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Van Sangyan

Note to Authors:

We welcome the readers of Van Sangyan to write to us about their views and issues in forestry. Those who wish to share their knowledge and experiences can send them:

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or, through post to The Editor, Van Sangyan,
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PO-RFRC, Mandla Road,
Jabalpur (M.P.) - 482021.

The articles can be in English, Hindi, Marathi, Chhattisgarhi and Oriya, and should contain the writers name, designation and full postal address, including e-mail id and contact number.

TFRI, Jabalpur houses experts from all fields of forestry who would be happy to answer reader's queries on various scientific issues. Your queries may be sent to The Editor, and the expert's reply to the same will be published in the next issue of Van Sangyan.

Cover Photo: Panoramic view of Achanakmar-Amarkantak Biosphere Reserve
Photo credit: Dr. N. Roychoudhury and Dr. Rajesh Kumar Mishra, TFRI, Jabalpur (M.P.)

From the Editor's desk

The biosphere reserves (BRs) of India are the repository of biodiversity as well as the abode of many traditional societies. Such traditional societies derive many of their livelihood requirements from the rich biodiversity around them. All the more, the BRs also contribute to food security of the people within their premises. Many of the forest-linked activities of the traditional societies are mediated through rich traditional ecological knowledge. Unfortunately, while the issues of biodiversity have been addressed at length, the cultural diversity has been relegated to the point of oblivion. The BR management, therefore, necessitates understanding not only of ecological issues, but also socio-economic and cultural issues linked with the former.

The concern for the protection and promotion of conservation led to the formulation and adoption of many measures. The initial approach to promote conservation has followed the 'hands off' philosophy by setting aside areas (now known as protected areas) at the cost of people who have depended on the rich biodiversity of the same for centuries.

The concept of protected areas (PAs) for the conservation of wild species of fauna and flora has changed drastically since the establishment of the Yellowstone National Park in the United States of America in 1872. It was the world's first national park. Here and in other areas, wildlife was protected against people. Central to this concept was the approach of non-interference, and public access to enjoy nature. It has been subsequently realised that in most parts of the world (particularly in the developing countries), PAs are neither completely insular nor isolated pieces of habitat. They have human habitation inside them that continues to eke out a living from these areas. All the more it was realised that the 'hands off' concept is not uniformly applicable and in many parts of the world, it has not worked.

Subsequently, it was recognised that the ideal approach for conservation is to preserve the health of the overall ecosystem, including diversity of species. It can be best accomplished by integrating it into the fabric of social, environmental and economic canvas. Under this ecosystem approach, man and environment are integrated together for a better future for all the living being. These considerations led to the origin of the concept of biosphere reserve (BR). The initiation of BRs goes back to the 'Biosphere Conference' organised by the UNESCO in 1968. This was the first inter-governmental conference examining as how to reconcile the conservation and use of natural resources, thereby foreshadowing the present-day notion of sustainable development. This conference resulted in the launching of the 'Man and the Biosphere' (MAB) Programme of UNESCO in 1970. It aimed to facilitate resolution of increasing conflict between the people and protected areas.

BRs, today, are addressing perhaps the biggest challenge in conservation, and, that is, how best to conserve biodiversity, while still meeting the needs of local communities in a socially and culturally sensitive manner. The idea to develop this 'non conventional' PA first took shape in 1974, within the framework of UNESCO's international research programme on MAB.

In line with the above this issue of Van Sangyan contains an article on Biosphere reserves - Holistic tool for biodiversity conservation. There are also useful articles viz.. Potential of intact forest landscape in mitigating climate change, Soil and water conservation on the growth of planted species in skeletal soil – some case studies, Conservation of Tecomella undulata – a threatened tree of multipurpose values, Chir pine defoliator, Cryptothelia crameri and its control measures, Carbon dioxide fix model: An essential tool for estimation of carbon sequestration potential of agroforestry system and Solid waste and their management

I hope that readers would find maximum information in this issue relevant and valuable to the sustainable management of forests. Van Sangyan welcomes articles, views and queries on various such issues in the field of forest science.

Looking forward to meet you all through forthcoming issues

Dr. Naseer Mohammad
Chief Editor

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Contents **Page**

1. **Biosphere reserves - Holistic tool for biodiversity conservation** 1
- Satish C Garkoti, Ritesh Joshi and Kanchan Puri

2. **Potential of intact forest landscape in mitigating climate change** 7
- Nahid Khan

3. **Soil and water conservation on the growth of planted species in skeletal soil – Some case studies** 13
- Saikat Banerjee, Avinash Jain and P. K. Shukla

4. **Conservation of Tecomella undulata – a threatened tree of multipurpose values** 21
- Sanjeev Kumar Chauhan, Sapna Thakur and Harmeet Singh Saralch

5. **Chir pine defoliator, Cryptothelia crameri and its control measures** 25
- N. Roychoudhury and Rajesh Kumar Mishra

6. **Carbon dioxide fix model: An essential tool for estimation of carbon sequestration potential of agroforestry system** 27
- Bhalawe, Shailendra, Kathal, D., Thakur, R.K., Shrivastava, P.K. and Bisen, Uttam

7. **Solid waste and their management** 32
- Rekha Agarwal

Biosphere reserves - Holistic tool for biodiversity conservation

Satish C Garkoti, Ritesh Joshi and Kanchan Puri

Ministry of Environment, Forest and Climate Change
New Delhi 110003
Email: genetics_1407@yahoo.co.in

India, with 2.4% of the world's area, has over 8% of the world's total biodiversity, making it one of the 12 mega-diversecountries in the world. However disappearance of species due to habitatalteration, overexploitation, pollution, global climatechange and invasion of exotic species are threatening the biodiversity of the country. In this context "Biosphere reserves" are the most effective tool in form of 'in situ' conservation of biodiversity. This term Biosphere reserves (BR) is an international designation given by UNESCO for representative parts of natural and cultural landscapes extending over large area of terrestrial or coastal/marine ecosystems or a combination thereof.

BRs are designated to deal with oneof the most important questions of reconciling the conservation of biodiversityinvolving local communities and all interested stakeholders in planning and management, the quest foreconomic and social development and maintenance of associated cultural values. They arethus special environments for both people and the nature and are living examples ofhow human beings and nature can co-exist while respecting each others' needs. These areas are internationally recognized within the framework of UNESCO's Manand Biosphere (MAB) programme, after receiving consent of the participating country. TheBiosphere reserves are nominated by national governments and remain under the sovereign jurisdiction of the states where they are located. The three main "functions" of BRs are:

- Conservation of biodiversity and cultural diversity
- Economic development that is socio-culturally and environmentally sustainable
- Logistic support, underpinning development through research, monitoring, education and training

BRs comprises of 3 interrelated zones that aim to achieve three complementary functions. 1) The Core zone which is the centrally located protected area (981 protected areas in India) comprising of National Park / Sanctuary / protected mostly under the Wildlife (Protection) Act, 1972. 2) The Buffer zone which is a natural corridor between the core zone and the transition zone for activities with sound ecological practices including restoration, eco-tourism, scientific research and training. 3) The third zone is transition zone wherein Socio-economic development which are socio-culturally and ecologically sustainable are permitted. Thus, biosphere reserves functions by integrating biological and cultural diversity, within the natural ecosystem, particularly by promoting the role of traditional knowledge in enhancing ecosystem management via sustainable practices.

Protected Areas of India

	No.	Total Area (km^2)	Coverage % of Country
National Parks (NPs)	104	43,716	1.33
Wildlife Sanctuaries (WLSs)	566	1,22,420	3.72
Conservation Reserves (CRs)	97	4,483	0.14
Community Reserves	214	1,302	0.04
Protected Areas (PAs)	**981**	**1,71,921**	**5.03**

(Source: http://www.wiienvis.nic.in)

Man and Biosphere (MAB) Programme

The MAB programme is an intergovernmental scientific programme that aims to establish a scientific basis for enhancing the relationship between people and their environments. It combines the natural and social sciences with a view to improving human livelihoods and safeguarding natural and managed ecosystems, thus promoting innovative approaches to economic development that are socially and culturally appropriate and environmentally sustainable.

Under MAB, there is a World Network of Biosphere Reserves (WNBR) which consists of a dynamic and interactive network of sites of excellence. It fosters the harmonious integration of people and nature for sustainable development through participatory dialogue; knowledge sharing; poverty reduction and human well-being improvements; respect for cultural values and society's ability to cope with change - thus contributing to the 2030 Agenda and the Sustainable Development Goals (SDGs).

MAB's mission for the period 2015–2025 is to:

- Develop and strengthen models of sustainable development through the WNBR;
- Communicate experiences and lessons learned, and facilitate the global diffusion and application of these models;
- Support evaluation and high-quality management of biosphere reserves, strategies and policies for sustainable development and planning, and accountable and resilient institutions;
- Help Member States and stakeholders to achieve the Sustainable Development Goals by sharing experiences and lessons learned related to exploring and testing policies, technologies and innovations for the sustainable management of biodiversity and natural resources and mitigation and adaptation to climate change.

Status of Biosphere Reserves In India

BRs are representative examples of natural biomes in Bio-geographic zones. In India there are 10 bio-geographic zones based on the topography, namely 1. Trans Himalayan, 2.Himalayan, 3.Desert, 4.Semi-Arid, 5.Western Ghats, 6.Deccan Penninsula, 7.Gangetic Plain, 8.North-East India, 9.Islands and 10.Coasts.

Ministry of Environment, Forest and Climate Change (MoEF & CC) initiated Biosphere Reserve programme and established its first Biosphere Reserve (Nilgiri) in 1986. Till date, India has designated 18 Biosphere Reserves nationally. And so far only 12 Biosphere Reserves, viz., Nilgiri, Gulf of Mannar, Sundarbans, Nanda Devi, Pachmarhi, Similipal, Nokrek, Achanakmar-Amarkantak, Great Nicobar, Agasthyamala, Khangchendzonga and Panna have been included in the list of the World Network of Biosphere Reserves of UNESCO.

List of 18 BRs in India which are as follows

Sl. No	Name of the Biosphere Reserve	Location in the State (s)/Union Territory
1	Nilgiri Biosphere Reserve	Part of Wyanad, Nagarhole, Bandipur and Mudumalai, Nilambur, Silent Valley and Siruvani hills in Tamil Nadu, Kerala and Karnataka.
2	Nanda Devi Biosphere Reserve	Part of Chamoli, Pithoragarh and Almora districts in Uttarakhand.
3	Nokrek Biosphere Reserve	Part of East, West and South Garo Hill districts in Meghalaya.
4	Manas Biosphere Reserve	Part of Kokrajhar, Bongaigaon, Barpeta, Nalbari, Kamprup and Darang districts in Assam.
5	Sundarban Biosphere Reserve	Part of delta of Ganges & Brahmaputra river system in West Bengal.
6	Gulf of Mannar Biosphere Reserve	India part of Gulf of Munnar extending from Rameswaram island in the North to Kanyakumari in the South of Tamil Nadu.
7	Great Nicobar Biosphere Reserve	Southernmost island of Andaman and Nicobar Islands.
8	Similipal Biosphere Reserve	Part of Mayurbhanj district in Orissa.
9	Dibru-Saikhowa Biosphere Reserve	Part of Dibrugarh and Tinsukia districts in Assam.
10	Dehang-Dibang Biosphere Reserve	Part of Upper Siang, West Siang and Dibang Valley districts in Arunachal Pradesh.
11	Pachmarhi Biosphere Reserve	Part of Betul, Hoshangabad and Chhindwara districts in Madhya Pradesh.
12	Khangchendzonga Biosphere	Part of North and West districts in Sikkim

	Reserve	
13	Agasthyamala Biosphere Reserve	Part of Thirunelveli and Kanyakumari districts in Tamil Nadu and Thiruvanthapuram, Kollam and Pathanmthitta districts in Kerala.
14	Achanakmar- Amarkantak Biosphere Reserve	Part of Anuppur and Dindori districts of Madhya Pradesh and Bilaspur district of Chhattisgarh.
15	Kachchh Biosphere Reserve	Part of Kachchh, Rajkot, Surendranagar and Patan districts in Gujarat.
16	Cold Desert Biosphere Reserve	Pin Valley National Park and surroundings; Chandratal & Sarchu; and Kibber Wildlife sanctuary in Himachal Pradesh.
17	Seshachalam Biosphere Reserve	Seshachalam hill ranges in Eastern Ghats encompassing part of Chittoor and Kadapa districts in Andhra Pradesh.
18	Panna Biosphere Reserve	Part of Panna and Chhattarpur districts in Madhya Pradesh

Why Biosphere Reserves

BRs are the crucial sites for fulfillment of community needs through sustainable practices along with biological and cultural diversity preservation.Forecologists, traditional ecological knowledge possessed by the locals offers ameans to improve research and also to improve resourcemanagement. The presence of a variety ofmedicinal plants, fruits, fodder, fuelwood, spices, etc. makes them a valuable place. With a comprehensive way of approaching Sustainable Development, Biosphere Reserves shall create new opportunities for the local population, while tackling poverty issues such as food securityand sanitation. It helps in mitigating the effects of climate change by promoting a healthy environment and preserving the ecosystems. They are places that provide local solutions to global challenges. Each site promotes solutions reconciling the conservation of biodiversity with its sustainable use.The ultimate aim is to protect nature and it is hoped that BRs continues to provide livelihood to local communities thereby reducing pressure on natural resources. In the era of accelerating changes, the efforts we invest in ecological sustainability shall be the key to our own survival.

Potential of intact forest landscape in mitigating climate change

Nahid Khan

Department of Farm Forestry
Sant Gahira Guru Vishwavidyalaya
Ambikapur, Sarguja (C.G.), INDIA
Email: nahidkhan1618@gmail.com

Abstract

Climate change is a worldwide phenomenon and topic of scientific debate and exploration for human wellbeing. This changing climatic situation leads to disruption of various natural process and balance that affecting and challenging the living entity of the biosphere. To adapt and combat this mega event requires best practices that not only fit into emission reduction but also signify as the measure of carbon sink. In these perspectives, vegetation seems to be promising tools followed by ecofriendly practices and technology towards green and clean environment as well as moving into sustainable world. The intact forest landscape (IFL) is the undisturbed and unfragmented vegetated area and serves as potential source of biodiversity and ecological services and functions. The promotion of forestry in the form of extension forestry, urban forestry, farm forestry, agroforestry, etc. also paves the path towards adapting and mitigating the negative consequence of changing climate. Thus, the IFL or any protected or managed forest serves a lot in the form of tangible and intangible products and services for human society.

Keywords: Climate change, Carbon sink, Forest, Intact forest, Mitigation

Introduction

Forest is very important part of earth and ecosystem. It plays various vital functions and help in maintaining the biodiversity and climate change impact (Khan et al. 2020a,b). Intact forests landscapes (IFL) are defined as forest areas which are unfragmented area of at least 500 km^2 and with minimal influence of by anthropogenic activities (Reddy et al. 2017). They also contain non-forested or treeless ecosystem component, e.g., lakes, swamps, mountains. IFL is the areas which are free from significant anthropogenic damage and provides better habitats to wildlife and are the home of many endangered species. These forests help in regulating the local and regional climate. As they play important role in climate change mitigation, there degradation may lead to reduction in cloud cover, increase drought chance or even the extinction of forest-dependent species. Research indicates degradation of intact forest affects the overall ecosystem (Reddy et al. 2017).

The scenario of IFL in India consists of blocks larger than 10 km^2 covering 34,061 km^2 of area. Eastern Himalayas represent 76.7% of the area followed by Western Himalayas (8.8%), Andaman and Nicobar Islands (6.2%), and Western Ghats (5.7%). Arunachal Pradesh has the largest intact forest landscape in India (Reddy et al. 2017). IFL plays vital roles in regulating earth atmosphere and climate. IFL interact with climate in many ways such as help in mitigating the climate change, taking up carbon from atmosphere. They help in providing habitat to many species and maintain the biodiversity as well as offer various ecosystem services in addition to climate change mitigation.

Ecosystem services by IFL

The IFL provides various ecosystem services such as maintaining the water cycle and also stabilizing the atmosphere temperature besides the direct benefits to the human being (Figure 1). Presence of IFL helps in providing habitat and biodiversity enhancement. They also soil organic carbon and may also sequester carbon from atmosphere. Presence of old tree also helps in mitigation climate change by sequestering more carbon than that of younger trees. They also bind more soil organic matter than younger ones. IFL influence the water availability by controlling the runoff and increase the infiltration rate of soil thus help in increasing water table levels and altering soil permeability. Tree root helps in stabilizing the soil and reducing the soil erosion rate and help in regulating the nutrient and sediment transports. Increasing rate of deforestation affects the services such as degrading the soil infiltration rate, and alters the soil structure and aggregation of organic matter and decrease plant litter production. IFL influence the hydrological cycle and increase the rate of precipitation and help in conserving the ground water resources, reducing the rate of drought cause by climate change (Reddy et al. 2017).

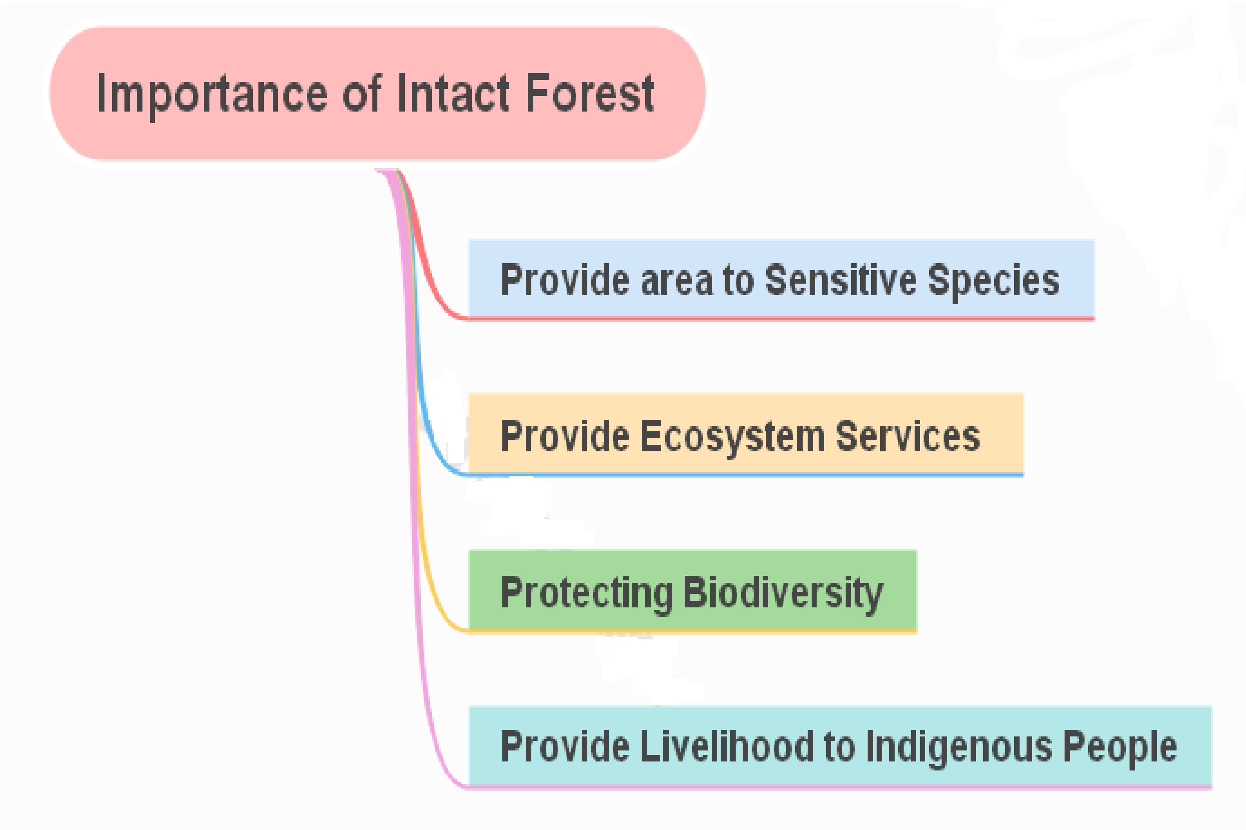

Figure 1 Importance and functions of intact forest landscape

IFL in climate change mitigation

In recent time climate change and biodiversity degradation are recognized as foremost environmental challenges. Forest helps in storing and sequestering atmospheric carbon for long pool (Raj and Jhariya 2021a, b). All components of IFLs such as woody, non-woody and soil system plays important role in climate mitigation by storing carbon and absorb atmospheric CO_2. IFLs are free from human interventions, both above and below ground component of forest store large amount of carbon from atmosphere for long carbon pool. As climate change is one of the major challenge for life and affecting the human and ecosystem across world. IFL plays very unique and important role in mitigating climate change, also help in maintain the temperature level and help in improving the forest ecosystem and trees remove CO_2 from atmosphere through process of photosynthesis.

Globally deforestation leads to 17% of annual CO_2 emissions according to IPCC. Conservation and preservation of forest lands is very critical for sequestering carbon from atmosphere and also for protecting the biodiversity and ecosystem services. IFL is globally important for environmental values, including in sequestering carbon, maintaining the indigenous culture, conserving biodiversity. Integrity of intact forest should be managed and should be the centrally focused in national and global environmental strategies along with reducing the pressure of deforestation and increasing reforestation. As IFL play potential role in maintaining the micro as well as the macro climate of an area. Help in reducing the climate change impact through reducing air temperature and providing various environmental services.

Conservation of biodiversity

Anthropogenic activities are the threats to forest and leading to the global biodiversity crisis, as majority of global terrestrial biodiversity is supported by the forest ecosystem. Biodiversity is an inherent value and intact forest help in strengthening the ecosystem services and intact the assemblage of species (Jhariya and Raj 2014; Raj et al. 2018; Khan and Jhariya 2021). IFL have show high potential in conserving the biodiversity. Ecosystem functioning include nutrient cycling, seed dispersal, pollination and improving the human well being. Logging, road construction are the major threat faced by species inhabiting in IFLs. Fragmentations of IFL are the one of the leading problem to loss of biodiversity, especially to those species with require large area for their population growth. Therefore presence of IFL is very important for their persistence. IFL provides shelter and food resource to many fauna species. Many endangered and rare flora and faunas are found in this type of landscapes. There conservation and protection is important for conserving the biodiversity. IFL show complex structure which is a characteristic feature which support diversity of lichens, many animals and bird species (Askins 2014; Zlonis and Niemi 2014).

Cause of IFL degradation

Degradation of intact forest show great impact on biodiversity, climate change and on environment. Forest degradation is mediated by anthropogenic accessibility to forested area, logging and felling of tree for fulfilling the requirement of timber and firewood, hunting of animals for food and their valuable of parts, deforestation of forest land for agricultural and mining work, due to human settlements (Figure 2). Forest fire cause by human affect the forest biodiversity and increase pressure on forest ecosystem. Degraded forests high risk for the invasion of alien species. Degradation of forest affects the major function played by them such as sequestering carbon into above and below ground (Heino et al. 2015).

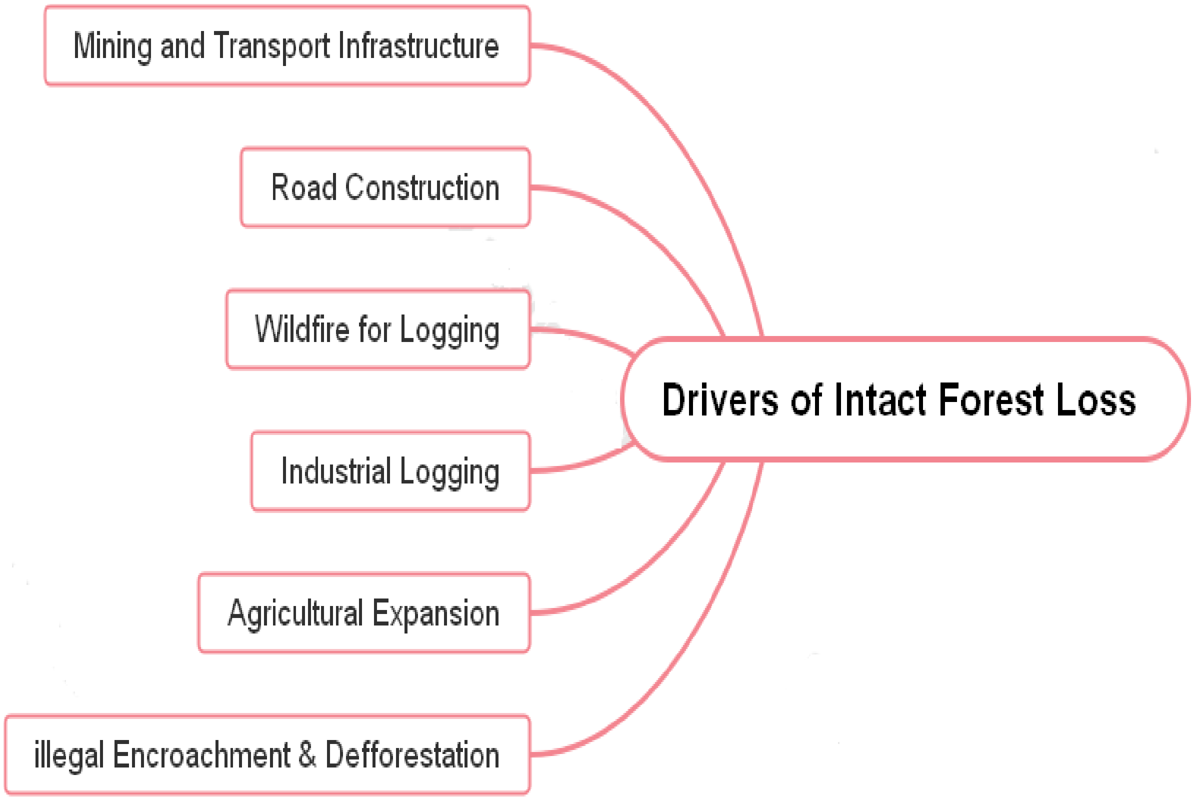

Figure 2 Drivers of intact forest landscape loss

Future and focal mechanisms for action on IFL

Anthropogenic pressure on forest resources is causing great impact on forest resources, illegal felling and high deforestation rate for fulfilling the timber requirement are the major cause of decreasing intact forest cover rate. Rising pressure on IFL and high anthropogenic activities create urgent need for the conservation and protection of IFL. Use for resources in unsustainable management approach lead to deterioration of forest resources. Thus, sustainable use and appropriate value of natural resources is very important for their proper protection and conservations. Rapid loss and increase deforestation rate of intact forest are the major threat to sustainable development and human well-being (Khan et al. 2021a, b, c). Challenges and constraints of IFL conservation need to be understood by policymakers. Policies and agreements focused on managing the intact forest and the policies which aim at maintaining the forest integrity should be adopted for conserving them (Jhariya et al. 2019a, b).

Conclusion

IFL contributes significantly in conserving the natural resources as well as maintains the precious biodiversity on the earth. These forests besides serving cultural, aesthetic, protective, productive and regulatory functions also pave the path towards climate change adaptation, mitigation as well as sustainability. Thus, more initiatives, research and development as well as protective measures should be opted to conserve and judicious management of these resources. The proper monitoring and creating more protective and intact forest is needed from future sustenance of the life.

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Soil and water conservation on the growth of planted species in skeletal soil – Some case studies

Saikat Banerjee, Avinash Jain and P. K. Shukla*
Tropical Forest Research Institute
(Indian Council of Forestry Research & Education, Ministry of Environment, Forests and Climate Change, Govt. of India)
P.O. RFRC, Mandla Road
Jabalpur-482021 (M.P.)
*Ex- Director, TFRI and PCCF (Retd.), M.P. State Forest Deptartment

Abstract
Moisture and thermal stress in soil affect the availability and absorption of water and nutrients by plants resulting their stunted growth. Any improvement programme concerning soil health cannot be achieved unless it incorporates soil and water conservation. In the present paper, response of conservation measures on the growth of planted species and improvement of soil properties in the skeletal soil having shallow soil depth, deficiency of nutrients and organic matter and moisture has been reported.

Key Words:- Skeletal soil, A.procera, A. lebbak, growth, soil and water conservation.

Introduction

None of the natural resources is so valuable as land. Productive land is essential to meet India's growing demand for food, fuel wood, fodder and fiber. Land also helps to conserve water resources and shelters biodiversity. India is endowed with a diversity of soil resources having different prospects and limitations. Inceptisols occupy the largest area (95.8 Mha) followed by Entisols, Alfisols, Vertisolsand Aridisols. These combined with a variation in geomorphology, topography, climate including rainfall, temperature and humidity etc. provide favourable environment for the growth of plants. Unfortunately, this valuable natural resource is under great pressure and maximum exploitation of the ever-increasing human population and livestock. According to an estimate (Lal and Stewart 1990), the rate of land degradation in India is around 5 to 7 million ha/year. Erosion in particular is responsible for removal of 6000 million tones of top fertile soil and 8.4 million tones of plant nutrients every year (Singh *et al.* 1994).

Land degradation has many direct and indirect negative impacts viz. accelerated water runoff, sedimentation of rivers and reservoirs, disruption of nutrient and water cycles, pollution of water bodies and emission of green house gases into the atmosphere. Land degradation also affects food and biomass production. Hence measure to restore such lands for productive and profitable utilization are urgently required and attention should be given to afforest these areas for increasing productivity and for conserving soil and water.

Forest is not merely a valuable natural resource of our country determining the economy of several states, but it also forms an inseparable component of the socio-economic and cultural heritage of tribal life style. There has been increasing realization that forests provide numerous benefits to mankind including improving of the quality of environment. Forests provide goods and services and maintain life support system like timber, fuel wood, fodder and a wide range of non-timber products. Moreover, forests are a source of natural habitat for biodiversity and respiratory of genetic wealth, provide means of recreation and opportunity for eco-tourism. In addition, forests help in watershed development, regulate water regime, conserve soil, and control floods. They contribute to process of carbon sequestration and act as carbon sink, which is important for reduction of greenhouse gases and global warming. Degradation of forest resources has a detrimental effect on soil, water and climate which in turn affects human and animal life. Industrial development and other developmental activities coupled with deforestation are main reasons for degradation of land in general and forests in particular. Therefore, any attempt to restore the vegetation and enhance the productivity should be based on the reversal of causative factors of degradation and provision of some additional inputs to minimize the associated problems.

Soil degradation due to erosion resulting in the formation of the skeletal soils has been a major problem in the Indian sub-continent. Shallow soil depth, little percolation of water, high evaporation and soil temperature and low nutrient status are the limiting factors for survival and growth of tree seedlings in these soils. Soil physical constraints can severely limit crop production even if nutritional constraints are alleviated by addition of chemical amendments. Such sites pose serious problem in their reforestation due to shallow soil depth, deficiency of nutrients and organic matter and moisture stress. Banerjee *et al.*(2003) studied the effect of soil conservation measure (staggered trenching) in association with VAM application on growth of tree species in such type of soil. In the following some case studies pertaining to soil-plant-water interaction have been presented.

Case Study

The study was carried out in an area around Tropical Forest Research Institute (TFRI), Jabalpur. Two study sites were selected, of which site II was located within the TFRI campus, while the other (site I) comprised of a small hillock having slope 15 – 20%, located at village Pipariya Khurd adjacent to TFRI campus. T site II the whole area was divided into two parts. One half was reserved for planting of *A. procera* and the other half was reserved for *A. lebbek.* At both the sites the plantatuion was done at 2m X 2m spacing in 45 cm^3pits and staggered trenches (3m x 0.5m x 0.5m) were dug in alternate rows of plants. After 4.5 years the results obtained are given below.

Table 1. Survival, mean height and collar girth after 4.5 years at site II

A. procera

Treatments	Survival (%)	Mean height (m)	Mean collar girth (cm)
To- No trenches, no fertilizer	58.32	3.01	13.84
T1- Staggered trenches only	86.64 (48.55)	3.55 (17.94)	17.32 (25.14)
T2- Staggered trenches + *Rhizobium* 20g/plant	91.66 (57.30)	3.69 (22.59)	18.61 (34.46)
T3- Staggered trenches + VAM	90.74 (55.69	3.58 (18.93)	17.38 (25.57)

20g/plant			
T4- Staggered trenches + VAM 20g/plant +*Rhizobium* 20g/plant	93.51 (60.34)	3.88 (28.90)	6(35.54)

A. lebbek

Treatments	Survival (%)	Mean height (m)	Mean collar girth (cm)
To- No trenches, no fertilizer	30.55	2.95	10.17
T1- Staggered trenches only	60.00 (96.40)	3.39 (14.91)	13.77 (35.39
T2- Staggered trenches + *Rhizobium* 20g/plant	55.55 (81.83)	3.65 (23.73)	15.37 (51.13)
T3- Staggered trenches + VAM 20g/plant	60.18 (96.98)	3.50 (18.64)	13.92 (36.87)
T4- Staggered trenches + VAM 20g/plant + *Rhizobium* 20g/plant	67.58 (121.21)	3.85 (30.30)	16.63 (63.52)

Figures within the parenthesis indicate per cent over control

Observations after 4.5 years revealed that digging of trenches and application of biofertilizers considerably affected the growth of *Al. procera* and *A. lebbek* (Table 1). Staggered trenches have added to the moisture content of the soil through checking run off and consequent increase in litter decomposition rate.

The properties of soil which are normally affected by plantation within a short period of time are available nutrients, organic matter content and the maximum water holding capacity (MWHC). Of these organic matter content and MWHC of the soil showed considerable improvement due to plantation of both the species with *A. procera* having an edge over *A. lebbek* (Table 3). Further, in both the species the effect of soil and water conservation was obvious due to considerable improvement in soil properties, which was further supplemented by the application of *Rhizobium*, VAM and *Rhizobium* + VAM.

Table 2. Physicochemical properties of soils at site I and II before plantation

Properties	Site II	Site I
Soil depth (cm)	10 – 12	15-25
pH	6.65 – 6.80	6.68 – 6.88
Organic matter (%)	0.23 – 0.33	1.12 – 1.48
MWHC (%)	40.00 – 52.30	45.00 – 55.20
Av. N (Kg/ha)	180.0 – 204.5	212.7 – 235.6
Av. P_2O_5 (kg/ha)	4.46 – 4.58	4.76 – 8.75
Av. K_2O (kg/ha)	150.0 – 162.0	156.5 – 210.7

Table 3. Improvement of soil properties with amendments in site II after 4.5 years

A. procera

Soil properties	To	T1	T2	T3	T4
pH	6.78	6.76	6.76	6.74	6.74
Org. matter (%)	0.52	0.71(36.53)	0.89 (71.15)	0.76 (46.15)	1.53 (194.20)
MWHC (%)	53.33	54.10 (1.44)	56.60 (6.13	54.70(2.56	57.50 (7.82
Av. N(Kg/ha)	206.60	210.70(1.98)	212.50(2.85)	210.70(1.98)	217.60(5.32)
Av. P2O5(kg/ha)	5.25	6.73(28.19)	6.85(30.47)	6.35(20.95)	7.35(110.00)
Av. K2O(kg/ha)	164.40	167.70(2.00)	171.30(4.19)	168.20(2.31)	173.40(5.47)

A. lebbek

Soil properties	To	T1	T2	T3	T4
pH	6.60	6.55	6.53	6.53	6.50
Org. matter (%)	0.34	0.47(38.23)	0.52(52.94)	0.48(41.17)	0.65(91.17)
MWHC (%)	42.30.	47.70(12.76)	50.50(19.38)	47.80(13.00)	56.30(33.09)
Av. N(Kg/ha)	182.20.	185.60(1.86)	183.30(0.60)	186.80(2.52)	192.60(5.70)
Av. P2O5(kg/ha)	4.96	5.75(15.92)	5.82(17.33)	5.77(16.33)	5.91(19.15)
Av. K2O(kg/ha)	152.00	154.50(1.64)	153.80(1.18)	154.50(1.64)	156.10(1.70)

Figures within the parenthesis indicate per cent over control

Similar experiment was also conducted in a hilly terrain (site I), but in that case *Rhizobium* was not taken as a treatment because the test species was a non-nitrogen fixing tree species (*Tectonagrandis).* The whole area at site I was divided into two equal parts along the central contour line forming the upper and the lower half sloppy portions. Both halves were further subdivided into sixteen equal blocks. Each half consisted of the following treatments replicated four times.

T0 – Control (No VAM, no staggered trenches)

T1 – 20 g VAM (mixed *Glomus*spp.) per plant, no trenches

T2 – No VAM, only staggered trenches

T3 – 20 g VAM + staggered trenches

The height growth of *T. grandis* registered increase between 57.29% with VAM alone and 133.35% with the combination of staggered trenches and VAM (Table 4). Individually, staggered trenching was found to be superior to VAM. This might be attributed to the fact that staggered trenches by checking soil and water losses increased the availability of water to plants for its absorption and growth. Staggered trenching was found to be highly beneficial in promoting survival and growth of *T. grandis* (Table 4). However, there were differences in growth of tree species in upper and lower slope positions. Differential growth of *T. grandis* under different treatments was expected to bring differential improvement in soil properties under various treatments. The changes in measurable soil properties were not wide enough (Table 6) due to higher uptake of nutrients as the plants were in establishment and initial growth phase. However appreciable improvement was noted to soil organic matter, MWHC and available phosphorus status of the soil in upper as well as lower sloppy portions.

Table 4. Performance of *T. grandis*under different treatments (Site I)

Upper slope

Treatments	Survival (%)	Height(cm)	Collar diameter (cm)
To – control	43.4	97.8	2.06
Only staggered trenches	64.8(49.31)	165.71(69.43)	2.68(30.09)
Only VAM @ 20g/plant	58.5(34.79)	153.83(57.29)	2.87(39.32)
20gVAM/plant + Staggered trenches	78.2(80.18)	228.22(133.35)	3.43(66.50)

Lower slope

Treatments	Survival (%)	Height(cm)	Collar diameter (cm)
To – control	51.3	126.6	2.21
Only staggered trenches	72.6(41.52)	246.62(94.80)	3.63(64.25)
Only VAM @ 20g/plant	63.7(24.17)	188.50(48.89)	2.91(31.67)
20gVAM/plant + Staggered trenches	84.4(64.52)	316.85(150.27)	4.46(101.81)

Figures within the parenthesis indicate per cent over control

Table 5. Physicochemical properties of soil at site I before plantation

Soil properties	Upper slope	Lower slope
pH	6.88	6.68
Organic matter (%)	1.12	1.48
MWHC (%)	45.00	55.20
Available N kg/ha	212.70	235.60
Available P2O5 kg/ha	4.76	8.75
Available K2O Kg/ha	156.56	210.70

Table 6.Physico-chemical properties of soils after plantation of *T. grandis* (siteI)
Upper slope

Treatments	pH	Org. M (%)	MWHC (%)	Av. N (kg/ha)	Av. P_2O_5 (kg/ha)	Av. K_2O (kg/ha)
To	6.86	1.36	45.0	215.8	5.88	240.44
T1	6.84	1.67(22.79)	48.4(7.55)	221.4(2.59)	6.67(13.43)	242.49(0.85)
T2	6.79	1.58(16.17)	48.2(7.11)	219.7(1.80)	6.42(9.18)	241.72(0.53)
T3	6.74	1.82(33.82)	50.6(12.44)	222.5(3.10)	6.85(16.49)	245.30(2.02)

Lower slope

Treatments	pH	Org. M (%)	MWHC (%)	Av. N (kg/ha)	Av. P_2O_5 (kg/ha)	Av. K_2O (kg/ha)
To	6.66	1.58	52.2	239.3	8.93	238.81
T1	6.64	1.84(16.45)	54.8(4.98)	243.5(1.75)	9.52(6.60)	243.35(1.90)
T2	6.61	1.67(5.69)	53.6(2.68)	247.4(3.38)	10.41(16.57)	240.42(0.67)
T3	6.56	2.48(56.96)	56.4(8.04)	256.3(7.10)	11.25(25.98)	252.70(5.81)

Figures within the parenthesis indicate per cent over control

From the above results it can be concluded that for rehabilitating such type of severely eroded soil, where soil depth and nutrients are the limiting factors, pits of 45cm3 should be dug along withstaggered trenches. Compost at least 2kg/pit should be added to the soil to provide initial nutrient support and *Rhizobium* + VAM should be mixed with the pit soil to increase microbial activities to obtain better survival and growth of nitrogen fixing tree species. In case of non-nitrogen fixing tree species VANM culture should be mixed with the pit soil along with staggered trenching whose spacing will depend on the severity of erosion and degree of slope.

The practice of applying a layer of dead waste material, such as straw, hay or old grass, composts or farmyard manure, to the surface of the soil around trees and bushes has been prevalent for a long time in many parts of the world. These surface mulches can have very important effects on the conditions in the surface layers of the soil, and in consequence on the crops with shallow root systems. Thus mulching has been widely used for many trees and bushes and for tropical plantation crops with superficial root systems. Mulching may be effective to a considerable extent in lowering soil temperature (Prihar*et al.* 1979) in the root zone as well as conserving moisture and checking evaporation Singh *et al.*(1994a, 1994b). In view of these an experiment in nutrient deficient skeletal soil was conducted with three mulches namely, stone (gravel), husk and leaf litter with four watering intervals such as daily,, one day , two days and three days' interval taking *Albiziaprocera*as test crop and various vegetational parameters were recorded. On the basis of the results obtained it was concluded that mulches by virtue of reduction in moisture loss help in increasing growth, biomass production, nodulation etc. even at increased watering intervals. Husk mulch was beneficial increasing height growth, root length and number of leaves, while stone mulch was found to be more suitable for increasing collar diameter, above ground biomass, number of nodules and leaf area at enhanced watering interval.

Plastic films are more widely used as mulch. They help in maintaining higher water content in soil resulted from reduced evaporation, induced infiltration, reduced transpiration from weeds or combination of all these factors. However, they are relatively more expensive and difficult to manage under large scale field conditions.

Mulches are used for various reasons but water conservation and erosion control are the most important objects in dry regions. Mulches when properly managed definitely aid wind and water erosion control. Other reason for high mulching is followed includes soil temperature modification, soil conservation, nutrient addition, improvement of soil structure, weed control and crop quality control. Reduced evaporation from root zone is major reason for th growth of the plants and thereby high crop production due to mulch.

Jalshakti, a granular, free flowing organic compound designed to improve plant-water relationshipis a novel super absorbent polymer with an amazing ability to absorb and retain water about 150-200 times its weight. It is non-toxic and biodegradable. The experiment conducted on mango trees at Malyan, Maharashtra showed that over a period of five months a dosage of one per cent Jalshakti was adequate to reduce the number of irrigation from 23 to 11. However, Jalshakti has not been tried in forestry to assess its effectiveness in the growth of species and moisture retention in combination with mulches.

An experiment was conducted with nutrient deficient skeletal soil, where mulches (control, stone or gravel, husk and leaf-litter) and watering frequency (daily, one day, two days and three days interval) along with Jalshakti to see their response on growth of *Albiziaprocera*(test crop). Jalshakti had some response towards the height at increased watering interval by conserving moisture. The results further revealed that application of Jalshakti along with mulches is more effective for better nodulation, in increasing photosynthetic area (leaf area), height growth of plants and resultant biomass production in skeletal soil.

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Conservation of *Tecomella undulata* – a threatened tree of multipurpose values

Sanjeev Kumar Chauhan, Sapna Thakur and Harmeet Singh Saralch

Department of Forestry & Natural Resources
College of Horticulture and Forestry, Punjab Agricultural University
Ludhiana
Email: sapnathakur@pau.edu

Recent years have witnessed an increasing global concern over the loss of genetic resources. Future progress in plant improvement depends to a great extent on immediate conservation of rapidly vanishing gene resources and their judicious utilization. The fundamental principal of genetic diversity conservation is the maintenance of broad genetic base within a species. Anthropogenic activities like habitat destruction, environmental degradation, over harvesting/illicit felling, over grazing, fire, introduction of exotics/ invasive species, inbreeding depression, genetic drift, MFP extraction, diverting land for non-forest use, shifting cultivation, encroachment, etc. have caused massive irreversible disturbances in the natural environment. As a consequence, we can no longer afford to leave the conservation of genetic diversity to nature; rather we must take active measures to conserve it ourselves by taking into consideration the biological, social, economic, ethical and other related dimensions. The phenotypically superior trees yielding more timber or biomass are harvested on priority, ultimately eroding the valuable genotypes. A large number of species have been identified for their multiple values but they are very little in use now. However, conserving those species about which we know little is highly desirable. The broad spectrum of genetic variability should be conserved so as to act as a reserve for the present and future needs through ***in-situ*** and ***ex-situ*** means.

Increasing deforestation, afforestation/ reforestation of exotics (poplar, eucalypt, etc.), change in land use pattern, diversion of forest land for non-forestry use, changing climate, etc. has far reaching effects on habitat of local species. Furthermore, soil tillage; excessive use of chemical fertilizers, toxic chemicals for pest, diseases, weed control; as well as overuse of irrigation have affected soil microbial composition and rhizospheric ecosystem in many areas, especially in arid regions. With this destruction or modification of natural habitats, the first victim is the local biodiversity, subsequently leading to extinction of species and conspicuous segments of genetic diversity has already vanished forever and more is threatened.

Conversion of ecosystem of South western Punjab into agricultural farms, monoculture plantations, forest land for non-forest use, levelling of undulating land, change in cropping rotation, overuse of agrochemicals, etc. in an ill planned way, has resulted in increased rate of extinction of native species. Owing to the ecological constraints and economic interests of the farmers, a large number of tree species have been listed as threatened species viz., *Tecomella undulata, Acacia modesta, Tamarix dioecia, Salvadora oleoides, Capparis aphylla, Prosopis cineraria, Ehretia revis,* *Butea monosperma*, *Eugenia cuspidata*, *Anogeissus latifolia*, *Zizyphus nimularia*, etc. Their conservation and non-judicious exploitation for economic use must be taken up so that the species, which are not of economic use today, may find some economic place tomorrow. Biodiversity has economic, social and educational value, therefore its conservation and enrichment is paramount for future generation.

Tecomella undulata is one such economically important species of arid and semi arid regions of Punjab and adjoining states, belonging to monotypic genus of family Bignoniaceae[1]. The species is deciduous or nearly evergreen in nature and known as Marwar teak or rohira. The species is indigenous to India and Arabia and its distribution is confined to the drier parts of the Arabia, southern Pakistan and north western India up to an elevation of 1200 meters[2]. In India, it occurs naturally in the states of Punjab, Haryana, Rajasthan, Gujarat and Maharashtra. It flowers gregariously in the month of April and available in different variants i.e. red, orange and yellow color. It is a key species of drier regions playing a crucial role in soil binding and protection against strong winds owing to its extensive root system. The species can survive even under extreme low and high temperatures conditions with scanty rainfall of 150–500 mm annually, and has therefore been widely accepted in arid region agroforestry. Rohira is a strong light demander, drought hardy, frost and fire resistant in nature. It thrives well on drained loamy to sandy loam soil with a pH in the range of 6.5–8.0 [3]. The species produce light, durable, quality timber highly valued for furniture making and wood crafts. It is also a good source of fodder and firewood. The species has also been reported to be highly mycorrhizal in natural habitat and possess good potential for phytoremediation[4]. Since time immemorial, the species had been used in the traditional medicine system for the treatment of leucoderma, leucorrhoea, spleen enlargement and urinary discharge due to pitta and kapha. Rohira leaves contains active compounds like oleanolic acid, ursolic acid and betulinic acid, that have been reported to be strong HIV prohibitors[3], whereas Lapachol compound extracted from the heartwood possess antibacterial, antifungal, antivirus and anticancerous properties. Further the importance of the plant is reflected in its economic and social values. The species has been much in use for traditional artifacts, and village like Jodhpur Pakhar (Talbandi Sabo), Punjab, where this timber was used for making traditional Charkha including other sports goods with export quality. The Gurdwara Rurha Saab in Pakistan reflects its social importance. The village Rurhewali, Dist. Shri Mukhtsar Saab has been named after the tree and the flower of the species has been designated as state flower of Rajasthan, indicating the social and economic importance of the tree species.

Despite the ecological and socio-economic significance of Rohira, systematic approach for its conservation or genetic improvement is lacking. Intensive and unscientific over-exploitation for timber and artifacts, change in land use from rainfed to irrigated systems, coupled with poor regeneration and sluggish growth, lack of sufficient knowledge of species ecology and biology & limited research initiatives are some of the major reasons for its habitat destruction and has threatened the survival of the plant species, rendering it more vulnerable to extinction.

The Union Ministry of Environment, Forest and Climate Change in its notification (SO 402E dated Feb. 4, 2014) under Biological Diversity Act 2002 notified ***Tecomella undulata,*** at the verge of extinction in Punjab. Therefore, it is becomes imperative to conserve this beautiful flowering species, which is socially and economically important for the state of Punjab.

In order to conserve this potential tree species estimation of genetic variability in *T. undulata* is highly desirable. Owing to low natural regeneration rate, there is an urgent need for germplasm conservation and standardization of vegetative propagation methods for its mass multiplication. One of the serious problems with *T. undulata* is the poor seed germination, which may be due to dormancy, seed infertility or low seed viability. Moreover, the natural regeneration is limited because of high temperature during seedling time and wind dispersal of seeds. Thus, systematic reproductive biology and inter and intra population variation studies are crucial for developing conservation plan for *T. undulata*. Moreover, diversity had utilitarian value and our present knowledge is not adequate to judge which aspects of biodiversity are sufficient for the future needs of mankind. Therefore, it is more important to conserve the species with known multiple uses. There is not only need to conserve the plant wealth but create awareness among different sections of the society through their active involvement.

Fig.1. Inflorescence of *Tecomella undulata*

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Chir pine defoliator, *Cryptothelia crameri* and its control measures

N. Roychoudhury and Rajesh Kumar Mishra

Tropical Forest Research Institute
(Indian Council of Forestry Research & Education, Ministry of Environment, Forests and Climate Change, Govt. of India)
Jabalpur -482 021, Madhya Pradesh
E-mail : choudhury_nr@yahoo.com, mishrark@icfre.org

Abstract

This article deals with the pest profile of *Cryptothelia crameri* Westwood (Lepidoptera: Psychidae), a potential defoliator of chir pine, *Pinus roxburghii* Sarg. (Family Pinaceae). The management aspects of this insect pest are summarized.

Key words: *Pinus roxburghii*, *defoliator*, *Cryptothelia crameri*, control measures

Introduction

The genus *Pinus* (family Pinaceae) contains over 90 species and constitutes an important group of conifers. Most of the pine species are distributed in the temperate and alpine regions but there are a few tropical pines distributed mostly in the cooler high altitudes of the tropics. Chir pine, *Pinus roxburghii* Sarg. is one of the important pines of India and the most widely occurring (Anon, 1996). It is also known as Indian chir pine. Chir pine is a native of the inter-ranges and principal valleys of the Himalaya. In India, its forests are found in Jammu and Kashmir, Haryana, Himachal Pradesh, Uttar Pradesh, parts of Sikkim, West Bengal and Arunachal Pradesh. The total area under chir forests is estimated to be 8, 90,000 hectares and occurs between 450 m to 2300 m altitude. Chir pine forms pure forests in its habitat but in its upper and lower limits occurs mixed with other conifers and broad leaved species.

Overview of insect pests

Chir pine is prone to insect damage at all stages of its growth, such as cones and seed, seedlings, standing trees and timber. About 32 species of insects belonging to five orders, such as Coleoptera (14 species), Hemiptera (3 species), Isoptera (2 species), Lepidoptera (6 species) and Orthoptera (7 species) have been recorded feeding chir pine at different stages of plant development (Beeson, 1941, Browne, 1968; Anon, 1996). Of these, *Cryptothelia crameri* Westwood (Lepidoptera: Psychidae) is a major insect defoliator causes serious outbreak in chir pine forests. The pest profile and control measures of this insect are mentioned below.

Pest profile

***Cryptothelia crameri* Westwood (Lepidoptera: Psychidae)**

C. crameri (syn. *Clania crameri*) is an important polyphagous bagworm insect pest commonly known as chir pine defoliator, found throughout India (Beeson, 1942; Browne, 1968). Eggs are laid in the case from December onwards to April, according to the climatic conditions of the area. The larva feeds on young leaves and tender bark by making and living within a portable bag of leaves, twigs, barks, spines, etc. (Baksha, 2000). The male moth has a wing span of 6-7 mm, its wings reddish brown streaked with black and the middle of the forewings translucent. The female is wingless and never leaves her bag, in which she lays her eggs. The generation is annual. Larvae feed for about 9-10 months and pupation occurs in the case suspended from a twig.

This insect species also infests cacao and tea bushes, and in southern India it is a prevalent and important pest in plantations of *Casuarina equisetifolia*. Other recorded food plants include *Acacia catechu*, *A. nilotica*, *Albizia* spp., *Bischofia javanica*, *Bobax malabaricum*, *Cassia* spp., *Hevea brasiliensis*, *Santalum album*, *Shorea robusta*, *Tamarindus indica* and *Terminalia chebula* (Beeson, 1941; Browne, 1968).

The first epidemic by this bagworm was reported in 1885 from Tons Valley, Uttarakhand. Subsequently, it was reported from Bilaspur, Himachal Pradesh in 1928. and also from Kahhula, Pakistan in 1934. From 1989-1990, an outbreak of *C. crameri* on *P. roxburghii* was reported in the state of Jammu and Kashmir. The outbreak caused 5% percent tree mortality over 2 000 ha with 0.3 million trees lost resulting in a net loss of 22.5 million rupees (Thakur, 2000).

Control measures

According to Baksha (2000), *Brachymeria* sp. was found to parasitize the larvae of *C. crameri*, hence, this Dipteran parasitoid after mass multiplication can be released during the population outbreak of bagworm in chir pine forests. The pest could be collected and destroyed by hand. It could also be controlled by the foliar application of 0.1% Malathion. Thakur (2000) suggested for use of an insect chitin inhibitor, Dimilin against chir pine bagworm, *C. crameri*.

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Carbon dioxide fix model: An essential tool for estimation of carbon sequestration potential of agroforestry system

Shailendra Bhalawe[1*], D. Kathal[2], R.K .Thakur[1], P.K. Shrivastava [1] and Uttam Bisen[1]
[1]College of Agriculture, Balaghat
[2]College of Agriculture, Powarkheda
Jawaharlal Nehru Krashi Vishwavidyalaya, Jabalpur (M.P.)
*Email: sbhalawe@gmail.com

Abstract
A carbon dioxide fix model is a tool or software that is widely used to assess beginning carbon and appraise carbon sequestration potential (CSP) in any land-use system, specifically for each component (*i.e*., trees, shrubs, agricultural crops or pastures, soil, *etc.*). Carbon stock tools not only quantifies carbon stocks, but can also quantify the carbon fluxes in biomass, soil organic matter, and the carbon fluxes in wood products chains. In addition, this model can simulate the outcome for "n" years and assess the forecast values. As a result, foresters, scientists, researchers, and academics can use this tool to estimate the CSP of any system and its future predictions in terms of carbon stock and fluxes.

Introduction
The most effective strategy to counteract climate change is to grow woody perennials in agroforestry systems. As a result, the most important features to analyse in general are tree biomass (above and below ground) and biomass carbon, which may evoke their value, particularly in terms of the ecological services provided by the trees under investigation in agroforestry. Furthermore, under climate change mitigation strategies, it offers a better potential for carbon sequestration. Author discovered that agroforestry may sequester an average of 25 Mg C ha^{-1}, however biomass production varies substantially across the country. The carbon dioxide fix (CO_2 FIX) model is a programme or software that may be used to assess baseline carbon and estimate carbon sequestration potential of any land-use system that can simulate at the hectare scale with one-year time steps and a simulation period of "n" years (for example, n = 20, 30, or 50 years). This model can be used to a variety of plants (trees, shrubs, agricultural crops, and so on) and land-use systems, as long as the user has a good understanding of how to handle and manage them. This model can be used to estimate biomass and changes in soil carbon stocks for forestry, agricultural, and agroforestry projects since it takes into consideration soil, climate, and other elements like crop residue. According to numerous studies, most scientists and researchers concentrate on the carbon sequestration potential (CSP) of individual forest or multipurpose tree species (MPTs) while ignoring non-woody crops, agricultural crops, and herbs/grasses. As a result, data on the CSP of the total system is still scarce (e.g., forest ecosystem). Many studies have shown that working with this CO2FIX model of any compatible version (i.e., dynamic carbon accounting model CO_2 FIX v3.1 for assessing the baseline tree biomass and biomass carbon as developed as part of the CASFOR II project for assessing the baseline tree biomass and biomass carbon as developed as part of

the CASFOR II project for assessing the baseline tree biomass and biomass carbon as developed as part of the CASFOR II project for assessing the baseline tree biomass and biomass carbon as developed as part of the baseline tree biomass (Namburs and Schelhaas, 2002). This model also includes the YASOO (Liski *et al.,* 2005) soil module, which considers the original litter quality as well as the effect of climate on decomposition. As a result, the CO_2FIX model can be used to temperate and tropical climates, biomass and soil carbon estimation (Namburs and Schelhaas, 2002; Masera *et al*., 2003), coniferous or deciduous forests, monocultures or mixed tree stands, and a wide range of ecosystems around the world.

Parameters needed to run the Carbon dioxide fix (CO_2 FIX) model

The cohort-wise values for the stem-CAI (current annual increment in m^3 ha^{-1} $year^{-1}$) over years; relative growth of the foliage, branches, leaf, and root with respect to the stem growth over years; turnover rates for foliage, branches, and roots; and climate data for the site are the main input parameters relevant to the Carbon dioxide (CO_2FIX) model. Other inputs to the model includes initial surface soil organic carbon (Mg C ha^{-1}), rotation length for the tree species, per cent carbon contents in different tree parts, wood density and initial values of baseline carbon (Mg C ha^{-1}) in different tree parts.

When calculating average tree volume (V) of a specific standing tree species and Current Annual Increment (CAI), one can use volume equations or calculate by averaging the tree volumes ($V_1$and V_2) after considering trees as average cylindrical and conical shape (Das *et al*., 2019).

Tree volume, V_1 (m^3 $tree^{-1}$) = (л x DBH^2 x H)/4 (for cylindrical shape) ……….(1)

Tree volume, V_2 (m^3 $tree^{-1}$) = (л x DBH^2 x H)/12 (for Conical shape) ……….(2)

Thus, V (m^3 $tree^{-1}$) = (V_1 + V_2)/2 ………………….(3)

The CO_2 FIX model requires some basic information to run

The CO_2 FIX model (Fig.1) requires both primary and secondary data on tree and crop components (referred to as "cohorts" in the model). The primary data comprises the names of existing tree species, as well as their numbers, diameter at breast height (DBH), and tree height, as well as crops cultivated on fields or in alleyways, as well as their productivity, area coverage, and so on. Secondary data includes annual growth rates of tree biomass components (stem, branch, foliage, and root) for various species, as well as the productivity of various crops grown in the area (Ajit *et al.*, 2013). Soil data 623, particularly soil organic carbon (t ha^{-1}), should be evaluated using the same approach as Naik *et al.* (2018), Das *et al.* (2017) and (2019).

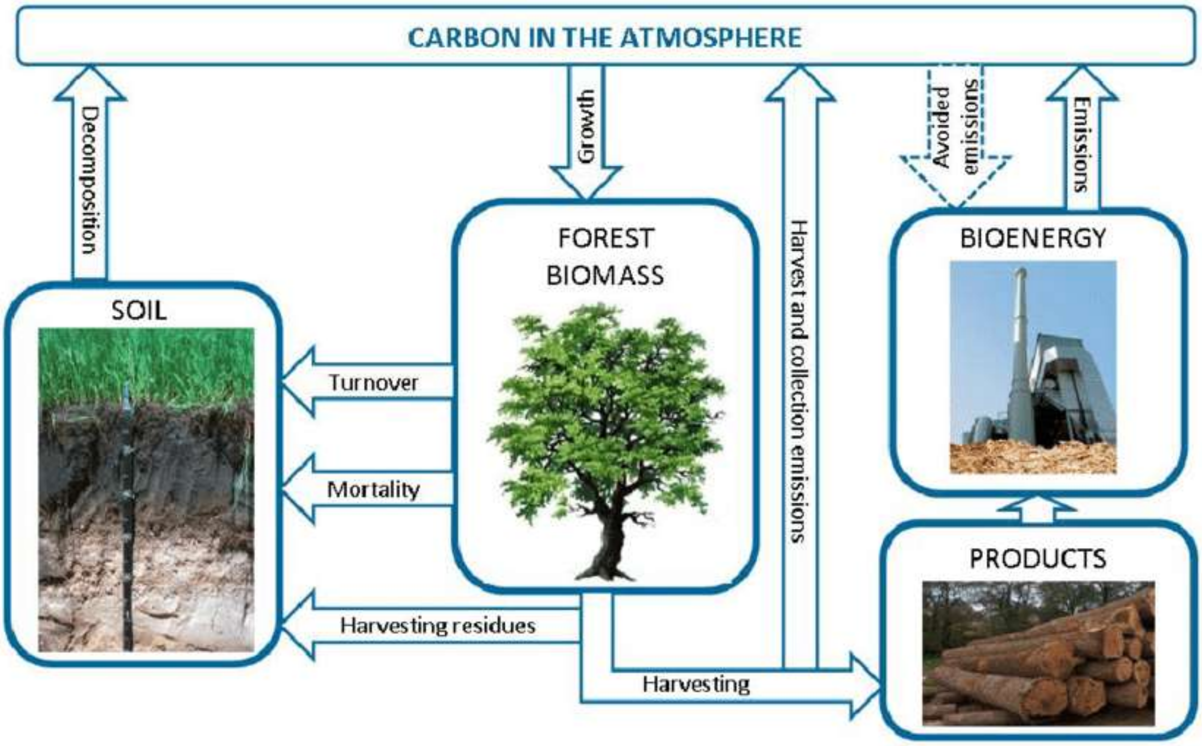

Fig. 1: Structure of the CO_2 fix model

Biomass validation of the model

An independent data set containing successive annual harvesting of trees of a specific era must be documented and examined in order to validate the tree biomass estimated using the model. Ajit *et al.* (2013) used this technology in poplar trees (*Populus deltoides*) for 9 years and reported that it was successful in validating tree biomass. For biomass measurements, a minimum of three numbers of trees must be harvested on a yearly basis. The observed variables, such as DBH, Height, above ground biomass components (stem, branches, leaves, and twigs), and below ground biomass components (primary, secondary, tertiary, and fine roots), must be measured, statistically calculated, and compared to the anticipated biomass about its location.

The bias/error in prediction

The measurement of bias/error in prediction is critical for verifying the model's output result, which must be statistically more accurate. The percent bias estimates from the CO_2 FIX model, according to Kaonga and Smith (2012), ranged from 2 to 19 percent for total above ground C stocks, 22 to 40 percent for branches, and 22 to 62 percent for leaves.

Sensitivity analysis of the model

Sensitivity analysis is the process of determining the impact of changing particular parameters or model outputs (Ajit *et al.*, 2013). The major elements of simulation are annual precipitation and monthly temperatures, which are two important site-specific factors. By default, the CO_2 FIX model treats them as constant during the simulation period, creating a source of uncertainty in model output. According to Ajit *et al.* (2013) and Bhalawe and Jadeja, (2015), a change of 0.5^0C in monthly temperature can result in a 0.7-2.46 percent change in C-sequestered rate, while a change of 20% in annual precipitation can result in a 5.39-10.88 percent change in C-sequestered rate. As a result of their research, it is more obvious that the rate of C-sequestration is more sensitive to precipitation than to temperature.

Significance over other available tools

CO_2 FIX is suggested above others (such as PROCOMAP, CENTURY, and ROTH) because it can reproduce the carbon dynamics of single or many species concurrently and can manage trees of varied ages and agroforestry systems (Ajit *et al.,* 2013). The species' Current Annual Increment (CAI) is critical for running this model. PROCOMAP, on the other hand, is commonly used for project-level carbon stocks (biomass and soil) for forestry projects, while both the CENTURY and ROTH models focus more specifically on soil carbon stock dynamics for agriculture and forestry projects (Ajit *et al.*, 2013). As a result, CO2FIX has been widely utilised in forestry, agricultural, and agroforestry projects to estimate biomass and changes in soil carbon stores.

Key points to be remembered while using the CO_2 FIX model

Users should keep the following crucial points in mind when utilising the model:

1. Check the model's compatibility with the system before executing it.
2. Both primary and secondary data must be appropriately evaluated and converted to the measurement units that the model accepts, and the model must be ready shortly before it is run.
3. When predicting the Current Annual Increment (CAI), the most crucial parameter to employ while running the model, users must have sufficient knowledge.
4. The user must have annual total harvesting data, including biomass of root, bole, branches, leaves, and so on, in order to validate the anticipated versus observed values.
5. The age of the plantation must be known; otherwise, the age of individual trees must be estimated using volume equations.
6. Run a sensitivity analysis to verify the % change in expected estimates by adjusting the temperature and rainfall parameters in the model while it is running.

Conclusion

The CO_2 FIX model is widely used to estimate the CSP (Carbon sequestration potential) of any land-use system, and more specifically, the potentiality of each individual component (i.e., trees, shrubs, agricultural crops or pastures, etc.). This tool can measure not only the carbon stock, but also the C-fluxes in biomass, soil organic matter, and the C-fluxes in the wood products chain. Users will find processing and analysing data in this model to be quite simple and quick. This model can also replicate the outcome for "n" years and measure the predictability. In addition, this model can simulate the outcome for "n" years and assess the forecast values.

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Solid waste and their management

Rekha Agarwal

Government Science College
(Department of Higher Education, Madhya Pradesh)
Old Robertson College, Estd.-1836
Jabalpur (MP)- 482 001

Solid waste refers to the range of garbage materials arising from animal and human activities that are discarded as unwanted and useless. Solid waste is generated from industrial, residential, and commercial activities in a given area, and may be handled in a variety of ways. As such, landfills are typically classified as sanitary, municipal, construction and demolition, or industrial waste sites. Waste can be categorized based on material, such as plastic, paper, glass, metal, and organic waste. Categorization may also be based on hazard potential, including radioactive, flammable, infectious, toxic, or non-toxic wastes. Categories may also pertain to the origin of the waste, whether industrial, domestic, commercial, institutional, or construction and demolition. Regardless of the origin, content, or hazard potential, solid waste must be managed systematically to ensure environmental best practices. As solid waste management is a critical aspect of environmental hygiene, it must be incorporated into environmental planning.

Solid waste management is defined as the discipline associated with control of generation, storage, collection, transport or transfer, processing and disposal of solid waste materials in a way that best addresses the range of public health, conservation, economic, aesthetic, engineering, and other environmental considerations. In its scope, solid waste management includes planning, administrative, financial, engineering, and legal functions. Solutions might include complex inter-disciplinary relations among fields such as public health, city and regional planning, political science,

geography, sociology, economics, communication and conservation, demography, engineering, and material sciences. Solid waste management practices can differ for residential and industrial producers, for urban and rural areas, and for developed and developing nations. The administration of non-hazardous waste in metropolitan areas is the job of local government authorities. On the other hand, the management of hazardous waste materials is typically the responsibility of those who generate it, as subject to local, national, and even international authorities.

Solid waste disposal management is usually referred to the process of collecting and treating solid wastes. It provides solutions for recycling items that do not belong to garbage or trash. Solid waste management can be described as how solid waste can be changed and used as a valuable resource.

Improper disposal of municipal solid waste can create unsanitary conditions, and these conditions in turn lead to pollution of the environment. Diseases can be spread by rodents and insects. The tasks of solid waste disposal management are complex technical challenges. They can also pose a wide variety of economic, administrative and social problems that must be changed and solved.

Solid waste management practices can differ for residential and industrial producers, for urban and rural areas, and for developed and developing nations. The administration of non-hazardous waste in metropolitan areas is the job of local government authorities. On the other hand, the management of hazardous waste materials is typically the responsibility of those who generate it, as subject to local, national, and even international authorities.

We can significantly reduce the amount of solid waste by following some basic principles of reducing the amount of waste that is created, reusing materials that would otherwise be discarded, by recycling materials and by using recycled materials. The commonly-used "3-R" phrase to describe this principle is: "Reduce, Reuse, and Recycle".

Through reduce

1. By taking reusable bags to the grocery store instead of single-use plastic bags.
2. By selecting items with limited or no packaging.
3. BY using a refillable container for water in place of bottled water.
4. BY reducing "junk mail". According to Donotmail.org, direct mail creates 10 billion pounds of solid waste each year, and approximately 44 percent of junk mail goes to landfills unopened. Think twice before printing material from the internet. When possible, print on both sides of the paper.
5. By setting a goal for reducing the amount of trash generated each week.
6. By recycling paper and cardboard. The cardboard and paper waste make up 41% of the municipal solid waste stream. Recycling cardboard takes 24% less energy and produces 50% less sulfur dioxide than making cardboard from raw materials.

Through reuse

1. By thinking of ways to use packaging materials and ways to reuse items that no longer serve their function.
2. By using cloth napkins and plates instead of paper.
3. By shredding or composting untreated wood and leaf wastes into chips and use them as mulch on garden beds to prevent weed growth, retain moisture, regulate soil temperature, and add nutrients back to the soil.
4. By having a yard sale to find new homes for clothes, toys, appliances, books, and other items.
5. By donating old cabinets, doors, fixtures and hardware to local charity centers, such as Habitat for Humanity's "Re-Store".

6. For useful items that you no longer want but do not want to throw away, consider the Freecycle Network, which provides options for participants to give away or trade items.

Through recycle/compost

- By making it a habit to separate out all items that are recyclable.
- By raising the cutting height of your lawn mower during the hot summer months to keep grass roots shaded and cooler. This reduces weed growth, browning, and the need for watering.
- During mow, leave grass clippings on your lawn instead of bagging them or use a mulching mower. The clippings will return nutrients to the soil instead of taking up space in landfills.
- By checking with local repair shops to see if they can use our old appliances for spare parts.
- By using food scraps, yard trimmings, and other organic waste to create a compost pile that can help increase water retention, decrease erosion, and replace chemical fertilizers.
- Buying recycled-content gardening equipment and tools, such as garden hoses made from old tires, stepping stones made from old glass bottles, or hand tools made with recycled plastic. You can also find composite lumber made from recycled plastic bottles and bags.
- By recycling hazardous waste during periodic hazardous waste collection programs.

Raw materials are becoming scarcer, energy more expensive, and, at the same time, the amount of waste is rising. In addition, soil, air and water pollution poses a risk to sustainable development all around the world. Less than ten per cent of the raw materials consumed are currently recycled. Waste disposal issues are exacerbated by changing patterns of consumption, industrial development and urbanization. Many developing countries and emerging economies are faced with the major challenge of improving their waste management systems. Waste must no longer be deposited in uncontrolled landfills, illegal rubbish tips or incinerated in the open, and it must also not end up in waterways, resulting in climate-damaging greenhouse gases as it breaks down. Plastic waste in the ocean does considerable damage to flora and fauna and finds its way into the human

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P.O. RFRC, Mandla Road
Jabalpur – 482021, M.P. India
Phone: 91-761-2840484
Fax: 91-761-2840484
E-mail: vansangyan_tfri@icfre.org, vansangyan@gmail.com
Visit us at: http://tfri.icfre.org or http://tfri.icfre.gov.in