
C.N.	-	Oak.
S/T	-	T
HA	-	Tree
HT	-	15 m
GR	-	Quick growing
E/D	-	Deciduous.
CS	-	Round.

No. Q2 Quercus petraea

Fam	-	Fagaceae.
C.N.	-	Oak.
S/T	-	T
HA	-	Tree
HT	-	15 m
GR	-	Quick growing
E/D	-	Deciduous.
CS	-	Round.

No. Q3 Quercus rubra

Fam - Fagaceae.
 C.N. - Oak.
 S/T - T
 HA - Tree
 HT - 15 m
 GR - Quick growing
 E/D - Deciduous.
 CS - Round.

No. R1 Ricinus communis Linn.

Fam - Euphorbiaceae.
 C.N. - The castor; Beng - Bheranda; Guj - Divaligo;
 Hin & Mar. Erandi; Kan-Haralu; Mal - Avanakku;
 Tam - Amanakku; Tel - Aamudamuchettu.
 S/T - T
 HA - Shrub
 HT - 6 m
 GR - Quick growing
 R - By seeds.
 E/D - Evergreen.
 Flo.S. - Sept. - Oct.
 CSA - 942.56 m²
 CS - Oblong.
 LA - 243.5 cm²
 SI - 15.71

No. S1 Salix alba Linn.

Fam - Salicaceae.
 C.N. - European willow; White willow. Kashmir - Butvir,
 Vivir; H.P. Punjab - Bisbhushan, Madnu,
 Malchang.
 S/T - T

- HA - Tree
 HT - 20 m
 GR - Quick growing
 R - By stem cutting, root cutting.
 E/D - Deciduous.
 Flo.S. - Mar. - May.
 CS - Oblong/Round.

No. S2

Salix babylonica Linn.

- Fam - Salicaceae.
 C.N. - Weeping willow. Garhwal - Gadhbanis;
 Kashmir - Biosa, Guir; Punjab - Biosa;
 Tel - Attuppalai,
 S/T - T
 HA - Tree
 HT - 10 m
 GR - Quick growing
 R - By stem, root cutting, suckers.
 E/D - Deciduous.
 Flo.S. - Mar. - May.
 CS - Round.

No. S3

Salix caprea Linn.

- Fam - Salicaceae.
 C.N. - The sallow, goat willow
 Hin & Punjab - Bedmushk.
 S/T - T
 HA - Shrub
 HT - 5 m
 GR - Quick growing
 R - By cutting.
 E/D - Deciduous.

Flo.S. - Mar. - May.
CS - Round/Oblong.

No. S4 Salix fragilis Linn.

Fam - Salicaceae.
C.N. - Crack or Kashmir willow; H.P. Tilchang.
S/T - T
HA - Tree
HT - 18 m
GR - Quick growing
R - By seeds, cutting.
E/D - Deciduous.
Flo.S. - Mar. - May.
CS - Oblong/Round.

No. S5 Salix tetrasperma Roxb.

Fam - Salicaceae.
C.N. - Indian willow; Beng - Panijama; Hin - Bod. jalmala; Kan - Niravanji; Mal & Tam - Vanji; Mar - Wallunj; Oriya - Baisi; Tel - Eetipaala; Assam - Veh; Kashmir - Vir, bin; Khasi - Jamyneri; M.P. Dhanie; Punjab - Bis, Bain
S/T - T
HA - Tree
HT - 15 m
GR - Quick growing
R - By cutting.
E/D - Deciduous.
CS - Round.

No. S6 Samanea saman Jacq.

Fam - Mimos eae.
C.N. - Rain Tree.

S/T	-	T
HA	-	Tree
HT	-	20 m
GR	-	Quick growing
R	-	By seeds cutting.
E/D	-	Evergreen.
Flo.S.	-	Mar. - June
CSA	-	99306.2 m ²
CS	-	Spreading/Round.
LA	-	282.6 cm ²
SI	-	15.64

No. S7 Sapindus emarginatus Vahl.

Fam	-	Sapindaceae.
C.N.	-	Soapnut; Assam - Haithaguti; Beng - Ritha; Mar- Ritha; Sans - Phenila.
S/T	-	T
HA	-	Tree
HT	-	10 m
GR	-	Quick growing
R	-	By seeds.
E/D	-	Evergreen.
Flo.S.	-	Oct. - Dec.
CSA	-	43,789.24 m ²
CS	-	Oblong/Round.
LA	-	110.6 cm ²
SI	-	23.6

No. S8 Sapium sebiferum Roxb

Fam	-	Euphorbiaceae
C.N.	-	Makhan tree. Chinese Tallow Tree.
S/T	-	T
HA	-	Tree

HT - 12 m
 GR - Quick growing
 R - By seeds.
 E/D - Deciduous.
 Flo.S. - June - Aug.
 CSA - 24980.3 m²
 CS - Round.
 LA - 74.2 cm²
 SI - 14.2

No. S9 Saraca asoka Roxb. De Wilde.

Fam - Caesalpinaceae.
 C.N. - Hin & Mar - Ashok, Punjab & Beng - Asok;
 Mar - Asoka; Sans - Ashoka; Tam - Asogam;
 Tel - Asokamu.
 S/T - T
 HA - Tree
 HT - 5 m
 GR - Quick growing
 R - By seeds.
 E/D - Evergreen.
 Flo.S. - Dec - May.
 CSA - 2295.2 m²
 CS - Spreading.
 LA - 68.8 cm²
 SI - 17.93

No. S10 Sesbania grandiflora Pers.

Fam - Fabaceae.
 C.N. - Swamp - pea, Agathi; Kan - Agase; Mal- Mathi;
 Mar - Hadga, Agasta; Oriya - Ogoti;
 Tam - Agathi; Tel - Arise - chetta.
 S/T - T

HA - Tree
 HT - 10 m
 GR - Quick growing
 R - By seeds.
 E/D - Evergreen.
 Flo.S. - Sept. - Dec.
 CSA - 4694.87 m²
 CS - Oblong.
 LA - 130 cm²
 SI - 20.45

No. S11 Sesbania sesban (Linn) Merrill.

Fam - Fabaceae.
 C.N. - Common sesban; Beng & Hin - Jainti;
 Guj - Jayati; Kan - Arisinajeenangimera;
 Mal - Sempa; Mar - Jayanti, Shewarie;
 Oriya - Joyontei; Sans - Jayantika;
 Tam - Chittagathi; Tel - Samintha;
 Assam - Jayantri; Punjab - Jaint.
 S/T - T
 HA - Shrub
 HT - 6 m
 GR - Quick growing
 R - By seeds.
 E/D - Evergreen.
 Flo.S. - Aug. - Dec.
 CSA - 4563.7 m²
 CS - Oblong.
 LA - 118.3 cm²
 SI - 19.2

No. S12 Sesbania speciosa Taub.

Fam - Fabaceae.

C.N. - Tam - Seemaiagathi.
 ST - T
 HA - Shrub
 HT - 4 m
 GR - Quick growing
 R - By seeds.
 E/D - Evergreen.
 Flo.S. - Sept. - Dec.
 CS - Oblong.

No. S13 Soymida febrifuga A. Juss

Fam - Meliaceae.
 C.N. - Indian Red wood, Beng & Hindi Mar - Rohan;
 Guj - Rohina; Kan - Suani; Oriya - Sohan;
 Tam - Shem; Tel - Sumi, Sonidamaanu.
 S/T - T
 HA - Tree
 HT - 15 m
 GR - Quick growing
 R - By seeds.
 E/D - Deciduous.
 Flo.S. - Mar.
 CSA - 78325.4 m²
 CS - Round/Oblong.
 LA - 49.7 cm²
 SI - 20.3

No. S14 Spathodea campanulata Beauv.

Fam - Bignoniaceae
 C.N. - Indian Tulip tree
 S/T - T
 HA - Tree
 HT - 12 m

GR	-	Quick growing
R	-	By seeds, cutting.
E/D	-	Evergreen.
Flo.S.	-	Nov. - Jan.
CSA	-	73,250.17 m ²
CS	-	Oblong / Round
LA	-	89.3 cm ²
SI	-	24.84

No. S15 Spondias pinnata (L.f.)

Fam	-	Anacardiaceae.
C.N.	-	Hin - Bemg & Mar - Amra; Kan - Ambate; San - Amrataka; Tam - Mabulichhi; Tel - Amratakamul; Mal - Mapuli.
S/T	-	T
HA	-	Tree
HT	-	10 m
Gr	-	Quick growing after 1st year.
R	-	By seeds.
E/D	-	Deciduous.
Flo.S.	-	Feb. - Apr.
CSA	-	25587.31 m ²
CS	-	Round.
LA	-	130.64 cm ²
SI	-	22.9

No. S16 Sterculia foetida Linn.

Fam	-	Sterculiaceae.
C.N.	-	Jangli badam, Hin & Mar - Jangli badam; Kan - Penari; Tam & Mal - Pinari; Tel - Manjiponaku.
S/T	-	T
HA	-	Tree

HT - 15 m
 GR - Quick growing
 R - By seeds.
 E/D - Deciduous.
 Flo.S. - Mar. - May.
 CS - Oblong/Round.

No. S17 Sterculia guttata Roxb.

Fam - Sterculiaceae.
 C.N. - Kukur, Golder.
 S/T - T
 HA - Tree
 HT - 15 m
 GR - Quick growing
 R - By seeds.
 E/D - Deciduous.
 Flo.S. - Jan. - Feb.
 CS - Oblong/Round.

No. S18 Strychnos nux-vomica Linn

Fam - Loganiaceae.
 C.N. - Beng & Punjab - Kuchila; Hin - Kuchla; Kan-
 Kanjira; Mal - Kanniram; Mar - Kajra;
 Sans - Visha - mushti; Tam - Etti; Tel - Mushti.
 S/T - T
 HA - Tree
 HT - 12 m
 GR - Quick growing
 R - By seeds.
 E/D - Deciduous.
 Flo.S. - Mar. - April
 CSA - 1067.441 m²
 CS - Oblong/Round.

LA - 67.37 cm²
 SI - 12.87

No. S19 Syncarpia glomulifera Sm.

Fam - Myrtaceae
 C.N. - Turpentine tree.
 S/T - T
 HA - Tree
 HT - 20 m
 GR - Quick growing
 R - By seeds.
 E/D - Evergreen.
 CS - Oblong/Round.

No. S20 Syzygium cumini Linn

Fam - Myrtaceae.
 C.N. - Black plum; Beng - Kalajam; Guj - Jambu;
 Hin & Punjab - Jaman; Mar - Jambhul;
 Kan - Nerale; Mal - Perinnaral; Oriya - Jamo;
 Tam - Neredum; Tel - Neereedu.
 S/T - T
 HA - Tree
 HT - 20 m
 GR - Quick growing
 R - By seeds, cuttings. Grafting. Budding.
 E/D - Evergreen.
 Flo.S. - Mar. - May.
 CSA - 112143.2 m²
 CS - Oblong/Spreading.
 LA - 77.82 cm²
 SI - 20.60

- No. T1 Tabernaemontana divaricata Linn.
 Fam - Apocynaceae.
 C.N. - Beng, Mar, Hin & Sans - Tagar, Chandani;
 Tam - Nandiyavattam; Tel - Gandhitagarapu.
 S/T - T
 HA - Shrub
 HT - 3m
 GR - Quick growing
 R - By cutting.
 E/D - Evergreen.
 Flo.S. - Throughout the year.
 CSA - 128.67 m²
 CS - Round.
 LA - 47.81 cm²
 SI - 30.2
- No. T2 Tamarindus indica Linn.
 Fam - Caesapinaceae.
 C.N. - The Tamarind tree; Beng - Anbli, Tentuli; Guj &
 Kan - Amlī; Hin - Imli; Mal - Amlam, Puli;
 Mar - Chinch; Oriya - Tentuli;
 Tam - Amilam pul; Tel - Chintachettu;
 Assam - Tetuli; Punjab - Imbli.
 S/T - T
 HA - Tree.
 HT - 20 m
 GR - Quick growing (Early)
 R - By seeds.
 E/D - Evergreen.
 Flo.S. - April - Oct.
 CSA - 276839.5 m²
 CS - Spreading.

LA - 128.60 cm²
 SI - 18.4

No. T3 Tecoma stans Linn.

Fam - Bignoniaceae.
 C.N. - Kan - Koreneklar; Tam - Sona - Patti;
 Tel - Pachagotla
 S/T - T
 HA - Shrub
 HT - 5 m
 GR - Quick growing
 R - By seeds, cutting.
 E/D - Evergreen.
 Flo.S. - Feb. - April
 CSA - 61.23 m²
 CS - Oblong.
 LA - 43.7 cm²
 SI - 23.8

No. T4 Tectona grandis Linn.

Fam - Verbenaceae.
 C.N. - Teak; Beng - Segun; Hin & Mar - Sagwan;
 Guj- Saga; Kan - Tega; Mal & Tam - Thekku;
 Oriya - Singuru; Tel - Adaviteeku, Peddateek;
 Assam - Chingjagu.
 S/T - T
 HA - Tree
 HT - 20 m
 GR - Quick growing
 R - By seeds.
 E/D - Deciduous.
 Flo.S. - June - Sept.
 CSA - 10272.14 m²

CS - Oblong/Round
 LA - 790.37 m²
 SI - 23.48

No. T5 Terminalia alata Heyne ex Roth.

Fam - Combretaceae.
 C.N. - Laurel; Beng - Asan; Guj - Sadar; Hin - Asan,
 Sain, Saj; Kan - Sadada; Mar - Ain;
 Oriya - Sahaju; Tam - Karramarda,
 Tel - Nallamaddi.
 S/T - T
 HA - Tree
 HT - 20 m
 GR - Quick growing
 R - By seeds, cutting.
 E/D - Deciduous.
 Flo.S. - May - July.
 CS - Oblong/Round.

No. T6 Terminalia arjuna (Roxb) Wight & Arn.

Fam - Combretaceae.
 C.N. - Arjun, Arjhan; Beng - Guj - Sadado; Hin &
 Punjab - Arjuna; Kan - Maddi; Mar - Sadaru,
 vellamarda; Oriya - Arjuno, sahajo;
 Tam - Vellamatta; Tel - Yerramaddi;
 Assam - Orjun.
 S/T - T
 HA - Tree
 HT - 15 m
 GR - Quick growing
 R - By seeds, cutting, air layering.
 E/D - Deciduous.
 Flo.S. - April - July.

CSA - 719,992.2 m²
 CS - Oblong/Round
 LA - 60.06 cm²
 SI - 24.57

No. T7 Terminalia bellerica (Gaertn) Roxb

Fam - Combretaceae.
 C.N. - Belleric myrobalan; Beng Bhairah; Hin - Bahera;
 Mal & Tam - Tani; Mar - Beheda;
 Oriya - Bhara, Tel - Thandrakaaya.
 S/T - T
 HA - Tree
 HT - 15 m
 GR - Quick growing
 R - By seeds, cuttings.
 E/D - Deciduous.
 Flo.S. - April - May.
 CSA - 82813.9 m²
 CS - Oblong/Round
 LA - 63.20 cm²
 SI - 19.06

No. T8 Terminalia catappa Linn.

Fam - Combretaceae.
 C.N. - The Indian Almond tree; Beng - Badam;
 Hin - Deshi badam; Mal - Adamarram;
 Tam - Natvadam; Tel - Baadamuchettu, Vedam.
 S/T - T
 HA - Tree
 HT - 10 m
 GR - Quick growing
 R - By seeds.
 E/D - Deciduous.

Flo.S. - Oct.- Nov.
 CSA - 94367.4 m²
 CS - Conical
 LA - 62.01 cm²
 SI - 20.9

No. T9

Terminalia chebula Retz.

Fam - Combretaceae.
 C.N. - Chebulic myrobalan; Beng - Haritaki;
 Guj - Hardo; Hin - Harra; Mar - Hirda;
 Oriya - Haridra; Tam - Kadukkai;
 Tel - Karakkaaya; Assam - Silikha; Punjab - Har
 S/T - T
 HA - Tree
 HT - 15 m
 GR - Quick growing
 R - By seeds.
 E/D - Deciduous.
 Flo.S. - Mar.- Oct.
 CSA - 82,314.16 m²
 CS - Round/Oblong.
 LA - 60.60 cm²
 SI - 19.06

No. T10

Thespesia populneoides (Roxb) Kostel.

Fam - Malvaceae.
 C.N. - Umbrella tree, Indian Tulip tree, Beng - Dumbila,
 parespical; Guj - Paarsapeepala;
 Hin & Punjab - Paraspical; Kan - Hoovarase;
 Mal - Poovarasu; Mar - Bhendi;
 Oriya - Gunjausto; Sans - Gardhabhanda;
 Tam - Chelanthi; Tel - Gangaraavichettu.
 S/T - T

HA	-	Tree
HT	-	10 m
GR	-	Quick growing
R	-	By seeds, cuttings.
E/D	-	Evergreen.
Flo.S.	-	Throughout the year.
CSA	-	34,635.32 m ²
CS	-	Round
LA	-	184.39 cm ²
SI	-	29.81

No. T11 Thevetia peruviana (Pers.) Merrill.

Fam	-	Apocynaceae.
C.N.	-	Yellow oleaner; Beng - Koklaphul, Haldi korubi; Guj & Hin - Pila kaner; Kan - Kadukasi; Mal - Manjaareli; Mar - Pivala kanhera; Bitti Oriya - Konyarphul; Tam - Pachaiyalari; Tel - Pachaganneru.
S/T	-	T
HA	-	Shrub
HT	-	6m
GR	-	Quick growing
R	-	By seeds, cutting.
E/D	-	Evergreen.
CSA	-	21,775.22 m ²
CS	-	Round / Oblong.
LA	-	11.08 cm ²
SI	-	27.8

No. T12 Thuja occidentalis Linn.

Fam	-	Cupressaceae.
C.N.	-	American Arborvitae, White cedar.
S/T	-	T

HA - Tree
 HT - 15 m
 GR - Quick growing
 R - By cutting.
 E/D - Evergreen.
 CS - Conical

No. T13 Thuja plicata D. Don.

Fam - Cupressaceae.
 C.N. - Giant arborvitae, Western red cedar.
 S/T - T
 HA - Tree
 HT - 20 m
 GR - Quick growing
 R - By cutting.
 E/D - Evergreen.
 CS - Conical

No. T14 Trema orientalis Blume

Fam - Ulmaceae.
 C.N. - Charcoal tree. Indian nettle tree. Beng - Chikan;
 Guj & Mar - Gol; Hin - Gio; Kan - Gorklu;
 Mal - Ama; Oriya - Kharkas; Tam - Ambaratthi;
 Tel - Bundamuru;
 S/T - T
 HA - Tree
 HT - 6 m
 GR - Quick growing
 R - By seeds, stumps.
 E/D - Evergreen.
 Flo.S. - Throughout the year.
 CSA - 42,5734.1 m²
 CS - Round/Oblong.

LA - 65.7 cm²
 SI - 27.30

No. V1 Ulmus wallichiana Planch.

Fam - Ulmaceae.
 C.N. - Hin - Mored pabuna; Kashmir - Brari;
 Kumaun - Maral; Punjab - Kain.
 S/T - T
 HA - Tree
 HT - 15 m
 GR - Quick growing
 R - By seeds.
 E/D - Evergreen.
 CS - Round

No. Z1 Zizyphus mauritiana Var. Fruticosa

Fam - Rhamnaceae.
 C.N. - Indian jujube; Beng & Hin - Ber; Guj - Bordi;
 Kan - Elanji; Mal & Tam - Elentha;
 Mar - Bera, bor; Oriya - Bodori;
 San - Karakandhy; Tel - Reegu.
 S/T - T
 HA - Tree
 HT - 10 m
 GR - Quick growing (Early)
 R - By seeds.
 E/D - Evergreen.
 Flo.S. - April - Oct.
 CSA - 2638.17 m²
 CS - Round
 LA - 24.08 cm²
 SI - 12.4

- No. Z2 Zizyphus oenoplia Mill
 Fam - Rhamnaceae.
 C.N. - Jackal jujube; Beng - Siakul; Hin - Makai;
 Kan - Barige; Mal - Kottavalli;
 Oriya - Kantokolli; Tam - Ambulam;
 Tel - Banka paragi.
 S/T - T
 HA - Straggler shrub.
 HT - 5 m
 GR - Quick growing
 R - By seeds.
 E/D - Evergreen.
 Flo.S. - April - June.
 CS - Round

- No. Z3 Zizyphus rugosa Lamk.
 Fam - Rhamnaceae.
 C.N. - Hin - Suran; Mar - Turan - Torni,
 Kan - Mahigotte; Mal - Malantutali;
 Tam - Kattilandai; Tel - Pinduparighamu.
 S/T - T
 HA - Straggler shrub.
 HT - 5 m
 GR - Quick growing
 R - By seeds.
 E/D - Evergreen.
 Flo.S. - Dec. - Feb.
 CS - Round

- No. Z4 Zizyphus xylopyra Willd.
 Fam - Rhamnaceae.
 C.N. - Hin - Kat - ber; Kan - Mullukare;
 Mar - Koddntegoti; Oriya - Goteoboro,

		Kantobohul; Tam - Kottei; Tel - Gotte.
S/T	-	T
HA	-	Straggler shrub.
HT	-	4 m
GR	-	Quick growing
R	-	By seeds.
E/D	-	Evergreen.
Flo.S.	-	April - June.
CS	-	Round

APPENDIX-C

Zonewise recommendation of plant species for constitution of Green Belt :

Note for the use of Appendix C :

For listing plant species for cultivation in an area of concern, please follow the following steps.

1. Place the area (as per District) of your concern in subzone and zone, after referring to Appendix A.
2. Refer to Appendix C at corresponding zone (Cz) and subzone (I.1, II.3, V.2 etc.).
3. List the alphabets and numbers under zone and subzone (e.g. Cz V.2 - A 1, 2, 3, 4, 5 etc.; B - 1, 2, 3, 4 etc.; C - 2, 3, 4, 12 etc.)separately on sheets.
4. Decipher the above numbers from Appendix B. (e.g. A - 1 - Abutilon indicum, A - 2 - Acacia auriculiformis etc.; B - 1 - Balanites roxburghii, B - 2 - Bambusa arundinacia, etc.; C - 2 - Callistemon citrinus, C - 3 - Calophyllum inophyllum, C - 4 - Calotropis gigantea etc. and so on.

Completion of the exercise will mean that your list of plants for cultivation in the area of concern is ready. Detailed information, useful for agronomic and other aspects, is available in Appendix B.

Cz I. Western Himalayan Region

Cz I.1 - **A** - 3,4,7,9-11,13,16,17,19,22-26,28-35,41,44;
B - 6-12,16; **C** - 14,21,22; **D** - 1; **E** - 4-6; **F**
 - 1-4; 7-9; **G** - 6-8; **H** - 4; **I** - 1,2; **J** - 2; **L**
 - 3,4; **M** - 1,8; **N** - 1,2; **O** - 1; **P** - 4-6, 10
 - 14; **Q** - 1-3; **S** - 1-5,8,15; **T** - 1-3, 6, 7,9,
 12,13; **U** - 1; **Z** - 1

- Cz 1.2** - **A** - 3,4,7,9-11,13,16,17,19,22-26,28-35,39,41, 44; **B** - 4,6-17; **C** - 2-5,14,18,21,22; **D** - 1,4; **E** - 1,4-6,8; **F** - 1-4,8; **G** - 4;6-8; **H** - 3,4; **I** - 1-3,5; **J** - 2; **L** - 3,4; **M** - 1,3,8,12,14; **N** - 1,2; **O** - 1; **P** - 4-6, 10-14,16,21; **Q** - 1-3; **S** - 1-5,7-10,14,15; **T** - 1-3,6,7,9,12,13; **U** - 1; **Z** - 1
- Cz 1.3** - **A** - 3,4,7,9-11,13,16,17,19,22-26,28-35,39,41, 44; **B** - 4,6-17; **C** - 2-5,9,11,14,18,21,22; **D** - 1,4,5; **E** - 1,2,4-6; **F** - 1-4,8; **G** - 3,4,6-8; **H** - 3,4; **I** - 1-3,5; **J** - 2; **L** - 1,4; **M** - 1, 3,8,12-14; **N** - 1,2; **O** - 1; **P** - 4-16; **Q** - 1 - 3; **S** - 2-5,7-10,14,15; **T** - 1-3,6,7,9,12,13; **U** - 1; **Z** - 1,3,4.
- Cz 1.4** - **A** - 1-4,7,10,11,13,16,17,19,22-26,28-32,34 - 36,39,41,44; **B** - 4,6-17; **C** - 2-8,9,14, 18,21, 22; **D** - 1,4,5; **E** - 1,2,4-6; **F** - 1-4,8; **G** - 3-4,6-8; **H** - 3,4; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 1,3,5,8,12-14; **N** - 1,2; **O** - 1; **P** - 4- 16; **Q** - 1 - 3; **S** - 1-5,7-10,14,15; **T** - 1- 3,6,7,9,12-14; **U** - 1; **Z** - 1

Cz II. Eastern Himamlayan Region

Cz II.1 - **A** - 1,3,4,7,10,11,13,14,16,17,19,22-26,28-36,
39-41; **B** - 1,4,6-17; **C** - 2-5,7-11,13-16,18,
20-22; **D** - 1,2,4,5,6; **E** - 1,2, 4-6; **F** - 1-4;
8; **G** - 6-8; **H** - 3, 4; **I** - 1-3, 5; **J** - 2; **L** -
1-3; **M** - 1,3,8,9,12-14; **N** - 1-2; **O** - 1; **P** -
4-6, 10 - 14; **Q** - 1-3; **R** - 1; **S** - 1-5,1-10,15;
T - 1-3, 5-7,9,11,13,14; **U** - 1; **Z** - 1

Cz II.2 - **A** - 1,3,4,7,8,10,11,13,14,16-26,28-36, 39-44;
B - 1-4,6-17; **C** - 2-9,11,13-16,18-22; **D** - 1-
6,8; **E** - 1-6; **F** - 1-8; **G** - 3,4,6-8; **H** - 3,4;
I - 2,3,5; **J** - 1,2; **L** - 1-4; **M** - 1-3, 5, 8,
9,12-14; **N** - 1,2; **O** - 1; **P** - 4-6, 10-14,16,
21; **Q** - 1-2; **S** - 2-5,7-10,15,20; **T** - 1-3, 5-
7,11,13,14; **U** - 1; **Z** - 1

Cz II.3 - **A** - 1,3,4,7,8,10,11,13,14,16-26,28,29,32-36,
39-44; **B** - 1-4,6-17; **C** - 2-9,11,13-16,18-22;
D - 1-8; **E** - 1-6; **F** - 1-8; **G** - 3,4,6-8; **H** -
3,4; **I** - 2,3,5; **J** - 1,2; **L** - 1-4; **M** - 1-3,5,
8,9,12-14; **N** - 1,2; **O** - 1; **P** - 4-10,12-16,21;
Q - 1-3; **R** - 1; **S** - 2-5,7-10,15,20; **T** - 1-3,
5-7,11,13,14; **U** - 1; **Z** - 1

Cz II.4 - **A** - 1,3-5,7,8,10,11,13,14,16-26,28-44; **B** - 1-4, 6-17; **C** - 2-9,11,13-16, 18-20; **D** - 1-5,8; **E** - 1-6; **F** - 1-8; **G** - 3-4,6-8; **H** - 2-4; **I** - 1-3,5; **J** - 1,2; **K** - 1; **L** - 1-4; **M** - 1-3,5,8,9, 12-14; **N** - 1,2; **O** - 1; **P** - 2,4-16,20,21; **Q** - 1 - 3; **R** - 1; **S** - 1-5,7-10,15,20; **T** - 1-3,5-7,9,13,14; **U** - 1; **Z** - 1

Cz II.5 - **A** - 1,3,5,7,8,10-14,16-26,28,29,31-44; **B** - 1-4, 6-17; **C** - 1-9,11,13-16, 18-20; **D** - 1-8; **E** - 1-6; **F** - 1-8; **G** - 3,4,6-8; **H** - 2-4; **I** - 1-5; **J** - 1,2; **K** - 1; **L** - 1-4; **M** - 1-3,5,8,9, 12-14; **N** - 1,2; **O** - 1; **P** - 2,4-16,20,21; **Q** - 1 - 3; **R** - 1; **S** - 1-5,7-10,15,20; **T** - 1-9,12, 14; **U** - 1; **Z** - 1

Cz III. Lower Gangetic Plains

(West Bengal)

Cz III.1 - **A** - 1,3-5,7,8,10-14,18-20,22,24-26,28-33,36-44; **B** - 1-10,12-16; **C** - 1-9,11-13,15-20, **D** - 1-4,7; **E** - 1-6; **F** - 1-8; **G** - 1,2-4,6-8; **H** - 3,4; **I** - 2-5; **J** - 1,2; **K** - 1; **L** - 1-4; **M** - 2, 3,5,6,8,9,11-14; **N** - 1,2; **O** - 1; **P** - 1,2,4-16,20,21; **Q** - 1 - 3; **R** - 1; **S** - 1-13,15-20; **T** - 1-3,6,7,9,11-14; **Z** - 1,3,4.

Cz III.2 - **A** - 1,3-5,7,8,10-14,18-20,22,24-26,28-33,36-44; **B** - 1-10,12-16; **C** - 1-9,11-13,15-20, **D** - 1-5,7; **E** - 1-6; **F** - 1-8; **G** - 1,2-4,6-8; **H** - 1,3,4; **I** - 2-5; **J** - 1,2; **K** - 1; **L** - 1-4; **M** - 2,3,5,6,8,9,11-14; **N** - 1,2; **O** - 1; **P** - 1,2,4-16,20,21; **Q** - 1-3; **R** - 1; **S** - 1-13,15-20; **T** - 1-3,5-7,9-14; **Z** - 1,3,4.

Cz III.3 - **A** - 1,3-5,7,8,10-14,18-20,22,24-26,28-33,36-44; **B** - 1-10,12-17; **C** - 1-9,11-20, **D** - 1-5,7; **E** - 1-6; **F** - 1-8; **G** - 1-4,6-8; **H** - 1,3,4; **I** - 2-5; **J** - 1,2; **K** - 1; **L** - 1-4; **M** - 2,3,5,6,8,9,11-14; **N** - 1,2; **O** - 1; **P** - 1,2,4-16,20,21; **Q** - 1-3; **R** - 1; **S** - 1-13,15-20; **T** - 1-14; **U** - 1; **Z** - 1,3,4.

Cz III.4 - **A** - 1,3-5,7,8,10-14,18-20,24-33,36-41; **B** - 1-10,12-16; **C** - 1-8,11-13,15-20; **D** - 1-5,7; **E** - 1-6; **F** - 1-6; **G** - 1,2-4,6-8; **H** - 1,3,4; **I** - 2-5; **J** - 1; **K** - 1; **L** - 1-4; **M** - 2,3,5,6,8,9,11-14; **N** - 1,2; **O** - 1; **P** - 1,2,4-16,20,21; **Q** - 1-3; **R** - 1; **S** - 1-13,15-20; **T** - 1-7,9-14; **Z** - 4.

Cz IV. Middle Gangetic plains.

Cz IV.1 - **A** - 1, 3, 4,7,10-15,18,20,22,24-26,28-33,36-42,44; **B** - 1-4,6-10,12-16; **C** - 2-13,15,16,18-20; **D** - 1-5,7; **E** - 1-5; **F** - 1-3,5-7,9; **G** - 3,4,6-9; **H** - 1-4; **I** - 2,3,5; **J** - 1; **K** - 1; **L** - 1-4; **M** - 2,3,5,6,8,9,11-14; **N** - 1,2; **O** - 1; **P** - 1,2,7-9, 12-16,20,21; **R** - 1; **S** - 1-15,20; **T** - 1-4,6,7,9-12,14 **Z** - 1,3,4.

Cz IV.2 - **A** - 1,3,4,7,10-15,18-20,21,24-26,28-30,32,33,36-44; **B** - 1-4,6-10,12-17; **C** - 2-13,15-20; **D** - 1-8; **E** - 1-3,5; **F** - 1-7,9; **G** - 3,4,6-9; **H** - 1-4; **I** - 2-5; **J** - 1; **K** - 1; **L** - 1-4; **M** - 2,3,5,6,8,9,11-14; **N** - 1,2; **O** - 1; **P** - 1,2,5-9,12-16,20, 21; **R** - 1; **S** 1-15,20; **T** - 1-4,6,7,9-12,14; **Z** - 1,3,4.

Cz V. Upper Gangetic Plains

(Uttar Pradesh)

Cz V.1 - **A** - 1-5,7,10-15,18,20-22,24-33,36-41,44; **B** - 1-4, 6-10,12-15,17; **C** - 2-16,18-20; **D** - 1-4,6-7; **E** - 2-5; **F** - 1-3,5-7,9; **G** - 3,4,6-9; **H** - 2-4; **I** - 1-5; **J** - 1,2; **K** - 1; **L** - 1-4; **M** - 2,3,5,8-14; **N** - 1,2; **O** - 1; **P** - 1-3, 5,7-9, 12-16, 19-21; **R** - 1; **S** - 1-17, 20; **T** - 1-3,6, 7,9-12,14; **Z** - 1,3,4.

Cz V.2 - **A** - 1-5,7,10-15,18,20-22,24-33,36-44; **B** - 1-4, 6-10,12-15,17; **C** - 2-12,15,16,18-20; **D** - 1-5,7,8; **E** - 2-5; **F** - 1-3,5,7,9; **G** - 3,4,6-9; **H** - 1-4; **I** - 1-5; **J** - 1,2; **K** - 1; **L** - 1-4; **M** - 2,3,5,8-14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7-9,12-16,19-21; **R** - 1; **S** - 1-17,20; **T** - 1-3,6,7,9-12,14; **Z** - 1,3,4.

Cz V.3 - **A** - 1-5,7,10-15,18,20-22,24-26,28-33,36-44; **B** - 1,3,4,6-10,12-15,17; **C** - 2-12,15,16,18-20; **D** - 1-5,7,8; **E** - 2-5; **F** - 1-3, 5-7,9; **G** - 3,4,6-9; **H** - 1-4; **I** - 1-5; **J** - 1,2; **L** - 1-4; **M** - 2,3,5,8-14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7,9,12-16,19-21; **R** - 1; **S** - 1-15,20; **T** - 1-4,6,9-12,14; **Z** - 1,3,4.

Cz VI. Trans Gangetic Plains

Cz VI.1 - A - 1-5,7,8,10-15,18,20,22,24-27,29-32,36-42, 44; **B** - 1-4,6-10,12-15,17; **C** - 2-13,15,16,18, 20; **D** - 1-8; **E** - 1-5; **F** - 1-3, 5-7,9; **G** - 3-4,6-9; **H** - 1-4; **I** - 1,3,4; **J** - 2; **K** - 1; **L** - 1-4, **M** - 2,5,8-14; **N** - 1,2; **O** - 1; **P** - 1-16,18-21; **R** - 1; **S** - 1-13,15,20; **T** - 1-3,6,7,9,11,14; **U** - 1; **Z** - 1,3,4.

Cz VI.2 - A - 1-5,7,8,10-15,18,20,22,24-26,29-32,36-42, 44; **B** - 1-4,6-10,12-15,17; **C** - 2-13,15,16,18, 20; **D** - 1-6,8; **E** - 1-5; **F** - 1-3,5-9; **G** - 3-4,6-9; **H** - 1-4; **I** - 1-3,5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2,3,5,8-14; **N** - 1,2; **O** - 1; **P** - 1-3,7,9,12,15-17,19; **R** - 1; **S** - 1-13, 15,20; **T** - 1-3,6,7,9-12, 14; **U** - 1; **Z** - 1-4.

Cz VI.3 - A - 1-5,7,8,10-15,18,20,22,24,26,29-32,36-42, 44; **B** - 1,3,4,6-10,13-14,17; **C** - 2-13,15,16,18,20; **D** - 2-8; **E** - 3,5; **F** - 1-3,5-7,9; **G** - 3,4,6-9; **H** - 1-4; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2,5,8-14; **N** - 1,2; **O** - 1; **P** - 1-3,7-9,12,15-17, 19-21; **R** - 1; **S** - 1-13,20; **T** - 1-4,6,9-11,14; **U** - 1; **Z** - 1-4.

Cz VII. Eastern Plateau and Hills.

- Cz VII.1 - **A** - 1,3,4,6,7,10-15,18-22,25,27,29-32,36-44; **B** - 1,3,4,6-10, 12-16; **C** - 2-11,13,15,16,18-20; **D** - 2-8; **E** - 2-5; **F** - 1-7,9; **G** - 3,4,6,8,9; **H** - 1-3,5; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2-5,9-14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7-9;12,13,15,16,19-21; **R** - 1; **S** - 5-18,20; **T** - 1-7,9-12; 14; **Z** - 1-4.
- Cz VII.2 - **A** - 1,3,4,7,10,11,13-15,18-22,25,27,29-32,36-44; **B** - 1-4,6-10,12-16; **C** - 2-11,13,15,16,18-20; **D** - 2-8; **E** - 1-5; **F** - 1-7,9; **G** - 3,4,6,8,9; **H** - 1-3,5; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2,3,5,9-14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7,9;12,13,15,16,20,21; **R** - 1; **S** - 5-18,20; **T** - 1-7,9,11,14; **Z** - 1-4.
- Cz VII.3 - **A** - 1,3,5,7,10-15,18-20,22,25,27, 29-32, 36-44; **B** - 1-4,6-10,12-16; **C** - 2-11,13,15,16,18-20; **D** - 2-8; **E** - 1-5; **F** - 1-7,9; **G** - 3,4,6,8,9; **H** - 1-3,5; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2,3,5,9-14; **N** - 1,2; **O** - 1; **P** - 1,2,5,7-9;12-15,16,20,21; **R** - 1; **S** - 5,6,9,13-16, 18, 20; **T** - 1-7,9-12,14; **Z** - 1-4.

Cz VII.4 - A - 1,3-5,7,10-15,18-20,22,25,27, 29-32, 36-44; B - 1-4,6-10,12-16; C - 2-11,13,15,16, 18-20; D - 2-8; E - 1-5; F - 1-7,9; G - 3,4,6,8,9; H - 1-3,5; I - 1-5; J - 2; K - 1; L - 1-4; M - 2,3,5,9,11-14; N - 1,2; O - 1; P - 1-3,5,7-9; 12,15,16,20,21; R - 1; S - 5,6,9-16,18-20; T - 1-7,9-12,14; Z - 1-4.

Cz VII.5 - A - 1,3-5,7,10-15,18-20,22,25-27, 29-32, 36-44; B - 1-4,6-10,12-16; C - 2-11,13,15,16, 18-20; D - 2-8; E - 1-5; F - 1-7,9; G - 3,4,6,8,9; H - 2-5; I - 1-3,5; J - 2; K - 1; L - 1-4; M - 2,3,5,9,10-14; N - 1,2; O - 1; P - 1,3,7,9;12,15,16,20,21; R - 1; S - 5,6,13-15,18-20; T - 1-7,9-12,14; Z - 1-4.

Cz VIII. Central Plateau and Hills.

Cz VIII.1 - A - 1-4,7,10-15,18,20,22,24-27, 29-32, 36-44;
 B - 1-4,6-10,13-17; C - 2-9,11,13,15,16,18-
 20; D - 2-8; E - 2-5; F - 1-7,9; G - 3,5,9; H
 - 1-3,5; I - 1-5; J - 2; K - 1; L - 1-4; M -
 2,3,5,9-14; N - 1,2; O - 1; P - 1-3,5,7-9,14-
 16,19-21; R - 1; S - 5,6,8-13,20; T - 1-
 3,6,9,10,12,14; Z - 1-4.

Cz VIII.2 - A - 1-4,7,10,11,13,14,18,20,22,24,25,27,29-44;
 B - 1-4,6-10,12-17; C - 2-9,11,13,15,16,18-
 20; D - 2-8; E - 2-5; F - 1-7,9; G - 3-9; H -
 1-3,5; I - 1-5; J - 2; K - 1; L - 1-4; M -
 2,3,5,9-14; N - 1,2; O - 1; P - 1-3,5,7-9,14-
 16,19-21; R - 1; S - 5,6,8-13,20; T - 1-
 3,6,9,10,12,14; Z - 1,3,4.

Cz VIII.3 - A - 1,3,4,8,10,11,13,14,18,20,22,25,27,29-
 32,36-44; B - 2-4,6-10,12-16; C - 2-11,13,
 15, 16,18-20; D - 2-8; E - 1,3-5; F - 1,7,9; G -
 3-6,8,9; H - 1-3,5; I - 1-5; J - 2; K - 1; L
 - 1-4; M - 2,3,5,9-11; N - 1,2; O - 1; P - 1-
 3,5,7,9,14-16,19-21; R - 1; S - 5-15,20; T - 1-
 4,6,7,9,11,14; Z - 1,3,4.

Cz VIII.4 - A - 1,3,4,8,10,11,13,14,18,20,22,25,27,29-32,36-44; **B** - 1-4,6-10,12,14-17; **C** - 2-11,13,15,16,18-20; **D** - 2-8; **E** - 1,3-5; **F** - 1,7,9; **G** - 3-6,8,9; **H** - 1-3,5; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2,3,5,9-14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7,9,14, 16,19-21; **R** - 1; **S** - 5-13,20; **T** - 1-4,6,7,9,11, 14; **Z** - 1,3,4.

Cz VIII. 5 - A - 1,3,4,8,10,11,13,14,18,20,22,25,27,29-32,36- 44; **B** - 1-4,6-10,12,14-17; **C** - 2-11,13,15,16,18-20; **D** -2-8; **E** -1-5; **F** -1-7,9; **G** - 3-6,8,9; **H** - 1-3,5; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2-5,9-14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7,9,16,19-21;**R** -1; **S** - 5,6,8-13,20; **T** - 1-3,6,9,10,12,14; **Z** - 1,3,4.

Cz VIII.6 - A - 1,3,4,8,10,11,13,14,18,20,22,25,27,29-32,36-44; **B** - 1,3,4,6-10,12-17; **C** - 2-11,13,15,16,18 -20; **D** -2-8; **E** -1-5; **F** -1-7,9; **G** - 3-6,8,9; **H** - 1-3,5; **I** - 1-3,5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2, 3,5,9-14; **N** - 1,2; **O** - 1; **P** - 1-3,7,9,14-16,19-21; **R** - 1; **S** - 5,6,8-13,20; **T** - 1 - 3,6,9, 10,12,14; **Z** - 1,3,4.

Cz VIII.7 - A - 1,3,4,8,10,11,13,14,18,20,22,25,27,29,32,36-44; **B** - 1,3,4,6-10,12-17; **C** - 2-11,13,15,

16,18-20; **D** - 2-8; **E** - 1-5; **F** - 1-7,9; **G** - 3-6,
8; **H** - 1-5; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1,4;
M - 2,3,5, 9-14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7-
9,14-16,19,20; **R** - 1; **S** - 5,6,8-13,20; **T** - 1
- 3,6,9, 10,12,14; **Z** - 1,3,4.

Cz VIII.8 - **A** - 1-4,7,8,10,11,13-15,18,20,22,25,29,32,36-
44; **B** - 1,3,4,6-10,12-17; **C** - 2-11,13,15,16,
18 -20; **D** - 2-8; **E** - 1-5; **F** - 1-7,9; **G** - 3-6,8;
H - 1-3,5; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1,4;
M - 2,5, 9-14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7-
9,14-16,19-21; **R** - 1; **S** - 5,6,8-13,18,20; **T** -
1-4,6,7,9,12,14; **Z** - 1-4.

Cz VIII.9 - **A** - 1-5,8,10,11,13-15,20,22,25,29,30,32, 36-
44; **B** - 1,3,6-10,12-14,16,17; **C** - 1-11,
13,15, 16,18-20; **D** - 2-7; **E** - 1-5; **F** - 1-7,9;
G - 3-6,8; **H** - 1-3,5; **I** - 1-5; **J** - 2; **K** - 1;
L - 1-4; **M** - 2,5, 9-14; **N** - 1,2; **O** - 1; **P** -
1-3,5,7,9,15, 16,19-21; **R** - 1; **S** - 5,6,8-
13,18,20; **T** - 1-4,6,7,9,10-12,14; **Z** - 2,3,4.

Cz VIII.10 - **A** - 1-5,8,10,11,13-15,20,22,25,29,30,32,36-
44; **B** - 2,3,6-10,12-14,16,17; **C** - 2-10,13,15,
16,18-20; **D** - 2-7; **E** - 1-5; **F** - 1-7,9; **G** - 3-

6,8; **H** - 1-3,5; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2,5, 9-14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7,9,15, 16,19-21; **R** - 1; **S** - 5,6,8-13,20; **T** - 1-4,6,7,9 -12,14; **Z** - 1,3,4.

Cz VIII.11 - **A** - 1-5,7,8,10,11,13-15,18,20,22,25,29,30,32, 36 -38,40-44; **B** - 1,3,6-10,12-14,16,17; **C** - 2,4, 6-10,15,18-20; **D** - 2-7; **E** - 1-5; **F** - 1-7,9; **G** - 3-6,8; **H** - 1-3,5; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2,5,9,11-14; **N** - 1,2; **O** - 1; **P** - 1,2,5,7,9, 14-16,19-21; **R** - 1; **S** - 5,6,8-13,20; **T** - 1-4,6, 9-12,14; **Z** - 2,3,4.

Cz VIII.12 - **A** - 1-5,8,10,11,13-15,18,20,22,25,27,29,30, 32, 36-44; **B** - 1-3,6-10,13,14,16,17; **C** - 2,4,6-8, 13-15,18,20; **D** - 2,3,5-7; **E** - 1-5; **F** - 1-7,9; **G** - 3-6,8; **H** - 1-3,5; **I** - 3,5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2,3,5,9-12,14; **N** - 1,2; **O** - 1; **P** - 1-3, 5,7,9,14-16,19-20; **R** - 1; **S** - 5-13,20; **T** - 1-4, 6,9,11,14; **Z** - 1-4.

Cz VIII.13 - **A** - 1-5,7,10,11,13-15,18,20,22,25,29,30, 32,36-44; **B** - 1-3,6-10,13,14,16,17; **C** - 2,4,6-8,13, 18,20; **D** - 2,3,5-7; **E** - 1-5; **F** - 1-7; **G** - 3-6, 8; **H** - 1-3,5; **I** - 3,5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2,9,11,12,14; **N** - 1,2; **O** -

1; **P** - 1-3,7,9,14, 15,19-21; **R** - 1; **S** - 5,6,8-
13,20; **T** - 1-4,6,9, 11,14; **Z** - 1-4.

Cz VIII.14 - **A** - 1-5,7,10,11,13-15,20,22,25,29,30,32,36-
38, 41,44; **B** - 1,3,6-10,13,14,16; **C** - 2,4,6-
8,13, 18,20; **D** - 2,3,5,7; **E** - 1-5; **F** - 1-7; **G**
- 3-6, 8; **H** - 1-3,5; **I** - 3,5; **J** - 2; **K** - 1; **L**
- 1-4; **M** - 2,5,8,10-12,14; **N** - 1,2; **O** - 1; **P**
- 1-3,7,9, 14-16,19-21; **R** - 1; **S** - 5,6,8-
13,20; **T** - 1-4,6, 9, 11,14; **Z** - 1-4.

Cz IX Western Plateau and Hills.

Cz IX. 1 - A - 1-3,7,10,11,13-15,18-20,22,25,27,29-32,
36-44, **B** - 1-4,6-10,12-17; **C** - 1-13,15,16,18-
20; **D** - 2- 8; **E** - 1-5; **F** - 1-7,9; **G** - 1,3-9;
H - 1-3,5; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1-4;
M - 2-6,9-14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7-9,
14-16,19-21; **R** - 1; **S** - 5-15,18,20; **T** - 1-
4,6,7,9,11,12,14; **Z** - 1-4.

Cz IX. 2 - A - 1-3,7,10-15,18-22,25,27,29-44, **B** - 1-4,6-10,
12-17; **C** - 1-13,15,16,18-20; **D** - 2-8; **E** - 1-
5; **F** - 1-7,9; **G** - 3-8; **H** - 1-3,5; **I** - 1-5; **J**
- 2; **K** - 1; **L** - 1-4; **M** - 2-5,9-14; **N** - 1,2; **O**
- 1; **P** - 1-3,5,7,9,14-16,19-21; **R** - 1; **S** - 5-
20; **T** - 1-4,6,7,9-12,14; **Z** - 1-4.

Cz IX. 3 - A - 1-5,7,10-15, 18-20,22,25,27, 29-32,36-44,
B - 1-4,6-10,12-17; **C** - 1-13,15,16,18-20; **D** -
2-8; **E** - 1-5; **F** - 1-7,9; **G** - 3-9; **H** - 1-3,5;
I - 1-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2-6,9-14;
N - 1,2; **O** - 1; **P** - 1-3,5,7-9,14-16,19-21; **R**
- 1; **S** - 5-17, 20; **T** - 1-4,6,7,9,11,12,14; **Z**
- 1-4.

Cz IX. 4 - A - 1-3,7,10-15,18-22,25,27,29-32,36-44, B -
2-4,6-10,12-17; **C - 1-13,15,16,18-20; D - 2-**
8; **E - 1-5; F - 1-7,9; G - 3-9; H - 2-5; I -**
1-5; **J - 2; K - 1; L - 1-4; M - 2,5,9-14; N -**
1,2; **O - 1; P - 1-3,5,7,9,14,16,19-21; R - 1;**
S - 5,6,8-17, 20; T - 1-4,6,7,9-11,12,14; Z -
1-4.

Cz X. Southern Plateau and Hills Region.

Cz X. 1 - A - 1-3,6-8,10-15,19-22,25,27-33,36-44, B - 1-4,6-10,12-17; C - 1-11,13,15-20; D - 2- 8; E - 1-5; F - 1-7,9; G - 3-9; H - 1-3,5; I - 1,3-5; J - 2; K - 1; L - 1-4; M - 2-5,9-14; N - 1,2; O - 1; P - 1-3,5,7-9,14-16,19-21; R - 1; S - 5,6,9-20; T - 1-7,9,11,12,14; Z - 1-4.

Cz X. 2 - A - 1-3,6-8,10-15,19-22,25-44, B - 1-4,6-10,12-17; C - 1-11,13,15,16,18-20; D - 2-8; E - 1-5; F - 1-7,9; G - 3-9; H - 1-3,5; I - 3-5; J - 2; K - 1; L - 1-4; M - 2-5,9-14; N - 1,2; O - 1; P - 1-3,5,7-9,14-16,19-21; R - 1; S - 5,6,9-20; T - 1-7,9,11,12,14; Z - 1-4.

Cz X. 3 - A - 1-3,6,8,10-15,18-22,25-32,36-44, B - 1-4,6-10,12-17; C - 1-11,13,15,16,18-20; D - 2-8; E - 1-5; F - 1-7,9; G - 3-6,8,9; H - 1-3,5; I - 3-5; J - 2; K - 1; L - 1-4; M - 2-5,9-14; N - 1,2; O - 1; P - 1-3,5,7-9,14-16,19-21; R - 1; S - 5, 6,9-20; T - 1-6,9,11,12,14; Z - 1-4.

Cz X. 4 - A - 1-3,6-15,18-22,25,27-33,36-44, B - 1-4,6-10,12-17; C - 1-11,13,15,16,18-20; D - 2-8; E -

1-5; **F** - 1-7,9; **G** - 3-6,8,9; **H** - 2,3,5; **I** -
 1,3-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2-5,9-14; **N**
 - 1,2; **O** - 1; **P** - 1-3,5,7-9,14-16,19-21; **R** -
 1; **S** - 5, 6,9-20; **T** - 1-6,9,11,14; **Z** - 1-4.

Cz X. 5 - **A** - 1-3,6-15,18-22,25,27,28,30-32,36-40, **B** -
 1-4,6-10,12-16; **C** - 1-11,13,15,16,18-20; **D** -
 2-8; **E** - 1-5; **F** - 1-7,9; **G** - 3-6,8,9; **H** -
 2,3,5; **I** - 3-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2-
 5,9-14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7,9,14-
 16,19-21; **R** - 1; **S** - 5-20; **T** - 1-6,9,11,14; **Z**
 - 1-4.

Cz X. 6 - **A** - 1-3,6-8,10-15,19-22,25,27-33,36-44, **B** -
 1-4,6-10,12-17; **C** - 1-11,13,15,16,18-20; **D** -
 2-8; **E** - 1-5; **F** - 1-7,9; **G** - 3-6,8,9; **H** - 1-
 3,5; **I** - 1-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2-
 5,9-14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7,9,14-
 16,19-21; **R** - 1; **S** - 5-20; **T** - 1-7,9,11,14; **Z**
 - 1-4.

Cz XI. East Coast Plains and Hills Region.

Cz XI. 1 - **A** - 1-3,6-8,10,11,13,14,18,19-22,25-32,36-44,
B - 1-10,12-16; **C** - 1-20; **D** - 1-8; **E** - 1-5; **F**
 - 1-7,9; **G** - 1-6,8,9; **H** - 1-3,5; **I** - 3-5; **J** -
 2; **K** - 1; **L** - 1-4; **M** - 2-6,9-14; **N** - 1; **O** -
 1; **P** - 1-3,5,7-9,14,16,19-21; **R** - 1; **S** -
 5,6,8-20; **T** - 1-3,5-12,14; **Z** - 1-4.

Cz XI. 2 - **A** - 1,3,6-8,10-15,18-22,25-32,36-44, **B** - 1-
 10, 12-17; **C** - 2-20; **D** - 1-8; **E** - 1-5; **F** - 1-
 7,9; **G** - 1-6,8,9; **H** - 1-3,5; **I** - 1,3-5; **J** -
 2; **K** - 1; **L** - 1-4; **M** - 2-6,9-14; **N** - 1; **O** -
 1; **P** - 1-3,5,7-9,14,16,19-21; **R** - 1; **S** -
 5,6,8-20; **T** - 1-3,5-12,14; **Z** - 1-4.

Cz XI. 3 - **A** - 1-3,6-8,10-15,18-22,25-32,36-44, **B** - 1-
 10,12-17; **C** - 1-20; **D** - 1-8; **E** - 1-5; **F** - 1-
 7,9; **G** - 1-6,8,9; **H** - 1-3,5; **I** - 1,3-5; **J** -
 2; **K** - 1; **L** - 1-4; **M** - 2-6,9-14; **N** - 1,2; **O** -
 1; **P** - 1-3,7-9,14-16,19-21; **R** - 1; **S** - 5,6,8-
 20; **T** - 1-3, 5-12,14; **Z** - 1-4.

Cz XI. 4 - **A** - 1-3,6-15,18-22,25,27-32,36-44, **B** - 1-10,
 12-17; **C** - 1-20; **D** - 1-8; **E** - 1,3-5; **F** - 1-
 7,9; **G** - 1-6,8,9; **H** - 1-3,5; **I** - 3-5; **J** - 2;

K - 1; **L** - 1-4; **M** - 2-6,9-14; **N** - 1,2; **O** - 1;
P - 1-3,7-9,14-16,19-21; **R** - 1; **S** - 5,6,8-20;
T - 1-3,5-12,14; **Z** - 1-4.

Cz XI. 5 - **A** - 1-3,6-15,18-22,25,27,32,36-44, **B** - 1-10, 12,
 14-17; **C** - 1-20; **D** - 1-8; **E** - 1-5; **F** - 1-7,9;
G - 1-6,8,9; **H** - 1-3,5; **I** - 1,3-5; **J** - 2; **K** -
 1; **L** - 1-4; **M** - 2-6,9-14; **N** - 1,2; **O** - 1; **P** -
 1-3,7-9, 14-16,19-21; **R** - 1; **S** - 5-20; **T** - 1-
 3,5-9,11,14; **Z** - 1-4.

Cz XI. 6 - **A** - 1-3,6-15,18-22,25,27-32,36-44, **B** - 1-10,
 12-14,16,17; **C** - 1-20; **D** - 1-8; **E** - 1-5; **F** -
 1-7,9; **G** - 1-6,8,9; **H** - 1-3,5; **I** - 3-5; **J** -
 2; **K** - 1; **L** - 1-4; **M** - 2-6,9-14; **N** - 1,2; **O** -
 1; **P** - 1-3,7-9,14-16,19-21; **R** - 1; **S** - 5-20;
T - 1-3,5-12,14; **Z** - 1-4.

Cz XII. West Coast Plains and Ghat Region.

- Cz XII. 1 -** A - 1,3,4,6-8,10-15,18-22,25,27-33,36-44, B - 1-10,12-17; C - 1-20; D - 1-8; E - 1-5; F - 1-7,9; G - 1-6,8; H - 2,3,5; I - 1,3-5; J - 2; K - 1; L - 1-4; M - 2-6,9-14; N - 1,2; O - 1; P - 1-3,5, 7-9,14-21; R - 1; S - 5-15,17-20; T - 1-4,11,12, 14; Z - 1-4.
- Cz XII. 2 -** A - 1,3,4,6-15,18-22,25,27-33,36-44, B - 1-10, 12-17; C - 1-20; D - 1-8; E - 1-3,5; F - 1-7,9; G - 1-6,8; H - 2,3,5; I - 1,3-5; J - 2; K - 1; L - 1-4; M - 2-6,9-14; N - 1; O - 1; P - 1-3,5,7-9,14-21; R - 1; S - 5,6,8-13,15-20; T - 1-11,14; Z - 1-4.
- Cz XII. 3 -** A - 1,3,4,6-8,10-15,18-22,25,27-33,36-44, B - 1-10,12-17; C - 1-20; D - 1-8; E - 1-5; F - 1-7,9; G - 1-6,8; H - 1-3,5; I - 1-5; J - 2; K - 1; L - 1-4; M - 2-6,9-14; N - 1,2; O - 1; P - 1-3,5, 7-9,14-21; R - 1; S - 5,8-20; T - 1-11,14; Z - 1-4.
- Cz XII. 4 -** A - 1,3,4,6-15,18-22,25,27-33,36-44, B - 1-10, 12-17; C - 1-20; D - 1-8; E - 1-5; F - 1-7,9; G - 1-6,8; H - 2,3,5; I - 1-5; J - 2; K

- 1; L - 1-4; M - 2-6,9-14; N - 1,2; O - 1; P
- 1-3,5,7-9,14-21; R - 1; S - 5-20; T - 1-9,
11,12,14; Z - 1-4.

Cz XIII. Gujarat Plains and Hill Region.

Cz XIII.1 - A - 1-6,10,11,13-15,18,20,22,25,27,29-32,36-44, B - 1-4,6-10,12-14,17; C - 2-20; D - 2-8; E - 1-5; F - 1-7,9; G - 3-9; H - 1-3,5; I - 1,3-5; J - 2; K - 1; L - 1-4; M - 2,3,5,6,9-14; N - 1; O - 1; P - 1-3,5,7-9,14-21; R - 1; S - 5,6,8-14,17-20; T - 1-4,6-12,14; Z - 1-4.

Cz XIII.2 - A - 1-6,10,11,13-15,18,20,22,25,27,29-32,36-44, B - 1-4,6-10,12-14,17; C - 2-18; D - 2-8; E - 1-5; F - 1-7,9; G - 3-5,9; H - 1-3,5; I - 1,3-5; J - 2; K - 1; L - 1-4; M - 2,3,5,6,9-14; N - 1; O - 1; P - 1-3,5,7-9,14-21; R - 1; S - 5,6,8-14,16,17,20; T - 1-4,6-12,14; Z - 1-4.

Cz XIII.3 - A - 1-6,10,11,13-15,18,20,22,25,27,29-32,36-44, B - 2-4,6-10,12-14,17; C - 2-20; D - 2-8; E - 1, 3-6,8,9; F - 1-7,9; G - 3-9; H - 2,3,5; I - 3-5; J - 2; K - 1; L - 1-4; M - 2,3,5,6,9-14; N - 1; O - 1; P - 1-3,5,7-9,14-21; R - 1; S - 5,6,8-14,16,17,20; T - 1-4,6-12,14; Z - 1-4.

Cz XIII.4 - A - 1-6,10,11,13-15,20,22,25,27,29-32,36-44,
B - 1,6-10,12-14,17; C - 2-20; D - 2-8; E -
1-5; F - 1-7,9; G - 3-9; H - 1-3,5; I - 1,3-
5; J - 2; K - 1; L - 1-4; M - 2,3,5,6,9-14; N
- 1,2; O - 1; P - 1-3,5,7-9,14-21; R - 1; S -
5,6,9-13,15-17,20; T - 1-4,6,8,12,14; Z -
1-4.

Cz XIII.5 - A - 1-6,10,11,13-15,18,20,22,25,27,29-32,36-
44, B - 1,6-10,12-14,17; C - 2-20; D - 2-8; E
- 1-5, F - 1-7,9; G - 3-9; H - 1,3,5; I -
1,3-5; J - 2; K - 1; L - 1-4; M - 2,3,5,6,9-
14; N - 1; O - 1; P - 1-3,5,7-9,14-21; R - 1;
S - 5,6,9-13,15-17, 20; T - 1-4,6,8-12,14; Z
- 1-4.

Cz XIII.6 - A - 1-6,10,11,13-15,18,20,22,25,27-32,36-44,
B - 1-3,6-10,12-14,17; C - 2-20; D - 2-8; E -
1-5; F - 1-7,9; G - 3-5,9; H - 1-3,5; I -
1,3-5; J - 2; K - 1; L - 1-4; M - 2,3,5,6,9-
14; N - 1,2; O - 1; P - 1-3,5,7-9,14-21; R -
1; S - 5,6,9-13,15-20; T - 1-4,6-12,14; Z -
1-4.

Cz XIII.7 - A - 1,3-7,10,11,13-15,18,20,22,25,27-32,36-
44, B - 1,2,6-10,12-14,16,17; C - 2-20; D -

2-8; **E** - 1-5; **F** - 1-7,9; **G** - 3-9; **H** - 1-3; **I**
- 3-5; **J** - 2; **K** - 1; **L** - 1-4; **M** - 2,3,5,6,9-
14; **N** - 1,2; **O** - 1; **P** - 1-3,5,7-9,14-21; **R** -
1; **S** - 5,6,9-13, 15-17,20; **T** - 1-4,6-12,14; **Z**
- 1-4.

Cz XIV. Western Dry Region

Cz XIV. - **A** - 1-7,10,11,13-15,20,22,27,29-32,37,38,
41,44; **B** - 1-3,6-10,12-14,17; **C** - 2-5,13,18;
D - 2,5,8; **E** - 2-5; **F** - 1-7,9; **G** - 3,4,9; **H** -
2-5; **I** - 3,5; **L** - 3,4; **M** - 2,5,14; **N** - 1; **O** -
1; **P** - 2,,7,9,15-21; **R** - 1; **S** - 6,8,10-
12,15,20; **T** - 1-4,6,9,14; **Z** - 1-4.

Cz XV. The island Region.

(Andaman, Nicobar And Lakshadweep)

Cz XV. - A - 1-3,5-7,9-13,18-20,22,24,25,27,30-32,37-44, B - 1-10,12-17; C - 1-20; D - 1-8; E - 1-6; F - 1-7,9; G - 1-9; H - 1-3,5; I - 1-5; J - 2; K - 1; L - 1,4; M - 1-3,5,6,8-14; N - 1,2; O - 1; P - 1-3,5-9,12,15-21; R - 1; S - 1,5,6,8,15-18,20; T - 1-14 Z - 1-4.

REFERENCES

- Agarwal, M. and D.N. Rao (1983). Effect of ozone and sulphur dioxide pollutants on seed characters of rice plants. *Sci. and Cult.* 49 (c) : 177-178.
- Agrawal M. and N. Khanam (1989). *Man and His Ecosystem*. L.J. Brassier & W.C. Mulder (Eds). Proceedings of the 8th World Clean Air Congress 1989, The Hague, The Netherlands, 11-15 September 1989.
- Agrawal M. and S.B. Agrawal (1989). Phytomonitoring of air pollution around a thermal power plant. *Atmosp. Environ.* 23 : 763-769.
- Ahmad K.J.; M. Yunus; S.N. Singh; K. Srivastava; N. Singh; V. Pandey and J. Misra (1991). *Air Pollution and Plants*. CSIR News. Vol. 41 No. 15 Aug. 91.
- Alagh, Y.K. (Summary by Wadia F.K.) (1990). Agro- climatic regional planning : Overview of a new approach. *Jour. Ind. School of Political Economy.* 2 (1) : 81-111.
- Ambasht, R.S. (1970). Conservation of soil through plant cover of certain slopes in India. *Proc. IX Tech. Meeting IUCN.* pp. 44-48.
- Arya, K.P.S. (1971). *Ecophysiological and Cytogenetical Response of Certain Crop Plants to Sodium fluoride and Sulphur dioxide Toxicity*. Ph.D. thesis, B.H.U., Varanasi.
- Banerjee, A.K. and S.B. Chaphekar (1978). A significant observation on the effect of sulphur dioxide on root nodulation in *Dolichas lablab*. I. *Proc. Internatl. Symp. Environmental Agents and their biol. effect*, Hyderabad.
- Banerjee, A.K. and S.B. Chaphekar (1978). Effects of SO₂ on germination and early growth of seedlings. *Geobios*, 7:8-11.
- Bedi, S.J.; M.D. Patel, and S.J. Shah (1982). Ecomorphological and phytochemical studies to determine the pollutant and its source, causing damage to vegetation. A case study of damage to banana plantation. *Ind. J. Ecol.* 2 : 335-338.
- Bell, D.C. and S.J. Bedi (1981). Effect of industrial air pollution on the biomass and yield of *Lycopersicon lycopersicum* L. Karsten (Tomato) Winter Crop. *Proc. Silver Jub. Symp. of VIISTE*, Bhopal.
- Bennett, J.H. and A.C. Hill (1973). Absorption of gaseous air pollutants by a standardized plant canopy. *J. Air. Pollut. Contr. Ass.* 23 : 203-206.
- Bennett, J.H. and A.C. Hill (1975). Interaction of air pollutants with canopies of vegetation. In : J.B. Mudd and T.T. Kozlowski (eds) *Response of Plants to Air Pollution*. Academic press, New York, 273-306.

Bhairavmurthy, P. V. and P.V. Kumar (1983). Air pollution and epidermal traits of *Calotropis gigantea* (L) R. Ind.J.Air.Pollut. Contr.1 : (1&2). 23-26.

Bhatia, Roop Rekha (1978). Effect of Fly-ash on Plant growth. M.Phil. Thesis, J.N.U.New Delhi.

Boralkar, D.B. and S.B. Chaphekar (1978). Sulphur dioxide effects on Jawar - *Sorghum vulgare* Var. CSH-1. Proc. Symp. Environ. Biol. Muzaffarnagar, 361-366.

Boralkar, D.B. and S.B. Chaphekar (1980). Effects of atmospheric pollution due to a glass industry on plants in Kera, Maharashtra.

Boralkar, D.B. and S.B. Chaphekar (1980). Nature of sensitivity of plant species to sulphur dioxide. Current Ecol.Res.in India.

Boralkar, D.B. and S.B. Chaphekar (1981). Effects of sulphur dioxide on sunhemp *Crotalaria juncea* L. Geobios, 8 : 236-237.

Boralkar, D.B. and S.B. Chaphekar (1983). Foliar injury to *Trigonella foenum graecum* due to sulphur dioxide exposure. Ind. J. Air. Pollut.Contr.4 :

Boralkar, D.B. and D.B. Shinde (1983). Effects of sulphur dioxide and ozone singly and in combination, on germination and chlorophylls of *Abelmoschus esculantus* Var. pusa savani. j. Environ. Biol. 4 : 99-102.

Bradshaw, A.D. and M.J. Chadwick (1980). The Restoration of Land. Blackwell Scientific. pp. 317.

Brennan, E.; I.A. Leone, and R.H. Daines (1965). Chlorine as Phytotoxic air pollutant. Int. J. Air Water Pollut. 9 : 791-797.

Carter, D.B. (1954). Climates of Africa and India according to Thornthwaite's (1948) Classification John Hopkins University Publication (in) Climetology, 7 (4).

Chadwick, R.C. and A.C. Chamberlain (1970). Field loss of radionuclides from grass. Atmospheric Environment 4, 51-56.

Chamberlain, A. C. (1970). Interception and retention of radioactive aerosols by vegetation, Atmospheric Environment, 4, 57-78.

Chamberlain, A.C. (1953). Aspects of travel and deposition of Aerosol and Clouds, A.E.R.E. Report H.P. 1261, Atomic Energy Research Establishment, Harward, Berks, U.K.

Chaphekar, S. B. (1972). Effect of atmospheric pollutants on plants in Bombay. J. Biol. Science. 15 : 1-6.

- Chaphekar, S.B. and M.R. Karbhari (1974). Sulphur dioxide injury to plants : some experiments. *Geobios*, 1 : 141-142.
- Chaphekar, S.B. (1979). An evidence of high pollution level in Chembur. *Scavenger* 9 : 22-25.
- Chaphekar, S.B. and D.B. Boralkar (1979). Effects of gaseous ammonia on plant growth and protection. *Ind. J. Air. Pollut. Contr.* 2 : 19-23.
- Chaphekar, S.B.; D.B. Boralkar, and R.P. Shetye (1980). Effects of Industrial Pollutants on Plants. Final Report of UGC sponsored project.
- Chaphekar, S.B.; V. Bhavani Shankar, and F.A. Poonawala (1986). Plantation in disturbed habitats. In : *Plantation Crops*. Vol.II : 171-174. Oxford & IBH.
- Chaphekar, S.B.; V. Bhavanishankar and F.A. Poonawala. *Plantation Crops* (Ed.) 171-174.
- Chaphekar, S.B. (1989). Revegetation of Zn-Pb Mine Tailings. Final Report to Sponsors.
- Cholak, J. (1952). The nature of the atmosphere in a number of industrial communities. *Proc. 2nd Nat. Air Pollut. Symp.* Stanford. Res. Inst. Los Angeles, Calif.
- Chowdhury, A.; H.P. Das and S.S. Singh (1993). Agro- climatic Classification of India *Mausam*, 44 (1) : 53- 60.
- Das, T.M. and P. Pattanayak (1978). Dust filtering property of green plants and the effect of air borne particles on growth and yield. pp. 224-234. In: *Proceedings of the Internat. Symp. Environmental Agents and their biol. effects.* Hyderabad.
- Das, T.M. (1981). Plants and Pollution. Presidential address in Section of Agricultural Sciences. Indian Sc. Cong. Ass. Meeting, B.H.U. Varanasi.
- Das, T.M.; A. Bhaumik; A. Ghosh, and A. Charkraborty (1981). Trees as dust filters. *Science Today*, 19 : 19-21.
- Davis, D.D. (1975). Variable tree response due to environmental factors climate. In : W.H. Smith and L.S. Dochinger (Eds.), *Air Pollution and Metropolitan Woody Vegetation.* U.S.D.A. Forest Service. PIEFR - PA-1, Upper Darby, Pennsylvania, 14-16.
- Dubey, P.S.; K. Pawar; S.K. Shringi, and L. Trivedi (1982). Effects of fly ash deposition on photosynthetic pigment and dry weight production of Wheat and Gram. *Agro. Ecosystem* 8 : 137-140.
- Dubey, P. S.; L. Trivedi, and S.K. Shringi (1982) - Pollution studies of Betul forest area due to Satpura Thermal Power Station aerial discharge. Final report. DOE project no.19/27/78. *Env.* 53.

Environmental Health Science Centre (1975). The role of plants in environmental purification. Oregon State University, Corvallis, Oregon, 53.

Evans, D.W. and J.P. Giesy (Jr) (1979). Trace metal concentrations in stream swamp system. In : Ecology and Coal Resource Development (ed) Mohan K. Wali, Vol.2. 782-790.

Flemming, G. (1967). When can forest belts reduce the emissions concentration? Luft and Kaeltechnik. 6, 255-258.

Fulekar, M.H. and J.M. Dave (1990). Environmental Impact Assessment of Fly-Ash from Coal-Fired Power Plants. Encology, Vol. 4, No. 8, pp. 25-34.

Ganguli A.K. (1976). A proposal for a national Programme of development of perennial green envelope and large scale afforestation. Scavenger 6 : 8-17, Bombay.

Garg, K.K. and C.K. Varshney (1980). Effect of air pollution on the leaf epidermis at submicroscopic level. Experintia, 36 : 1364-1366.

Ghouse, A.K.M. and F.A. Khan (1983). Growth responses of Melilotus alba L. to air pollutants emerging out of coal burning. Geobios, 10 : 227-228.

Gupta, V.K. and R.K. Kapoor (1985). Reducing the consequences of reactor accidents, with a green belt. Nuclear Technology, 70,2, : 204-214.

Gupta V.K. and R.K. Kapoor (1992). Attenuation of air pollution by green belt - Optimisation of density of tree plantation. Conference on Precipitation Scavenging and Atmosphere Surface Exchange, Washington D.C., U.S.A.

Halbwachs, G. (1983). Effects of air pollution on vegetation. In : W. Holzner, M.J.A. Werger and I. Ikusimaa (eds.) Man's Impact on Vegetation. Dr.W.Junk Publishers, London, 55-67.

Hanson, G.P. and L. Thorne (1970). A partial pollution solution - plant trees. Lasca Leaves 20 : 35-36.

Hill, A.C. (1971). Vegetation : A sink for atmospheric pollutants. J. Air pollution control Assoc. 21 : 341-346.

Hill, A.C. and E.M. Chamberlain, Jr. (1974). The removal of water soluble gases from the atmosphere by vegetation. Atmospheric surface. Exchange of Particulate and Gaseous pollutants symp. Richland, Washington, Sept. 4-6, 1974, 12 pp.

Hukkoo et al (1988). Manual of dose evaluation from atmospheric releases, Bhabha Atomic Research Centre, BARC - 1412, Bombay.

IAEA (International Atomic Energy Agency) Safety Guide, Safety Series No. 50-SG-S3 (1980), Atmospheric Dispersion in Nuclear Power Plant Siting.

IAEA - TEA DOC - 379 (1986) Atmospheric Dispersion Models for Application in Relation to Radionuclide Releases.

Jafri, S.; K. Srivastava, and K.J. Ahmed (1979). Environmental pollution and epidermal structure in *Syzygium cumini* L. Skeel. *Indian J. Air Pollut. Contr.* **2** : 74-77.

Jha, A.K. and J.S. Singh (1944). Rehabilitation of mine spoils with particular reference to multipurpose trees in agroforestry systems for sustainable land use Ed. Punjab Singh, P.S. Pathak, and M.M. Roy. Oxford and IBH publishers. : 237-250.

Juwarkar, A.S.; V.P. Thergaonkar; A.S. Malhotra, and Animesh Kumar (1989). Reclamation of mined land and mine spoil using sewage sludge and soil. *Natl. Sem. Protection of Environ. and Ecol by Mining Ind., Panjim.* Vol. I : 396-408.

Kalyushnyi, Y. et al, (1952). Effectiveness of sanitary clearance zones between industrial enterprises and residential quarters. *Giceniai sanit* **4** : 179.

Kapoor R. K. and V.K. Gupta (1984). A pollution attenuation coefficient concept for optimisation of green belt. *Atmospheric Environment* **18** : 1107-1113.

Keller, T. and H. Schwager (1977). Air pollution and ascorbic acid. *Eur. J. Forest Pathol.* **7 (6)** : 338-350.

Keller T. (1978). How effective are forests in improving air quality? Eight World Forestry Conference, Jakarta, Indonesia, 1978, pp. 9.

Kellogg, W.W.; R.D.Cadle; E.R. Allen; A.L. Lazarus, and E.A. Martell (1972). The Sulphur Cycle. *Science* **175** : 587-596.

Knabe, W. (1976). Effects of sulphur dioxide on terrestrial vegetation, *Ambio.*, **5** : 213-218.

Krishnan, A. (1988). Delineation of soil climatic zones of India and its practical application in agriculture fertilizer *News*, **33 (4)** : 11-19.

Kumar, S. and C.B. Prakash (1978). Sulphur dioxide : The major gaseous pollutant. *Ind. J. Air. Pollut. Control*, **1** : 102-109.

Kumar, S. and S.N. Upadhyay (1983). Atmospheric emissions from thermal power plants in India. In : *Proceedings of symposium of Air Pollution Control, India.* 119-131.

Linzon, S.N. (1978). Effects of airborne sulfur pollutants on plants. In : J.O. Nriagu (Ed.), *Sulfur in the Environment : Part II, Ecological Impacts.* Wiley, New York, 109-162.

McMohan, T.A. and P.J. Denison (1979). Empirical atmosphere deposition parameters - a survey, *Atmospheric Environment*.

Meenakshy, V.; T.N. Mahadevan, and U.C. Misra (1981). Nature and extent of biomagnification of fluoride in forage around a phosphate fertilizer plant. Proc. Biol. Ind. Env. Pollut. pp 9.

Mishra, L. C. (1980). Effect of sulphur dioxide fumigations on ground nut, *Arachis hypogea* L. Environ and Expt. Bot. 20 : 397-400.

Mudd, J.B. (1973). Biochemical effects of some air pollutants on plants. In J.A. Naegele (Ed.) Air Pollutants damage to vegetation. Adv. Chem. Series. No.122, Amer. Chem. Soc., Washington D.C., pp. 31-47.

Murthy, M.S.R.; O. Bhagyalakshmi; S.H. Raza, and A. Ahmad (1991). A new Method for Evaluating Sulfur Dioxide Tolerance of Certain Trees. Intern. J. Environmental Studies. Vol. 39, pp. 85-94.

National Academy of Sciences (1977 a). Ozone and other Photochemical Oxidants. National Academy of Sciences. Washington, D.C., pp. 717.

National Academy of Sciences (1977 b). Effects of nitrogen oxides on vegetation. In : Nitrogen Oxides. NAS, Washington D.C., pp. 147-158.

Painter, D.E. (1974). Air pollution technology. Mc Graw Hill publishers.

Pandey, R.N. and S.D. Vaidya (1976). Plants and pollution. Scavenger 6 : 8-14.

Pandey, G.P. (1979). Eco - Physiological Responses of Plants to Gaseous Hydrogen fluoride Pollution. Ph.D. Thesis, B.H.U., Varanasi.

Pandey, G.P. and D.N. Rao (1980). HF induced effects and their amelioration by $\text{Ca}(\text{OH})_2$ solution in *Gladiolus* plants. Beitr. Biol. Pflanzen 55 : 119-128.

Pandey, S.N. and D.N. Rao (1979). Eco-physiological investigation of sulphur dioxide pollution effects on Soybean. Proc. Symp. Environ. Biol. 173-182.

Pandey, V.; J. Misra; S.N. Singh; N. Singh; M. Yunus and J. Ahmad (1994). Growth response of *Helianthus annuus* L Grown on fly-ash Amended soil J. Environ. Biol. 15 (2) : 117-125.

Pawar, K.; L. Trivedi, and P.S. Dubey (1982). Comparative effects of cement, coal, dust and fly - ash on *Abelmoschus exculantus*. Inter. J. Env. studies 19 : 221 - 223.

Pawar, K. and P.S. Dubey (1982). Growth response of wheat cultivar N-14 to fly ash incorporated black cotton soil. All India seminar on Air pollution, 19-21. April. Indore.

Pawar, K. and P.S. Dubey (1983). Effects of atmospheric pollutants on the morphology and pigment content of *Mangifera indica* L. Proc. VI World Congr. Air Quality. Paris, pp. 501-507.

Pawar, K.; L. Trivedi, and P.S. Dubey (1983). fly ash deposition and productivity measurements in beans. *Ind. J. Air. Pollut. contr*, **5** : 18-20.

Pieser, G.D. and S.F. Yang (1978). Chlorophyll destruction in the presence of bisulfite and linoleic acid hydroperoxide. *Phytochem.*, **17** : 79-84.

Prasad, B.J. and D.N. Rao (1979). Influence of Nitrogen dioxide (NO₂) on photosynthetic apparatus and net primary productivity of wheat plant. *Acta. Bot. Indica*. **7** : 16-21.

Prasad, B.J.(1980). Phytotoxicity of petroleum refinery air pollutants. Ph.D. Thesis, B.H.U., Varanasi.

Prasad, B.J. and D.N. Rao (1981). Growth responses of Phaseolus aureus plants to petro-coke pollution, *J. Expt. Bot.* **32** : 1343-1350.

Prasad, B.J. and D.N. Rao (1982). Relative sensitivity of a leguminous and a cereal crop to sulphur dioxide pollution. *Environ. Pollut. Ses. A*. **29** : 57-70.

Rao, D.N. and F. Leblanc (1966). Effects of sulphur dioxide on the lichen algae, with special reference to chlorophyll. *Bryologist*, **69** : 60-75.

Rao, D.N. (1971). A study of air pollution problem due to coal unloading in Varanasi, India. pp : 273-276. In *Proceeding of Second International Air Congress* (Eds. M.M. Englend and G.T. Beny), Academic Press, New York.

Rao, D. N. (1972). *Mangifera indica*, a bioindicator of pollution in the tropics. *Proc. 22nd Int. Geog. Cong. Montreal*, p. 272.

Rao, D.N. and O. Pal (1978). Effect of hydrogen fluoride on growth and yield of corn. (*Zea mays*) In : *Glimpses of Ecology*, Ed. J.S. Singh and B. Gopal. International Scientific Publications. Jaipur, India, 461-470.

Rao, D.N. (1979). Plants as a pollution monitoring device. *Fertiliser News*. **24** : 25-28.

Rao, D.N.; R.S. Srivastav; R.S. Rai; P. Jain; B.J. Prasad; S.K. Singh; M. Agarwal; V. Singh, and P.K. Nandi (1983). To Study the Relative Susceptibility of Saplings of Some Common Fruit and Avenue Trees to Sulphur diokide Pollution. Final Tech. Report of UGC sponsored research project Nc. F-23-115/79 (SR II) 29.

Rao D.N., M. Agrawal, J. Singh (1990). Study of Pollution Sink Efficiency. Growth Response and Productivity Pattern of Plants with Respect to Fly-ash and SO₂. Final Tech. Report of MAB project DOE / 14 /256 / 85-MAB/RE.

Raynor G. S.; J.V. Hayes, and E.C. Ogden (1974). Particulate dispersion into and within a forest. *Boundary - Layer Met.* **7** : 429-456.

Raza, S.H.; M.S.R. Murthy, and A. Ahmed (1988). Foliar sulfate content in certain tropical trees under low levels of SO₂. *Air Pollution and Forest Decline* (J.B. Bucher & I. Bucher

Wallin, eds.) Proc.14th Int. Meeting for specialists in Air Pollution Effects on Forest Ecosystems, IUFRO P₂ 05, Interlaken, Switzerland, Oct. 2-8, 1988. Birmensdorf, 1989, pp. 105-109.

Raza, S.H.; M.S.R. Murthy; O. Bhagylakshmi and G. Shylaja (1990-91). Effect of vegetation on urban climate and healthy urban colonies. Energy and Buildings. 15-16 (1990-91) : 487-491.

Raza, S.H.; G. Shylaja (1992). Studies of tolerance of certain succulent plants to ambient air sulfurdioxide levels in urban environments of a city in India. A New Approach. Intern. J. Environmental Studies. Vol. 42 : 301-318.

Roberts, B.R. (1974). Foliar sorption of atmospheric sulphur dioxide by woody plants.. Environ. Pollut. 7 : 133-140.

Seiler, W. (1974). The cycle of atmospheric CO. Tellus 26 : 116-135.

Sharma, H.C. (1981). Plant Responses to Sulphur-dioxide and Hydrogen fluoride Air Pollutants. Ph.D. Thesis, B.H.U., Varanasi.

Shetye, R.P. (1979). Investigations of Responses of Some Common Plants to Air Pollution. M.Sc thesis. University of Bombay.

Shetye, R.P. and S.B. Chaphekar (1980). On measurement of dustfall with plants. pp. 205-213. in Proc. Sem. Management of Environment, BARC, Bombay. (Ed.) Patel. B.

Singh, S.N and D.N. Rao (1978). Possibilities of using chlorophyll and potassium contents in plants to detect cement dust pollution. J. IPHE, India, 1 : 10-13.

Singh. N and D.N. Rao (1979). Studies of the effect of sulphus dioxide on alfafa plants especially under conditions of natural precipitation. I. Changes pertaining to growth pattern , phytomass accumulation and productivity in plants. Indian J. Air Pollut. Contr. 2 : 55-69.

Singh, N. and D.N. Rao (1980). Growth responses of wheat plant to cement dust polluted environment. Proc. Indian Natl. Sci. Acad. 3 : 325-320.

Smith, W.H. (1981). Air Pollution and Forests Interactions between Air Contaminants and Forest Ecosystems. Springer-Verlag New York.

Smith, W.H. and L.S. Dochinger (1976). Capabilites of metropolitan trees to reduce atmospheric contaminats. In : H. Gerhold, F. Santamor and S. Little (Eds.) Proc. Better Trees for Metropolitan Landscapes, U.S.D.A., Forest Service, Gen. Tech. Report No. NE-22, Upper Darby, Pennsylvania, pp. 49-59.

Sreeranga swamy, S.R.; O. Padmanabhan; R. Jambulingam, and M. Gurunathan (1973). Effect of cement dust on plant ecotypes. Madras agric I. 60 : 1776.

- Srivastava, K.; S. Jafri, and K.J. Ahmed (1980). Effect of Air pollution on epidermal features of *Tabernaemontanacoronaria*. Willd. *New Botanist*, 167- 170.
- Sutton, O.G. (1953). *Micrometeorology*, McGraw Hill Book Co. Inc.
- Tandon, G.L. (1989). Planning for sustained mineral development by 2001 A.D. Proc. Sem. Protection of Environment and Ecology by Mining Industry. Panjim. Vol. 1, 15-45.
- Taylor, O.C.; C.R. Thompson; D.T. Tingey, and R.A. Reinert (1975). Oxides of nitrogen. In : J.G. Mudd and T.T. Kozlowski (Eds.), *Responses of Plants to Air Pollution*. Academic Press, New York, pp. 121-139.
- Treshow, M. (1970). *Environment and Plant Response*. Mc Graw Hill, New York.
- Vaishnavi, M. L. (1975). Pollutants and plants. *Scavenger*, 5 : 8-9.
- Varshney, C.K. and S.R.K. Varshney (1979). Effects of sulphur dioxide on pea seedlings. *Indian J. Air pollut. Contr.* 2 : 47-49.
- Varshney, C.K. Use of sulphur content in *Nerium indicum* for monitoring sulphur dioxide pollution in Delhi.
- Varshney, S.R.K. and C.K. Varshney (1981). Effect of sulphur dioxide on pollution generation and pollen tube growth. *Environ. Pollut. Ser. A* 24 : 87-92.
- U.S. Environmental Protection Agency (1976). *Diagnosing Vegetation Injury Caused by Air Pollution*. U.S.E.P.A., Washington, D.C.
- U.S. EPA (1978). *Guideline on air quality models*. OAQPS guideline series no. 1.2-080, EPA-450/2-78-027.
- Warren, J.L. (1973). *Green space for air pollution control*. N.C. State University Sch. for Resour. Tech. Rep. 50. Raleigh N.C.
- Wash - 1400 (1975). *Reactor safety study : An assesment of accident risks in U.S. commercial nuclear power plants*, Appendix - VI, U.S. Nuclear Regulatory Commission, Report NUREG - 75/014, National Technical Information Service.
- Weinstein, L.N. (1977). Fluoride and plant life. *J. Occupa. Med.* 19 : 49-78.
- Winner, W.E. and H.A. Mooney (1980). Ecology of SO₂ resistance II. photosynthetic changes of shrubs in relation to SO₂ absorption and stomata behaviour. *Oecologia (Berlin)*, 44 : 296-302.
- Yunus M. and K.J. Ahmad (1979). Use of epidermal traits of plants in pollution monitoring. Proc. of Nat. Sem. on Environ. Pollut. and Its Control. A Status Review. National Productivity Council, Bombay.

Yunus, M and K.J. Ahmed (1980). Effect of air pollution on leaf epidermis of *Psidium guava* L. *Indian J. Air. Pollut. Contr.* **3** : 62-67.

Yunus, M. and K.J. Ahmad (1981). Changes in cuticular and epidermal features of *Calotropis procera* (Ascl. epiadaceae) due to air pollution. *J. Biol.* **10** (2 and 3) 275-282.

Yusuf, M. and L.N. Vyas (1982). Effect of cement dust pollution on some selected plant species growing around udaipur cement works, Bajaj Nagar, Udaipur. Presented at the All India Seminar on Air pollution, April, 1982, Indore.

Zeevart, A.J. (1976). Some effects of fumigating plants for short periods with NO_2 . *Environ. Pollut.* **11** : 97- 108.

Some of the Important Literature in the subject referred

In addition to the Reference List, the following were offered extensively as sources of information.

Air Pollution and Plants; A State-of-The-Art-Report. Ed. Subramanyam G.V.; D.N. Rao; C.K. Varshney and D.K. Biswas; Ministry of Environ. and Forests, Govt. of India. 1985 pp. 193.

Effects of Air Pollutants on Plants Ed. T.A. Mansfield. Society for Experimental Series 1, Cambridge Univ. Press, 1976.

Flora of Eastern Karnataka. Vol. I, II by N.P. Singh, Mittal Publ. Delhi, 1988 pp. 794.

Flora of Coibatore. M. Chandrabose and N.C. Nair, Publ. Bishan Singh Mahaendral Pal Singh Dehradun, 1988 pp. 398.

Flora of the Presidency of Bombay by Theordore Cooke. Vol. I, II, III. pp. 1-649. Publ. by BSI, Calcutta 1901, 1902, 1903.

Glossary of Indian Medicinal Plants. R.N. Chopra, S.L. Nayar; I.O. Chopra. CSIR New Delhi, 1956 pp. 329.

Indian Medicinal Plants. Vol. I, II by K.R. Kirtikar, B.D. Basu, Published by Sudhindra Nath Basu, 1918 pp. 1419.

Name changes in Flowering Plants of India and adjacent regions. SSR Bennet; Triseas Publishers, Dehradu, 1987 pp. 772.

Presepectives in Botanical Museums with Reference to India. V.S. Agarwal; Today and Tommorrow's Publ. New Delni, 1983.

Trees for Drylands Ed. By Drake Hocking Publ. by Mohan Primalani Oxford IBH New Delhi.