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Social Forestry and Agro-Forestry

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Department of Forestry and Environmental Science
School of Earth and Environmental Science

Uttarakhand Open University
Haldwani, Nainital (U.K.)

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Board of Studies

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UNIT 1: Introduction to social forestry

Unit Structure

1.0 Learning Objectives

After completing this unit you shall be able to:

- Define the concept of social forestry
- Explain the types of social forestry
- Explain the meaning and concepts of people's participation. Discuss the importance of local Self Governance, people's participation in development.
- People participation and the programmes of the Government for the promotion of people's participation in forest management; and
- Major factors affecting the success of social forestry projects.

1.1 Introduction

Widespread loss of tree vegetation in the developing world in the past few decades led to the emergence of social forestry. It was a response to meet the growing scarcity of

biomass and to preserve the environment. Several countries in the developing world launched this type of programme to meet the demands of an expanding population for fuel, fodder and timber. Social forestry was new approach to solve the problem of fuel scarcity with the participation of rural people who would plant, tend and maintain trees by themselves. The species planted would be of their choice. People's Republic of China was one of the first countries to embark on a major community reforestation programme.

A massive nationwide campaign was launched during 1950s as a means of replenishing the country's stock of trees depleted by the previous decades of war and overexploitation. The Republic of Korea was another country where a nationwide tree growing was taken up. In 1962, Korea took the reforestation programme on a communal basis and as a major national priority. By early seventies, the problem of deforestation and environmental degradation were expressed at International Conference at Stockholm during 1972 bringing in to sharp focus the changes required in policies towards environment and the crisis of tree depletion. The World Congress (1978) added the dimension of forestry for the people and by the people. Food and Agricultural Organization also brought the programme of forestry for local community development. Although it was recognized at most forums that local community forestry was the only solution to the problem of tree depletion but support , both financial and technical was negligible. It was only in the early eighties that several International organizations and agencies agreed to aid rapid tree development programme.

Social forestry was first recognized as an important component of forestry development and meeting the rural need in the Interim Report of the National Commission on Agriculture on social forestry during 1972. The commission stressed on the socioeconomic importance of social forestry for rural community as well as in the management of forest resources. It was felt that by taking up the programme of raising trees , grasses and fodder in the farmers own lands, village commons, wastelands and degraded forests close to habitations, it would be possible to meet the requirements of fuel wood, fodder, small timber for rural housing and agricultural implements etc. Afforestation in the post independence period can be divided in to three phases. In the first phase 'Van Mahotsav' was started in fifties which failed to attract attention largely due to ignorance at all levels. In the second phase, farm forestry was started in some states in the 1970's. The third phase was the period when

social forestry programme actually took off in eighties with massive programmes and ambitious targets.

1.1.1. Definition and concept of social forestry

1.1.1.1 Social forestry-definition

Social Forestry is the practice of forestry which aims at meeting the requirement of rural and urban population (society). It is also called as forestry of the people, by the people, for the people. It refers to a collective utilization of unutilized common land to meet the necessities of the local people particularly underprivileged section of the society. It is also known as "forestry for local community development" or "participatory forestry". The term was coined by J.C. Westoby (1968, during Common Wealth Forestry congress New Delhi) and defined as "Social Forestry, is a forestry which aims at producing flow of protection and recreational benefits for the Community". But it was first used in India in 1976 by The National Commission on Agriculture, Government of India. Gujarat state was first in the country to initiate social forestry activities in 1970. Later on separate social forestry divisions has been created in various states.

According to Prasad (1985) Forestry practices outside the conventional forest which primarily aims at providing continuous flow of goods and services for the benefit of people". This definition implies that the production of forest goods for the needs of the local people is Social forestry. Thus, social forestry aims at growing forests of the choice of the local population. Shah (1985) stated that Conceptually Social forestry deals with poor people to produce goods such as fuel, fodder etc. to meet the needs of the local community particularly underprivileged section.

1.1.1.2 Concept of social forestry

The basic concept of social forestry is to raising plantations by the common man so as to meet the growing demand for timber, fuel wood, fodder, etc., thereby reducing the pressure on the traditional forest area. In our country the concept of social forestry is not new. It is found in the preaching's of Buddha about 2500 years ago. Lord Buddha preached that every good Buddhist should plant one tree and look after it over five years so that it grows to a full tree and in this way he should plant about 5 trees in his life time. The Great Emperor Ashoka is credited to have got planted shady trees and fruit trees long the roadsides for the benefit of travelers. During early period of British rule, need for industrial expansion and communication required timber from the forests. Attempts made by the British were simply to reserve and demarcate forests for their

industrial needs. No significance was attached to important role of trees to the local population. In the monumental Report on Improvement of Indian Agriculture (1893) Voelcker observed that forests had not been preserved. His observation on keeping aside village forests for the local people was probably the first observation of importance of forests to people's economy. Social Forestry constitute a major element in India's overall program of rural development. As it has a rural development focus and therefore, is heavily dependent on the active participation of people in formulating and implementing the afforestation schemes based on their needs, potential and availability of inputs. Social forestry projects take varying forms depending on the particular (political, economic, cultural, ecological) environment and remain flexible because of the "social creativity" of the participating interest groups shaping this forest management

1.1.2 Objectives of Social forestry

The objectives of Social forestry adopted by the Commission (1976) were based on the economic needs of the community aimed at improving the conditions of living. The main objectives are

i) Fuel wood supply to the rural area so as to replace cow-dung as a source of energy

(ii) Meeting the fodder, fertilizer (green manure) fiber and small timber requirements

(iii) Protection of agricultural fields against adverse climatic factors

(iv) Meeting recreational needs

(v) Maximizing production and increasing farm returns

(vi) Provide jobs for unskilled workers

(vii) Reclaim wastelands, control soil erosion and water logging conditions

(viii) To raise the standard of living and quality of life of the rural and urban people.

1.2 Types of social forestry

The scope or components of social forestry defined by the Commission includes Farm forestry, Extension forestry, reforestation in degraded forests and Recreation forestry.

1. Community Forestry (village woodlots)
2. Farm Forestry (tree growing on private land)
3. Extension Forestry (strip plantations alongside roads, canals, railways, etc.)

4. Mixed forestry (fodder grass, fodder trees, fruit trees fuel wood on panchyat lands
5. Shelterbelts (belt of trees maintained for the purpose of shelter from wind, sun and snow-drift.
6. Recreational Forestry (Urban Forestry)
7. Reforestation or rehabilitation of degraded forest areas

1. Community Forestry (village woodlots): It consists of plantations of fuelwood species on community village lands, with intended objective of increasing a villager's access to fuel wood, fruits and fodder. Community forestry seeks the involvement of community in the creation and management of such forests. The practice of forestry on lands outside the conventional forest area for the benefit of local population has been called Community forestry.

2. Farm Forestry : Farm forestry is the name given to programmes which promote commercial tree growing by farmers on their own land Farm forestry was defined by NCA (1976) as the practice of forestry in all its aspects in and the around the farms or village lands integrated with other farm operations. The main Objectives is to meet their own needs, whether through the direct production of fuel wood, fodder, and poles. Tree seedlings may be planted in blocks (small plantations), on field boundaries. or around homesteads or may be intermixed with agricultural crops in several forms of agroforestry.

- **Farmer leasehold or *tree palta-*** denotes a kind of farm forestry in which poor farmers or landless laborers are given leases to a tracts of public land on which, with varying degrees of public support, they are constrained to grow trees.
- **Village woodlots -** are small plantations on communal or government lands, operated by or on behalf of the village, for the benefit of the village as a whole. Although, there may be special arrangements which provide preferential treatment to the under-privileged.

3. Extension forestry: Extension Forestry is the practice of forestry in areas devoid of tree growth and other vegetation. It is situated in places away from the conventional forest areas with the object of increasing the area under tree growth. It includes - **Mixed forestry, Shelterbelt**s, **Wind breaks, Linear Strip Plantation**

i) Mixed forestry: Mixed forestry is practice of forestry for raising fodder grass with scattered fodder trees, fruit trees and fuel-wood trees on suitable waste lands, panchayat land and village commons land.

ii) Shelterbelts: Shelterbelts is defined as 'a belt of trees, shrubs and/or grasses maintained at right angle to the direction of prevailing wind in order to Reduce wind velocity, Deflect wind current, Protect public properly in leeward side.

iii) Wind breaks: It is a protective planting around a garden, a farm or a field to protect it against strong winds. It usually consists of 2-3 rows of trees or shrubs, spaced at 0.5 m to 2.5 m apart, depending on the species.

iv) Linear Strip Plantation: These are plantations of fast-growing species on linear strips of land on the sides of public roads, canals and railway lines.

4. Rehabilitation of Degraded forests: The degraded area under forests needs immediate attention for ecological restoration and for meeting the socio economic needs of the communities living in and around such areas. The reforestation or rehabilitation of degraded forests refers to large plantations on public lands which have been severely degraded and which are often in environmentally critical areas. National Wastelands Development Board (established in 1985 under the Ministry of Forests and Environment) has started massive social forestry program and watershed management programs. . To grow short rotation fuel and timber species in order to organize fuelwood supplies at reasonable rates and to provide employment

5. Recreation Forestry: Recreation forestry is the practice of forestry with the object of raising avenue/flowering trees and shrubs mainly to serve as recreation forests for the urban and rural population. This type of forestry is also known as **Aesthetic forestry** which is defined as the practice of forestry with the object of developing or maintaining a forest of high scenic value. Recreational forests are being developed near towns and cities. The areas are being planted with flowering trees, shrubs and creepers to provide forest atmosphere near towns and cities.

1.3 People participation

1.3.1 People's Participation- Concept and Importance

Most simply defined, 'participation' means taking part. In the context of development theories, participation means direct involvement of all those people in the decision

making process which is likely to affect their lives. The way participation is defined largely depends upon the context and background in which participation is applied. While the Economic Commission for Latin America (1973) considers contribution by the people to Public Programmes to the complete exclusion of any involvement in the decision making process as participation. Cohen and Uphoff (1977) maintains that participation includes the people's involvement in the entire decision making process. FA0 (1982) emphasizes participation in all decision making process but by the People's own Organization and through self organized actions. Paul (1987) introduces the concept of enhancement of well being in terms of values cherished by the communities as being the ultimate objective of participation. Participation can be seen in two extreme forms. It can begin as passive participation where people are told what is going to happen or happened. People are just objects on whom action is thrust. On the other extreme is self mobilization where people participate by taking initiatives independent of external institutions to change systems. Participation starts from the conception stage up to the delivery of the product and its consumption. The process involves decision making at various stages, independent of any external influence. Participation can be categorized into various stages in which degree of involvement varies. The Typology of Participation are: Passive Participation t Participation in

Information giving Participation by Consultation Participation by Material Incentives Functional Participation Interactive Participation Self Mobilization In the above typology passive participation is at the one end of the spectrum where people are told what to do while on the other end is the self Mobilization where local people themselves are in total command. As one move from passive participation to self Mobilization control of local people &creases and outsiders decreases. According to Zubair Meenai (2008) "The principle of participation is widely recognized as a right in itself. The right to take part in the conduct of public affairs means that every person and all people are entitled to participate in, contribute to, and enjoy civil, economic, social and political development."

1.3.2 Importance of People's Participation:

Participation as a concept has found 'favour among masses, policy makers, politicians, and sociologists. Croft and Bensford (1994) have elaborated some arguments for participation. Most people want to be involved - People have intrinsic desire to get involved. People have right to be involved - people have the legal entitlements to be

involved, the rights to redress, to comment and to be consulted on issues impacting their lives and society. Participation has accountability - Accountability means not just being responsive but also answerable to the people. People have the right to know what is happening and why? Increased direct involvement of the service users results in more effective accountability of the service providers. Participation makes more efficient and cost effective services. Involving people challenges institutionalized discrimination. The Food and Agriculture Organization (FAO) looks at participation from three participation perspectives: (a) Functional, (b) Empowering and (c) Philosophical. Participation is understood at various levels. Conceptualization of participation has ranged from contributions by the people to Public Programme to the involvement of people in the entire decision making process (Zubair Meenai, 2008). Participation is seen from two perspectives:

1. Participation as a process - If seen as a process in development Programme, there is involvement of local people in implementation of externally designed initiative. There is collaboration along with external agency and local population whereby externally designed development activities are implemented in a participatory manner. Thus, participation is a means or instrument to implement a programme to achieve desired goals. **2. Participation as an end** - Participation as a goal of a policy initiative entails empowering people in terms of their acquiring skills, knowledge and experience to take greater responsibility for their development. People are. Provided access to power and resources to create opportunities which are self sustaining. Bastain (1997) sketches four different thematic variations in the concept of participation. First, participation is employed	**Participation** **Functional participation:** to increase efficiency and effectiveness of Research & Development. **Empowering Participation:** To increase the independence, awareness and capacity of marginalized groups.

as a simple means of getting unpaid, labour from the people. It serves the purpose of creating a sense of belonging among the public about the public utilities created. ,, Second, participation is interpreted as an attempt to provide self reliance. Third, participation approach is resorted as a technique to create ideal villages. Finally, participation is resorted as a method of Project Management	**Philosophical Participation:** Participation to allow expression of alternative views. Source: FAO /Org/.Participation /

1.3.3 People's Participation in Governance and Development:

The importance of people's participation in governance and development in recent years is highly recognized both by national and international organizations. , According to Joel and Bhore (2003). "The essence 'of development is nothing but people's participation. There are many components that are involved in development like money, material, resources, technology, human etc. Of all the social factors, human factors are the crucial elements. People are the pivot around whom the entire development processes are supposed to revolve." The above statement underlines the importance of peoples' participation in development process. Ever since societies have strived to develop, the methods of development have been widely debated. The early phase of development era emphasized on the Top down approach to development based on trickledown theory. During this phase, the emphasis was on planning at the top with focus on achieving higher growth rate. This approach was based on the premise that centralized planning ensures higher growth which automatically tickles down to grass root level. During 1950s and 1960s - modernization theories had been so pervasive that it was almost impossible to separate modernization from development linked to capitalism and economic growth" (Zubair Meenai, 2008).

However, the experience gained during this time reflected that these development strategies were losing battle against the poverty and hunger. Even a higher growth ' rate could not ensure equitable growth and disparities in development levels continued to either remain or get wider and wider. Participation as a concept and a strategy of

development is an outcome of the profound disillusionment with the established development strategy in post Industrial Revolution period. The experiences of the fifties and sixties have demonstrated the fundamental weakness of the Top down, GNP focused, growth centered strategy of development based on professional expertise and modernized technologies. The development strategy followed during this period emphasized economic growth and industrialization in the context of increasingly centralized planning and control over the distribution of resources (Joel and Bhore, 2003).

The origin of participatory approach to development is based on the failure of the growth cantered approach to achieve all around development. This phenomenon was observed across the countries and international agencies like UN, UNDP, ADB, FAO, hotly debated the feasibility of this model. Gunnar Myrdal, the Noble Prize winning Economist in the late 1960s urged governments to plan their economies actively, adopt social policies that enhanced people's welfare and take steps to redistribute income and wealth. This led to the publication of a major policy document from the UN (197l), 'Social Policy and Planning in National Development.'

It is now said that development is no longer a favour or a privilege to the people. It has to revolve around them. They cannot be treated as mute observer or objects or passive receivers as they are powerless and un-endowed. They are supposed to be prime movers of development at any given point of time. FAO, while, emphasizing the role of people's participation in governance and development, has listed various ways by which people's participation can be strengthened.

- ✓ Participation by information - a unilateral means of providing information to people without seeking their response.
- ✓ Participation in information giving - people do not participate in process of decisions making but are encouraged to share their views.
- ✓ Consultation - People participate by being consulted - The programmes and plans are subject to modifications based on response and input from people. However, same is non-obligatory.
- ✓ Joint Planning - people participate in joint planning, analysis and formulations of new methods. Local groups control local decisions and hence have stake in maintaining structures and practices.

- ✓ Decision making - when consensus is acted upon through collective decision, this marks the initiatives of shared responsibilities for outcomes that may result.
- ✓ Empowerment - The ultimate objective of participation wherein the local community has the right and capability to have a say in decision concerning their lives.

Participation in development is now being sought in World over, not because it is fad but because there has been a consensus on the usefulness of people's involvement in governance and development. This has several advantages like- .

Efficiency: Participation can ensure effective utilization of available resources. The people and other agencies work towards achieving their objectives, involvement and cooperation among all stake holders to improve efficiency and effectiveness of planning process.

Effectiveness: Failure of conventional growth strategy because of lack of grass roots knowledge and absence of people's role in development ma& most of the plans ineffective. People's participation can make the development strategy more effective by granting a say in dividing the objectives and strategies and participation in management ensures effective utilization of resources.

Coverage: People's participation in decision making process widens the coverage among all sections including deprived and weaker sections.

Sustainability: External interventions through government or other agencies lack potential for long term sustainability of schemes if local participation is not ensured. People's involvement in governing the scheme creates local capability and ownership of resources

1.3.4 Constraints in obtaining people's participation in Social forestry

- ✓ Antipathy to trees.
- ✓ Credit schemes, market support measures and tax rules.
- ✓ Lack of appropriate technology.
- ✓ Lacking of appropriate policies and public awareness.
- ✓ Lacking of suitable organization.
- ✓ Most people show future ignoring behaviour.

- ✓ Small size of holdings and land ownership.
- ✓ Social forestry generates common property resource.

1.4 Status of Social forestry projects in different states of India

Today a new consciousness is developing in our country about the importance of forests and social forestry. Social forestry is a new catch word which aims at meeting the fuel, fodder, fruit and timber needs of the people. The programme aims at covering a total of Rs 2.15 million hectares (ha) of land of which 1.52 million ha land will be covered under social forestry programme and the rest under production forestry. The afforestation in general and social forestry programme in particular have increased substantially in recent years. Several state governments have already started social forestry projects with the financial support of international agencies like world bank, Swedish International development authority (SIDA), Canadian International Development Authority (CIDA), US Agency for International Development (USAID). Important government initiatives to support social forestry are MGNREGA, Silviculture and Forestry Research, Natural Regeneration and Enrichment of Forests etc. and awareness campaigns like of Van Mahotsava, environment day, wildlife week etc. A well implemented and managed social forestry programme can meet the requirements of people, besides generating additional income from the sale of the surplus products. A well executed and accomplished Social Forestry programme can play important role in uplifting village life along with enhancing environmental sustainability.

The Government of India has already sponsored programmes like a “tree for every child”, eco-development camps involving college students in tree planting and free distribution of seedlings to farmers. State sponsored Agro-forestry schemes in Gujarat and Karnataka have resulted in plantation of trees of commercial values.

The World Bank has funded extension of the existing social forestry programme to bring under tree cover some 110,000 ha private land holdings currently being used for growing crops. Despite these developments, many environmentalists are critical of government’s social forestry schemes.

They often question the choice of tree species, monoculture plantations and the actual beneficiaries of these schemes. Critics of these schemes like Sundarlal Bahuguna

from the Garhwal district of Uttaranchal have charged that paper Mill owners and synthetic fibres manufacturers are using social forestry programme to meet their selfish end rather than helping the poor man facing energy famine.

In the hills of Uttaranchal recent afforestation pattern has changed and in place of naturally growing broad leaved deciduous tree species such as oak, Ash, Pangar etc., timber trees like Pines, Deodar and other conifers are being planted now which have industrial and commercial values. While the old stands of broad leafed trees produce rich humus and hold the rain water well, the new trees don't play an adequate ecological role. The survival rate of new tree species is also poor because local people don't care for commercial value of those trees as they do not gain anything from them.

1.5 Factors effecting success of social forestry projects and urban forestry

Baynes et al. (2015) identified five main interconnected factors that are likely to affect the success of a project, broadly defined as positive outcomes both social and environmental. These are:

(1) Inequality based on socio-economic status or gender,
(2) Security of property rights,
(3) Governance within community forestry groups,
(4) Government support or interference to community forest groups, and
(5) Material benefits to community members (See Figure 1 adapted from Baynes et al. 2015).

There are few studies that report project-level factors contributing to success of agricultural research projects. An ACIAR impact assessment study (Pearce, 2010) surveyed 30 people, who were Australian project leaders or ACIAR-employed research program managers and country managers and identified 14 factors that contributed to successful project outcomes, with the following six factors most often identified by respondents. There were few studies on the Participants' views on factors that enhance success or diminish success of the project are discussed in table 1.

- ✓ Clearly defined objectives and research questions based on a clear stakeholder needs and with a project plan that assigns clear responsibilities to participants.

- ✓ Strong communication leading to good collaboration, including formal and informal communication arrangements and compatible language skills.
- ✓ Trust, complementarily and alignment of interests, including effective interpersonal relationships and mutual empathy and respect.
- ✓ Good project leadership and management support, including the capacity to empower the research team, co-ordinate diverse groups and engender institutional support.
- ✓ Strong and capable research team, including having the right technical abilities and the time commitment to undertake the required research; and
- ✓ Institutional support both for the Australian and in-country partner.

Table 1: Participants' views on factors that enhance success or diminish success

Factor no.	Success factors	Participants' views on factors that enhance success or diminish success	
		Enhance success	**Diminish success**
1	Collaborative scoping and design	Good collaboration with partners on scoping and the specifics and achievability of project design	Inadequate consultation with partners, incorrect assumptions and too ambitious or poorly focussed design
2	Skills mix and time allocations	Having appropriate skilled and experienced scientists with sufficient time allocations, including some full-time staff	Team with inappropriate skills mix, inexperienced or overcommitted scientists and no dedicated project staff
3	Funding, facilities and equipment	Adequate funding and other resources, including donor and partner contributions	Inadequate funding, facilities or equipment to undertake planned activities and delays in provision of funds to project activities
4	Scientists commitment, collaboration and focus	Dedicated and focused and accountable scientists and with collaborative team work	Scientists lacking interest, commitment or focus and poor collaboration within team
5	Team and technical capacity building	Supporting team and institutional capacity building, informal and formal study opportunities	Poor focus on capacity building of project partners
6	Mutual benefit of research topic	Selection of research issue with mutual benefits	Research does not provide mutual benefits for each country

7	Selection and commitment of partner institutions	Effective selection and ongoing commitment of project partners	Poor institutional support or functionality, changes in priorities or conflict with partners and having too many partners to coordinate
8	Site selection and scientific rigour of trials	Appropriate sites for research trials with good scientific design and stakeholder support	Inappropriate trial location or poor scientific discipline in trial establishment
9	Leadership and management	Good leadership and effective project planning and oversight	Poor leadership and inefficient project management
10	Strong, culturally appropriate team relationships	Respect of culture, patience and developing friendships	Poor relationships or misunderstandings within team and no mechanisms for resolving conflicts or misunderstandings
11	Time spent on in-country collaboration	Sufficient resourcing to enable adequate time of external researchers in country, with frequent visits by project leader and various project staff	Infrequent visits by project leader, lengthy gaps in visits from project staff, inadequate travel funds or other restrictions limiting travel
12	Effective communications and research networks	Good and regular communications within project and effective dissemination of knowledge	Poor communications between team members, unavailability and unreliability of public communications systems and failure to disseminate results to stakeholders
13	Links to impact pathway and user benefits	Results linked to stakeholder benefits	Poor communication of project results to users or lack of benefits for stakeholders from research
14	Implementation flexibility, monitoring and review	Flexibility to adapt activities and appropriate monitoring and review of progress, including a mid-term review process	Overly prescriptive outputs, no flexibility to adapt, poor monitoring, no mid-term review or lack of follow-up on review recommendations
15	Continuity of partner institutions and team	Continuity of key staff in partner institutions and with partner researchers	High turnover or non-replacement of project staff and changes of structures or leadership support within partner institutions
16	Duration of project	Not identified	Duration too short to implement activities and obtain results
17	Donor influence on design	Not identified	Donor finalising project or insisting on design elements not agreed to by all partners

18	Long-term research collaborations	Long-term relationships supported via follow on projects	Lack of follow on research projects
19	Continuation of research post-project	Agencies continue research after project, donor facilitates ongoing monitoring of trials or has a clear exit strategy	No funding available after project or no exit strategy
20	Alignment with national development objectives	Research relevant to national policies, priorities and programs	Not identified
21	Experience of project leader in country	Good understanding of local culture and operating environment	Naivety of project leader about local context
22	Trust within team	Trust between project participants	Lack of trust within team or of confidence with stakeholders
23	Local government and community support	Engaging with local government and communities to achieve good support but manage expectations	Poor collaboration or conflicts with local government or communities
24	Engagement with private sector	Effective engagement of private sector partners in conduct and adoption of research, including managing expectations	Lack of engagement with or support from private sector partners
25	Publication and dissemination of results	Joint involvement in scientific articles and effective dissemination of scientific and extension information	Ineffective dissemination of scientific or extension information
26	External factors: policies, markets, environmental, security	Supportive policies, established markets, good local security situation	External factors influencing research facilities, trials or markets and lack of appropriate supporting policies or unforeseen delays related to national elections or security problems affecting travel
27	Engagement of policy actors	Effective engagement of policy actors to translate findings into policy	Inability to engage policy makers to generate supportive policies
28	Willingness to adopt innovation	Farmers and communities willing and able to adopt and adapt innovations	Culture, finance or risk limit adoption of technologies
29	User champions	Engagement of farmer or industry champions	Not identified
30	Collaboration with international scientists	Benefits from collaboration with international scientists	Not identified
31	Clarity of roles and responsibilities	Clear definition of roles, responsibilities and delivery expectations	Partner staff do not understand their roles or what is expected of them

32	Stakeholder and partner coordination	Appropriate mechanism to coordinate stakeholders and provide feedback	Lack of an advisory committee mechanism to discuss issues and promulgate results to key stakeholders
33	Provision of incentives	Payment of incentives to local staff and collaborators	No tangible or financial incentives to participate in project
34	Community or land disputes	Not identified	Disputes within community or about land tenure disrupt project
35	Corruption or misuse of funds	Appropriate management of project funding	Corrupt practices and misappropriation of project funding
36	Political support or interference	Supportive political and institutional environment	Unsupportive political environment or direct interference in project
37	Gender roles and empowering women	Not identified	Focusing on empowering women without understanding role of men

1.6 Urban forestry

Urban forestry is the art and science of managing trees and forest resources in and around urban community ecosystems for availing physiological, sociological, economic and aesthetic benefits trees provide for society. Urban Forestry concentrates on all tree-dominated as well as other green resources in and around urban areas, such as woodlands, public and private urban parks and gardens, street tree and square plantations, botanical gardens and cemeteries.

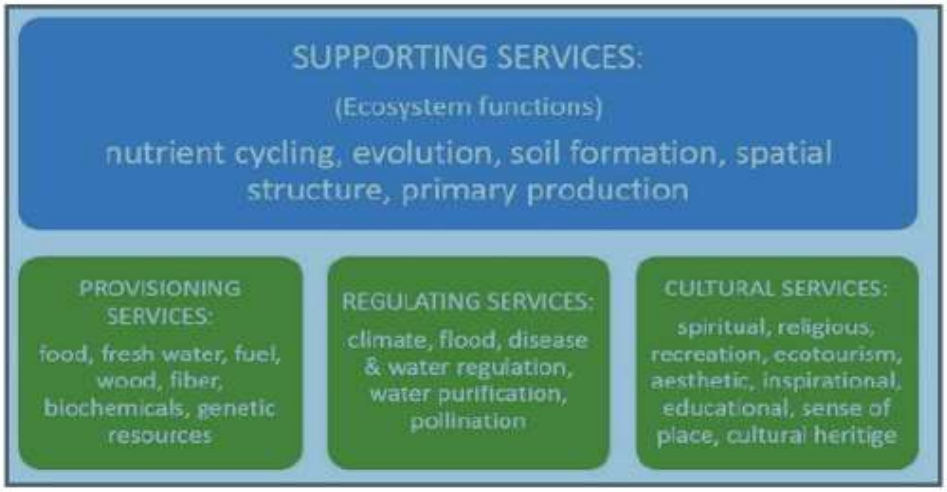
Gandhinagar leads in per capita urban greenery among Indian cities with Chandigarh taking second. Cities renowned for their urban green spaces often have 20% to 35% coverage of total geographical area. For Chandigarh it is 35%, Delhi 20% and Gandhinagar it is 57.13%.

Benefits of Urban forestry

A) Ecological Benefits

- ✓ Microclimate and Urban Heat Island effect: Urban trees can help to improve the air quality by cooling and cleaning the air, reducing smog, ground-level ozone and greenhouse effect. They can mitigate the heat island effect by giving green lungs to cities.

- ✓ Carbon Sequestration: Urban forests can sequester huge amounts of carbon by capturing carbon dioxide from atmosphere.
- ✓ Biodiversity: Trees and forests present in urban areas can provide shelter and habitat to many important animals especially avifauna.
- ✓ Management of Urban Hydrological Cycle: Through water provisioning, regulating, recharging and filtering role, urban forests play key roles in supporting water management in and around urban settlements.
- ✓ Ecosystem services



B) Social Benefits

- ✓ **Checks Haphazard Urbanization:** Urban forests can check rapid and unplanned urbanization; development of slums by demarcating city limits and industrial spaces.
- ✓ **Aesthetic Benefits:** Urban trees enhance beauty and environmental quotient of city contributes to aesthetic quality of residential streets and community parks.
- ✓ **Improves Mental Alertness And Reduce Stress:** Green areas reduce stress and improve physical health for urban residents while providing spaces for people to interact.
- ✓ **Education:** Urban forests in the form of parks, botanical gardens, zoological gardens, avenue trees and other urban green spaces are centres of education on flora and fauna.
- ✓ **Recreation:** Green parks provide a break from the busy, tiring, often repetitive and tedious routine jobs and works for people and safe playgrounds for children

- ✓ **Cultural Regeneration:** Urban green spaces can enhance cultural activities by providing venues for local festivals, civic celebrations, political gatherings and theatrical performances.

C) Economic Benefits

- ✓ Real estate prices: Landscaping with trees—in yards, in parks and greenways, along streets, and in shopping centres—can increase property values and commercial benefits
- ✓ Employment: Tree planting and maintenance in urban forests can be labour intensive and provide work opportunities which may be especially important in poorer cities.
- ✓ Reduced energy consumption: Urban forest offers significant benefits in reducing building air-conditioning demand and reducing energy consumption.

Summary

Suggested readings

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UNIT 2: Social forestry plantations I

Unit Structure

2.0 Learning Objectives

After completing this unit you shall be able to:

- Define the concept of social forestry plantations
- Know about the energy plantations
- Plantations techniques for different regions

2.1 Introduction

India was one of the first countries to have launched social forestry. In 1950, the festival of tree planting was instituted by the Central Government as an annual feature. Since then, rapid developments have taken in the field of social forestry. The National Forest Policy (1952) strengthened the emphasis to be laid on these programmes.

Forest plantations now cover about 140 million hectares (Mha) globally, representing about 4 per cent of the global forest area (FAO, 2005a). In terms of wood production, plantations are much more important than their share of the forest area indicates, and their importance is expected to increase with time. In 2000, plantations supplied one-third of the total demand for industrial round wood. According to some estimates, approximately half of the global industrial round wood supply will be provided by

plantations and planted forests by the year 2040. Globalization of markets for forest products and services brings new opportunities and challenges for plantation-based forestry and forest enterprises. In addition to meeting the growing demands of the pulp and paper industry with fiber from fast-growing plantations, there are opportunities for value-added wood products for expanding international and domestic markets. However, in forest plantations those are managed sustainably and competitively, intensive silvicultural interventions are required in order to fully optimize the production of high-quality products. In addition to production of wood and fiber, forest plantations provide several other ecosystem services, including carbon sequestration, clean water production, regulation of the hydrological cycle, and improvement in the connectivity of landscape mosaics for biodiversity conservation and the alleviation of desertification. It is expected that the relative importance of such services provided by forest plantations will increase in the future.

FAO (2006a) defines plantations as 'forests of introduced species and in some cases native species, established through planting or seeding, with few species, even spacing and/or even-aged stands'. This definition includes not only industrial plantations established for the production of biomass and timber, etc., it also includes small-scale home and farm plantations, agroforestry plantations and plantations established to achieve ecological objectives, such as soil protection and wildlife management. This broad definition of plantations is encapsulated in the typology of planted forests provided by the Center for International Forestry Research CIFOR, 2001). The types of plantations are not only distinguished by their different purpose, but also by their spatial scale, management intensity, structure and ownership. In the typology provided by CIFOR (2001), the 'managed secondary forests' can be regarded as a transitional type between plantations and other forest types. This evolution of concepts and definitions has had its pros and cons. On the positive side, experts argue that the introduction of 'planted forests' is a move towards a more inclusive concept allowing a better reflection on all the seeding', are divided into two sub-groups: productive plantations and protective plantations. In turn, they are defined by FAO (2005a) as:

- ✓ **Productive plantation**: forest plantations predominantly intended for the provision of wood, fiber and non-wood products; and

- ✓ **Protective plantation:** forest plantations predominantly for the provision of services such as the protection of soil and water, rehabilitation of degraded lands, combating desertification, etc.

2.2 Energy plantations

Energy is the key factor for the economic growth of any nation and India is no exception. In spite of increasing availability of energy, there is always need for more. This is the reason which has prompted the world countries to develop alternative sources of energy like geothermal, solar nd wind. Moreover we must use the available coal reserves sustainably.

In this context, crops producing hydrocarbons are very important. Petro plants accumulate photosynthetic products like hydrocarbons of high molecular weight. In 1979, M. Calvin of the University of California reported the collection and use of photosynthetically produced hydrocarbons. He suggested them as a substitute for conventional petroleum sources.

Most of the plants belonging to the family Euphorbiaceae, Asclepiadaceae, Anacardiaceae, Asteraceae, Caprofoliaceae and Lamiaceae are promising petroplants. Euphorbia lathyris of family Euphorbiaceae is considered as most suitable petrocrop containing more than 5% oil and polymeric hydrocarbons.

Technically, energy plantation means growing selected species of trees and shrubs which are harvestable in a comparably shorter time and are specifically meant for fuel. These plantations help provide wood either for domestic or industrial purposes.

The energy plantations provide almost inexhaustible renewable sources of energy which are local and independent of unreliable and finite sources of fuel. The total time constant for each cycle is 3-8 years only.

2.2.1 Features of Energy Plantations The attractive features of energy plantations are:

- ✓ Good amount of heat content of wood
- ✓ Wood low in sulphur and non-polluting
- ✓ Ash from burnt wood is a valuable fertilizer
- ✓ Raising plantations in erosion-prone lands helps to reduce soil erosion
- ✓ Help in rural employment generation

2.2.2 Significance of Energy Plantations

Energy plantations are the plants planted only for use as fuel. The woody plants have been used since ancient times to generate fire for domestic and industrial purpose. In recent years, to meet the ever growing demand of energy, plantation of energy plants is been encouraged. We are all aware that trees are cut in many of the forest belts of India like Gangetic plains, Siwalik region and foot-hills of Himalayas.

In terms of fuel wood production, India is the biggest, but the per capita fuel wood production is very low. In India, people of hill area hardly get fire-wood plants and they have to go to interior of forest to collect wood-falls. Also introduction of technologies developed for plains is not achievable in these areas.

For example, they cannot be motivated to use solar cooker, because of being solely traditional and religious. Even gobar gas plant cannot be useful in hills, due to low temperatures. Therefore, renewable source of energy is highly desirable for survival of population in hills and for reducing the pressure on forests. And thus, energy plantation has got great support in our country.

For obtaining good amount of biomass, afforestation and forest management government has started many plans like social forestry, silviculture and agro-horticulture practices in waste and barren lands. These programmes include growing of drought resistant, salt resistant, pollutant resistant and high density energy plantations (HDEP) in waste and barren

The technique used in high density energy plantations, HDEP is the practice of planting trees at close spacing. Here the trees grow rapidly due to struggle for survival. It provides fast and high returns with many opportunities of permanent income and employment.

2.2.3 Social Forestry: Energy plantation and power programme

Plantation through social forestry has been highlighted by the Government of India to meet the demand of fuel and fodder in the rural areas. Through social forestry, trees are planted along road sides, canals, railway lines and waste lands in villages.

The following must be considered while selecting plant species for energy plantations:

- ✓ The species should be local. This helps for better climatic and soil adaptation.
- ✓ Species should show rapid growth and high coppicing ability.

- ✓ The species should also produce additional products like fruits, seeds, fodder and green manure apart from fuel wood.
- ✓ The species must have hard wood.
- ✓ The species must have low requirement of water and fertilizer.
- ✓ The species must have ability to increase the soil quality.
- ✓ The species also should have high calorific value of wood.

2.2.4 List of Social forestry plants

The following is the list of plants included in social forestry: Petro crops

Petro crops	**Family name**
Acacia nilotica	Fabaceae
Albizia lebbek	Fabaceae
Albizia procera	Fabaceae
Anthocephalus chinensis	Rubiaceae
Azardirachta indica	Meliaceae
Bauhinia variegata	Fabaceae
Butea monosperma	Fabaceae
Cassia fistula	Fabaceae
Dalbergia sisso	Fabaceae
Eucalyptus globulus	Mrytaceae
Eucalyptus citriodora	Myrtaceae
Ficus glomerata	Moraceae
Lagerstroemia speciosa	Lythraceae
Madhuca indica	Sapotaceae
Morus alba	Moraceae
Populus ciliata	Salicaceae
Populus nigra	Salicaceae
Terminalia arjuna	Combritaceae
Toona ciliata	Melicaceae
Salix alba	Salicaceae
Salix tetrasperma	Salicaceae

2.3 Plantations at different sites

In view of getting maximum biomass, afforestation and forest management systems will have to be developed. These must include social forestry, silviculture (short-rotation forestry) tree-use systems, coppicing system, drought, salt-, pollutant - resistant plantations and high density energy plantations (HDEP). HDEP is the practice of planting trees at close spacing. This leads to rapid growth of trees due to struggle for survival. It provides quick and high returns, and opportunities for permanent income and employment. Therefore, annual plants should be grown to meet the demand of energy. Keeping in view the climatic and edaphic factors, plantation of deciduous trees should be encouraged, as their growth is faster than the coniferous ones. The species to be planted should have the following characters:

- ✓ fast growth,
- ✓ stress resistance,
- ✓ less palatable to cattle and other animals,
- ✓ early propagable,
- ✓ high caloric value,
- ✓ absence of deleterious volatiles when smokes come out,
- ✓ high yield of biomass, and
- ✓ disease/pest resistant.

Plantation through social forestry has been much emphasized by the Government of India to meet the demand of fuel and fodder in the rural areas. It will certainly decrease the gradually increasing pressure on the forests. This includes planting trees along road sides, canals, railway lines and waste lands in villages. Some of important plants are: *Acacia nilotica, Albizialebbek, A. procera, Anthocephalus chinensis, Azadirachta indica, Bauhinia variegata, Butea monosperma, Cassia fistula, Dalbergia sissoo, Eucalyptus globulus, E. citriodora, Ficus glomerata, Lagerstroemia speciosa, Madhuca indica, Morus alba, Populus ciliata, P. nigra, Terminalia arjuna, Toona ciliata, Salix alba* and *S. tetrasperma*.

2.3.1 Road side plantations

Roadside plantations have several objectives:

- ✓ Trees increase the comfort of travellers by providing shade and attractive surroundings;
- ✓ Trees may protect the road itself against moving dunes or act as a windbreak for adjacent fields.
- ✓ Trees may become an important factor by alleviating timber and fuelwood shortage. In fact, roadside trees are frequently considered a part of the national forest planting programme. Such trees may produce edible fruit, yield pods for feeding animals, furnish food and shelter for birds or, when in bloom, be valuable in beekeeping.

Species should be carefully chosen. Among the important factors which should be considered in planning the use of trees along highways are :

- ✓ Selection of the species for hardiness, longevity, freedom from windthrow and breakage, attractive appearance and minimal maintenance. In the arid zone there are a large number of native small trees and large shrubs which can be used, as well as some exotic species. Where the environment is suitable, consideration should be given to small patches of deciduous species with colorful foliage.
- ✓ Suitability of the species to the climate, topography and soil.
- ✓ Location of the trees in relation to road formation. Firstly consideration should be given to the existing road formation so that trees ar not planted close to the inside of curves or near road junctions where they could obscure vision and so create a driving hazard. Secondly, consideration should be given to the possibility of the future widening of roads, including the development of double traffic lanes.

Plants along the Road Sides	Plants for Road Dividers
Acacia auriculiformis or *A. nilotica*	*Acalypha wilkesiana*
Ailanthus excelsa	*Bougainvillea spectabilis*
Albizzia lebbeck	*Caesalpinia pulcherrima*
Alstonia macrophylla	*Callistemon lanceolatus*
Anogeissus sericea	*Callistemon polandii*
Azadirachta indica	*Cassia surattensis*
Bauhinia acuminate	*Duranta plumeri*
Bauhinia purpurea	*Euphorbia milli*
Butea monosperma	*Haemilia patens*
Cassia fistula	*Hibiscus rosa – sinensis*
Cassia marginata	*Ixora coccinea*
Cassia siamea	*Jatropha panduraefolia*
Ceiba pentandra	*Lantana camara*
Dalbergia latifolia	*Lantana depressa*
Dalbergia sissoo	*Neruim oleander*
Emblica officinalis	*Vinca rosea*
Eucalyptus globulus	
Ficus benghalensis	**Plants for Traffic Islands**
Ficus religiosa	*Bougainvillea cultivars*
Guazuma ulmifolia	*Neruim oleander*
Lagerstroemia duperreana	*Cycas revoluta*
Lagerstroemia rosea	*Plumbago capensis*
Lagerstroemia flosreginae	*Hibiscus geranioides*
Tamarindus indica	*Themeda triandra*
Polyathia longifolia	*Nandina domestica "Nana"*
Pongamia pinnata	
Tectona grandis	
Terminalia arjuna	
Thespesia populnea	

2.3.2 River bank plantations

There are many areas where river lengths are considerable. The ground on either side of the river is partly within the reach of the high level of water during the period the rivers are in flood. Beyond this level - and on the fringes of the agricultural land, strip plantation can be established to produce wood, fuelwood and fodder. Generally, the width of such strips is limited but does constitute a useful and productive linear plantation. Underground water is available at different levels. With the stress on irrigation and power projects, in all the states, every state has very large and extensive canal systems. The canals are dug up and the excavated earth is heaped on one or side, these banks or embankments are poor in their fertility. They need to be projected from erosion, which starts with rills and slowly gullies are formed and these thus create breaches in the canal. Tree growth protects the bank and also prevents evaporation of the water in the canal. Canal bank plantation also serves as shelter belts to many fields

adjoining the canals. These belts or strips are also available for growing tree vegetation.

Species suitable for canal or river bank plantations are those which can yield fuel, pulpwood and timber. The species to be planted should be matched with this water level variation. Spacing within and between the rows depends on the characteristics of the species and the rotation planned for the crop. In the more arid areas, trees with xerophytic habit constitute the outermost rows while those close to the river bank are the ones with higher water requirement. In such locations, phreatophyte species such as *Populus spp., Acacia nilotica, Dalbergio sisso, Prosopis* spp. can be planted. Bamboo and teak is raised in suitable well drained soils, will prove of high economic value. Bamboo can be harvested after every 3 to 4 years. The other species recommended are *Eugenia Jambolana, Dalbergia sissoo, Mangifera indica, Acacia arabica. Ailanthus excelsa, Terminalia arjuna, T belerica, Pongamia glabra, Muduca latifolia, Tamarindus indica, Azadirechta indica, Sesbania species, Eucalyptus species and Casuraina equisitifolia*. In soils with stony and gravel, Agave species can be successfully established. Punjab, Uttar Pradesh and Haryana have raised to considerable extent canal bank plantations.

2.3.3 Coastal Regions Plantations

Coastal areas have their own particular climate: there is less rainfall than there is inland, the sun shines longer and the wind is usually stronger with powerful gusts. The salt that the sea wind brings with it also means the trees are prone to dry out more quickly. Trees on the coast therefore need first and foremost to be wind resistant, tolerant to drought and impervious to salt. An additional complicating factor is that the soil is often barren and dry. Trees need to be able to put down deep roots to anchor themselves properly and get the water they require out of the soil. Fortunately there are trees that are very good at this and thrive perfectly well on the coast. As a result of the wind, trees in coastal area are shorter than their inland cousins and the crown may also be different. Close to the coast, in open dune areas, the crowns are usually asymmetric and the most common wind direction is revealed by their shape.

A) Suitable species for the seaside

Trees with hard leaves and grey leaved trees, such as *Hippophae* and Elaeagnus do well on the coast, as does the trembling poplar. A lot of limes are also resistant to sea

wind but they do make more demands on the soil. It may not be too infertile. Furthermore, almost all pines are suitable for coastal areas with *Pinus sylvestris* being the most common. This tree can still grow well on the most infertile soils and also has the ability to extend its roots deep into the ground. The Scots pine is therefore able to cope well with storms coming off the sea.

One exceptional species of pine that is suited to the coast is *Pinus parviflora 'Glauca'*. This cultivar doesn't grow so tall but it can be wide-spreading. '*Glauca'* has an irregular habit and blue-grey needles: an attractive tree that can be used as a solitaire for planting in coastal gardens. *Pinus nigra* subsp. *nigra* also lends itself for use in private gardens. This species has very long, dark-green needles and is also available as a multi-stem tree. The trees mentioned are just a few examples, but there are many more such species.

B) Trees for coastal areas

Coastal areas have their own particular climate: there is less rainfall than there is inland, the sun shines longer and the wind is usually stronger with powerful gusts. The salt that the sea wind brings with it also means the trees are prone to dry out more quickly. Trees on the coast therefore need first and foremost to be wind resistant, tolerant to drought and impervious to salt. An additional complicating factor is that the soil is often barren and dry.

UNIT 3: Social forestry plantations II

Unit Structure

3.0 Learning Objectives

After completing this unit you shall be able to:

- Plantations in marshy and waterlogged areas
- Trees suitable for waterlogged areas
- Trees Suitable for Marshy Areas
- Plantations in sand zone and mountainous regions

3.1 Introduction

Water logging is a condition of land in which the soil profile is saturated with water either temporarily or permanently. In waterlogged lands, the water table rises to an extent that the soil pores in the crop root zone are saturated resulting in restriction of the normal circulation of air. This causes a decline in the level of oxygen and increase in the level of carbon dioxide. Generally, the water table is located at or near the surface resulting in poorly drained soils, adversely affecting crop production. Areas with water table within 2 m below the ground surface are considered as prone to waterlogging and those with water table within 2-3 m are considered to be at risk. Waterlogging can reduce the agricultural and economic value of land causing yield reductions or at times, total crop failures. Waterlogging is a drainage problem. A marsh is a type of wetland, an area of land where water covers ground for long periods of time. Unlike swamps, which are dominated by trees, marshes are usually

treeless and dominated by grasses and other herbaceous plants. The areas where rainfall occurred for long duration and high. The soil remains moist but not necessarily waterlogged. High humidity pervades the atmosphere. This type of situation is common throughout the plains in the country. Waterlogged areas along the roads are generally due to inadequate drainage pattern. The road acts as a bund and contributes to water logging in the region of high water table or the low lying nature of the terrain.

3.2 Plantations in marshy and waterlogged areas

Planting of such sites after proper drainage is now a common practice. *T. Arjuna, Jamun* and *Eucalyptus* sp. are usually recommended for waterlogged areas. Bamboos can also be planted in such areas. Plantation scheme for such areas should be so decided that the plants can grow well under the waterlogged conditions, do not need much maintenance and, if possible, can even help in lowering the water table.

3.1.1 Trees suitable for waterlogged areas

1. Alstonia scholaris

2. A. macrophylla

3. Amherstia nobilis

4. Barringtonia acitamgia

5. B. racemosa

6. Bauhinia variegate

7. B. pupurea

8. Brownea coccinea

9. B. ariza

10. Cassia marginata

11. C. javanica

12. C. nodosa

13. Colvillea recemosa

14. Delonix regia

15. Dillenia indica

16. Guaiacum officinale

17. Lagerstroemia speciosa

18. L. thorelli

19. Millettia peguensis

20. Peltophorum ferrugineum

21. Samanea saman

22. Polyalthia lognifolia

23. Rpendula

24. Pongamia pinnata

25. Putranjiva roxburghii

26. Saraca asoca

27. Terminalia arjuna

28. Tamarindus indica

3.2.2 Trees Suitable for Marshy Areas

Areas which remain waterlogged for a considerable period of the year come under this ecological environment. Trees suitable for such areas are:

1. Barringtonia acutangula -

2. B. racemosa

3. Eucalyptus rostrata

4. Hibiscus tiliaceus

5. Salix babylonica

6. S. tetrasperma

7. Tamarix articulate

From the above species eucalyptus rostrata can not only grow under marshy conditions, but has capacity to draw up large quantities of water for transpiration. Sometimes this species is used for drying up marshy land.

3.3 Plantations in sand zone and mountainous regions

Forests play crucial roles in the sustainable development of mountain regions, which are home to about one-tenth of the global population. More than half of humanity relies

on the fresh water that accumulates in mountains, for drinking, domestic use, irrigation, hydropower, industry, and transportation. Mountain forests help to capture and store essential atmospheric moisture, to regulate river flow, and to reduce erosion and sedimentation downstream. Mountain forests are important sources of valuable timber and other wood and non-wood products in many countries. The main fuel source for mountain people in developing countries and, to a lesser extent, industrialized countries, is wood. Fuelwood collected in the mountains is a major fuel source both for local people and those in nearby settlements in the foothills and plains; cooking fires can also help heat homes, dry and prevent insect damage to stored crops, and purify water. Many mountain forests are subject to high, and often unsustainable, levels of logging and clearance for agriculture. There are many types of mountain forests. They range along a continuum from wholly natural forests, never influenced by human activities; to various forests whose composition has been altered by people through the removal and planting of selected species; to man-made plantations. Tree replanting also altered the ecological balance of the hills: slow-growing oaks and deodar (Himalayan cedar) were replaced with chir pine, for both timber and resin use. The forest department became the main enforcer of both appropriated "reserve" forest boundaries and the new plantations.

While plantations are man-made tree formations, they retain some of the value of natural forests and can maintain some biodiversity by providing limited wildlife habitat. The management practice employed is the decisive factor; lack of field or ground layers (understory vegetation) can exacerbate soil erosion and runoff. Plantations are more effective carbon sinks than late-seral forest, and some plantations mature into secondary forest if allowed to do so, or act as nurse crops for natural re-vegetation. Plantations may also provide some protection for watersheds, or capture water from clouds where appropriate cloud forest conditions exist. Planting conifers in place of broadleaved woodland, however, causes almost irreversible damage: the soil becomes acidified, which causes a whole range of ecological effects, not least to the local drainage area. Conifer plantations have a higher transpiration rate than natural vegetation, which reduces overall runoff. Similarly, in Fiji, water flow into a reservoir was significantly reduced as a result of the establishment of *Pinus radiata* plantations intended to protect the watershed. Where drainage channels are necessary -- as in Sitka spruce plantations on the wet uplands of the UK -- water leaves the catchment

more rapidly than it would with natural upland vegetation (such as the highly absorbent Sphagnum moss), and results in greater peaks and lows in runoff patterns

In sandy areas, only such species of vegetation are recommended which have the least water requirement and are of succulent and spring type with thinner leaves. As far as possible, local plants should be preferred from the angle of easier maintenance and bringing up. Besides beautification, one of the functions of vegetation in desert areas is to act as a barrier against shifting sand. Where it is not possible to grow plants for this purpose all along the road, effort should be to develop at least smaller pockets at intervals which could also act as rest areas. Such rest areas in the desert will be able to provide considerable relief to road users in intense heat.

Table1. Some Fuelwood and fodder tree species

1	*Acer acuminatum Wallich ex D.Don*	33	*Cynodon dactylon Persoon*
2	*Acer caesium Wallich ex Brandis*	34	*Cynoglossum glochidiatum Wallich ex Benth.*
3	*Achyranthus aspera L.*	35	*Debregeasia longifolia Wedd.*
4	*Aesculus indica Hook.*	36	*Debregeasia salicifolia Rendle.*
5	*Agrostis pilosula Trinius*	37	*Dendrocalamus strictus Nees*
6	*Alnus nepalensis D.Don*	38	*Desmodium elegans DC*
7	*Amaranthus viridis L.*	39	*Desmodium laxiflorum DC.*
8	*Anemone vitifolia Buch.-Ham. ex DC.*	40	*Dicliptera bupleuroides Nees*
9	*Apluda Mutica L.*	41	*Dodecadenia grandiflora Nees*
10	*Aplula aristata L.*	42	*Echinochloa crus-galli P. Beauv.*
11	*Artemisia nilagirica*	43	*Eleusine coracana Gaertner*
12	*Arthraxon lancifolius Hochst.*	44	*Engelhardtia spicata Leschenault ex Blume*
13	*Arundinella pumila Steudel*	45	*Eragrostis sp.*
14	*Astilbe rivularis Buch.-Ham. ex D.Don*	46	*Eranthemum palchellum Andrews*
15	*Bauhinia purpurea L.*	47	*Euonymus pendulus Wallich*
16	*Bauhinia semla Wunderlin*	48	*Euonymus tingen Wallich*
17	*Bauhinia vahlii Wight & Am.*	49	*Eurya acuminata DC.*
18	*Bauhinia variegata L*	50	*Fagopyrum dibotrys Hara*
19	*Betula alnoides Buch.-Ham. ex*	51	*Fagopyrum esculentum Moench*

D.Don

20 *Bidens pilosa L.*
21 *Boehmeria macrophylla D.Don*
22 *Boehmeria platyphylla D.Don*
23 *Boehmeria rugulosa Wedd.*
24 *Bothriochloa pertusa A. Camus*
25 *Brachiaria villosa A. Camus*
26 *Bridelia retusa Sprengel*
27 *Broussonetia papyrifera Ventenat*
28 *Carpinus viminea Lindley*
29 *Celtis australis Hook. f.*
30 *Cenchrus ciliaris L.*
31 *Chenopodium album L*
32 *Chenopodium botrys L*
65 *Chrysopogon fulvus Chiovenda*
66 *Chrysopogon gryllus Trinius*
67 *Commelina benghalensis L.*
68 *Corylus jacquemontii Decne.*
69 *Cotoneaster bacillaris Wallich*
70 *Pouzolzia zeylanica J. Bennett & Brown*
71 *Prinsepia utilis Royle*
72 *Prunus armeniaca L*
73 *Prunus cerasoides D.Don*
74 *Prunus cornuta Steudel*
75 *Pyrus pashia Buch.-Ham ex D.Don*
76 *Quercus leucotrichiphora A. Camus.*
77 *Quercus semecarpifolia J.E. Smith*
78 *Quercus floribunda L.*
79 *Quercus glauca Thunb.*
52 *Ficus auriculata Lour.*
53 *Ficus hederacea Roxb*
54 *Ficus hispida L. f.*
55 *Ficus neriifolia Smith*
56 *Ficus palmata Forsk.*
57 *Ficus racemosa L.*
58 *Ficus sarmentosa Buch-Ham.*
59 *Ficus semicordata Buch.-Ham..*
60 *Ficus subincisa Buch.-Ham.*
61 *Galinsoga parviflora Cav.*
62 *Galium elegans Hara & Gould*
63 *Geranium wallichianum D.Don*
64 *Girardinia diversifolia Friis*
107 *Grevia optiva Drummond ex Burret*
108 *Hedera nepalensis K. Koch*
109 *Heteropogon contortus P. Beauv.*
110 *Holarrhena pubescens Wallich.*
111 *Hordeum vulgare L.*
112 *Hypericum choisianum* Wallich
113 *Hypericum elodeoides Choisy*
114 *Ilex dipyrena Wailich*
115 *Ilex excelsa Hook, f*
116 *Impatiens balsamina L.*
117 *Impatiens scabrida DC.*
118 *Indigofera heterantha Wallich*
119 *Justicia simplex D.Don*
120 *Leucaena leucocephala De Wit*
121 *Leucas aspera*

80 *Reinwartia indica Dumortier*
81 *Rhamnus persica Boissier*
82 *Rhododendron arboreum Smith.*
83 *Rubia manjith Roxb. ex Fleming*
84 *Rubus ellipticus Smith*
85 *Rubus niveus Thunb.*
86 *Rubus paniculatus Smith*
87 *Salix acenophylla Boissier*
88 *Salix denticulata Anderson*
89 *Salix tetrasperma Roxb.*
90 *Sarcococca saligna Muell-Arg.*
91 *Schleichera oleosa Oken*
92 *Scurrula elata Danser*
93 *Senecio nudicaulis Buch-Ham. Don*
94 *Setaria pumila Roemer & Schultes*
95 *Smilax glaucophylla Klotzsch*
96 *Solanum nigrum L.*
97 *Spiraea canescens D.Don*
98 *Sterculia villosa Roxb.*
99 *Swida oblonga Sojak*
100 *Symplocos paniculata Miq.*
101 *Symplocos ramosissima Wallich ex G.Don*
102 *Synotis rufinervis C. Jeffrey & Y.L.Chen*
103 *Taraxacum officinale Weber*
104 *Terminalia alata Heyne ex Roth*
105 *Terminalia bellirica Roxb.*
106 *Terminalia chebula Retz.*
122 *Lonicera quinquelocularis Hardwicke*
123 *Lyonia ovalifolia Drude.*
124 *Machilus duthei King ex Hook, f.*
125 *Mallotus phillipiensis Muell.-Arg.*
126 *Maoutia puya Wedd*
127 *Melia azedarach L.*
128 *Meliosma dilleniifolia Walpers*
129 *Miscanthus nepalensis Hackel*
130 *Morus alba L.*
131 *Morus serrata Roxb*
132 *Murraya koeinghii Sprengel.*
133 *Neolitsea cuipala Kostermans*
134 *Nicandra physalodes Gaertner*
135 *Oogeinia oojeinensis Hochreutiner*
136 *Oryza sativa L.*
137 *Oxalis corniculata L.*
138 *Pennisetum orientale L*
139 *Persicaria capitata H. Gross*
140 *Persicaria nepalensis H. Gross*
141 *Phoebe laceolata Nees*
142 *Pilea scripta Wedd.*
143 *Pimpinella achilleifolia C.B. Clarke*
144 *Pimpinella acuminata C.B. Clarke*
145 *Pistacia khinjuk Stocks*
146 *Polygonum amplexicaule D.Don*
147 *Polygonum capitatum Buch.-Ham. ex D.Don*
148 *Polypogon fugax Nees ex Steudel*

Table 2 Some Fuelwood species

1	*Abies pindrow (Royle)*	41	*Ficus neriifolia Sm.*
2	*Abies spectabilis (D.Don)*	42	*Ficus racemosa L.*
3	*Acacia catechu (L.f) Willd.*	43	*Ficus roxburghii Steud.*
4	*Acacia modesta Wall.*	44	*Ficus subincisa Buch.–Ham. ex*
5	*Acer acuminatum Wall. ex*	45	*Fraxinus micrantha Lingelsh*
6	*Acer caesium Wall. ex Brandis*	46	*raxinus xanthoxyloides (G.Don Wall.)*
7	*Justicia adhatoda L.*	47	*Grewia optiva*
8	*Aegle marmelos (L.) Correa*	48	*Haldina cordifolia (Roxb.)*
9	*Aesculus indica (Wall.*	49	*Ridsdale*
10	*Albizia chinensis (Osbeck)*	50	*Holmskioldia sanguinea Retz.*
11	*Albizia lebbeck (L.)*	51	*Holoptelea integrifolia (Roxb.)*
12	*Anogeissus acuminata*	52	*Ilex dipyrena Wall.*
13	*Anogeissus pendula Edgew.*	53	*Indigofera heterantha Brandis*
14	*Bombax ceiba L.*	54	*Juglans regia L.*
15	*Bauhinia variegata L*	55	*Lagerstroemia parviflora Roxb.*
16	*Berberis aristata DC.*	56	*Lannea coromandelica (Houttuyn)*
17	*Berberis asiatica Roxb. ex DC*	57	*Lantana camara L.*
18	*Berberis lyceum Royle*	58	*Lindera pulcherrima (Nees)*
19	*Betula alnoides Buch.–Ham.*	59	*Litsea elongata (Nees) Hook. f.*
20	*Betula utilis D.Don*	60	*Lyonia ovalifolia (Wall.) Drude*
21	*Cedrus deodara (Roxb.)*	61	*Hododendron campanulatum DDon*
22	*Celtis australis L.*	62	*Brucea javanica (L.) Merr.*
23	*Cinnamomum tamala (Buch.)*	63	*Rhus parviflora Roxb.*
24	*Cornus macrophylla Wall.*	64	*Robinia pseudoacacia L.*
25	*Cotoneaster bacillaris Wall.*	65	*Salix daphnoides Vill.*
26	*Cotoneaster microphyllus Wall.*	66	*Chleichera oleosa (Lour.) Merr*
27	*Crateva adansonii DC.*	67	*Shorea robusta Gaertn*
28	*Dalbergia sissoo DC*	68	*Sorbaria tomentosa (Lindl.)*
29	*Daphniphyllum himalayense (Benth.)*	69	*Spiraea canescens D. Don*
30	*Debregeasia saeneb (Forssk.)*	70	*Symplocos chinensis (Thunb.)*
31	*Hepper & J.R.I.Wood*	71	*Symplocos paniculata (Thunb.)*
32	*Desmodium elegans DC.*	72	*ymplocos ramosissima Wall.*
33	*iospyros exsculpta Buch.–Ham*	73	*Taxus baccata L.*
34	*Dodecadenia grandiflora Nees*	74	*Terminalia alata Heyne ex Roth*
35	*Dodonaea viscosa (L.) Jacq.*	75	*Terminalia bellirica Roxb.*
36	*Ehretia laevis Roxb.*	76	*Toona ciliata M. Roemer*
37	*Elsholtzia flava Benth.*	77	*Toona hexandra Roxb.*
38	*Engelhardtia spicata Lechen ex*	78	*Mallotus repandus (Willd.)*
39	*Eurya acuminata DC.*	79	*Ulmus wallichiana Planch*
40	*Ficus auriculate Lour.*	80	*Viburnum cotinifolium D. Don*

UNIT 4: Introduction to Agroforestry

Unit Structure

4.0 Learning Objectives

After completing this unit you shall be able to:

- Define Agro forestry
- Explain the concept, objectives, attributes and potential of Agroforestry
- Explain the difference between Agro forestry and social forestry
- Define constraints in agro forestry and
- Status of forest in India

4.1 Introduction

4.1.1 Agroforestry Definitions:

Agroforestry means practice of agriculture and forest/ horticulture tree on the same piece of land. However, the agroforestry has been defined by various workers working in the field of agroforestry. Some of the definitions given by different workers are as follows:

- ✓ Bene et al. (1977) defined agroforestry as a sustainable management system for land that increases overall production, combines agriculture crops, forest plants and tree crop and/or animals simultaneously or sequentially and applies

management practices that are compatible with the cultural patterns of a local population.

- ✓ King and Chandler (1978) agroforestry is a sustainable land management system which increases the overall yield of the land, combines the production of crops (including tree crops) and forest plants and/or animals simultaneously or sequentially, on the same unit of land and applies management practices that are compatible with the cultural practices of the local population.
- ✓ Nair (1979) defines agroforestry as a land use system that integrates trees, crops and animals in a way that is scientifically sound, ecologically desirable, practically feasible and socially acceptable to the farmers.
- ✓ According to Lundgren and Raintree (1982), agroforestry is a collective name for land use systems and technologies, where woody perennials (trees, shrubs, palm bamboos, etc.) are deliberately used in the same piece of land management units as agriculture crops and/or animals in some form of spatial arrangement or temporal sequence. In agroforestry systems, there are both ecological and economical interactions between the different components.

4.1.2 Concept of Agroforestry

Agroforestry is an age old practice, indeed very old. Farmers of the tropical area have long tradition of growing food crops, tress and animals together as well as exploiting a multiple range of production from natural wood lots. Trees and forests are an integral part of the Indian culture. The best of Indian culture was born in the forests. Our rishis who evolved the Hindu philosophy, lived in forests in complete harmony with the nature. In fact, so much has been said about trees in our ancient literature that planting tree was being done by individuals on their own along with agricult several categories and identifies areas which are sustainable for planting trees, all wet and dry lands and areas around houses, wells, tanks are specifically identified for tree planting. But foresters and agriculturists, who have traditionally operated within rather rigid disciplinary boundaries concentrating on monoculture production of their preferred commodities of crops, animals and trees used to ignore such combined integrated production systems.

More recently, however, the forest area has receded and resources have shrunk considerably. The people are no longer able to meet their requirements of firewood,

fodder, timber, bamboo, etc. from the forest. Due to shortage of wood the prices of these commodities have, therefore, increased substantially. Many forest based industries have been facing problems in supply of raw material. Many farmers quite recently started planting trees on their farm lands to meet these shortages along with agriculture crop; thus from the concept of agroforestry it emerged out

- ✓ Agroforestry is collective name for land use systems involving trees combined with crops and/or animals on the same unit of land. Further it,
- ✓ Combines production of multiple outputs with protection of resource base
- ✓ Places emphasis on the use of multiple indigenous trees and shrubs
- ✓ Is particularly suitable for low-input conditions and fragile environments
- ✓ Involves the interplay of socio cultural values more than in most other land-use systems
- ✓ Is structurally and functionally more complex than monoculture

4.1.3 Objectives of Agroforestry

In all agroforestry land management there are two essential and related aims such as

- ✓ The AFS should conserve and improve the site
- ✓ Optimize the combine production of tress, agricultural crops and animals

4.1.4 Attributes of Agroforestry

There are three attributes which, theoretically, all agroforestry system possess, these are:

Productivity: Most, if not all, agroforestry systems aim to maintain or increase production (of preferred commodities as well as productivity (of the land). Agroforestry can improve productivity in many different ways. These include: increased output of tree products, improved yields of associated crops, reduction of cropping system inputs, and increased labour efficiency.

Sustainability: By conserving the production potential of the resource base, mainly through the beneficial effects of woody perennials on soils, agro forestry can achieve and indefinitely maintain conservation and fertility goals

Adoptability: Agro forestry is a relatively new word for an old set of practices means that, in some cases, agroforestry already been accepted by the farming community.

However, the implication here is that improved or new agroforestry technologies that are introduced into new areas should also conform to local farming practices.

4.1.5 Potential of Agroforestry

The different aspects in which agroforestry can help in enhancing the productivity of our lands to meet the demand of ever- growing human and livestock population. are as follows:

- ✓ Meeting the demand of food & fodder
- ✓ Enhanced food production from crops associated with trees through nitrogen fixation, better access to soil nutrients brought to surface from deep tree roots, improved availability of nutrients due to high cation-exchange capacity of the soil and its organic matter and mycorrhizal associations
- ✓ Food for man from trees as fruits, nuts and cereal substitutes
- ✓ Fodder for meeting rural needs
- ✓ Water conservation
- ✓ Improvement of soil-moisture retention in rainfed croplands and pastures through improved soil structure and micro-climate effect of trees
- ✓ Regulation of stream flow, reducing flood hazards and a more even supply of water through reduction of run-off and improvement of interception and storage in infiltration

4.1.6 Differentiation between Social Forestry and Agroforestry

Social Forestry	Agroforestry
1. Social forestry is a plantation made on lands outside conventional forest areas for the benefit of rural and urban communities, with objectives to supply fuel wood to divert cow dung from village hearths to village fields, small timber for housing and agricultural implements and fodder for cattle of the rural population, living far away from the forest area, protection of agriculture by creation of diverse ecosystem, and arresting wind and water erosion, provide raw material for village cottage	1. Agroforestry is a sustainable Land management system that increases the overall production, combines agricultural crops, tree crops and forest plants and/or animals simultaneously or sequentially, and applies management practices that are compatible with the cultural patterns of the local population. 2. Agroforestry is a system which is

industries and improve scenic value in rural and urban areas. 2. It is thus the forestry of the people, by the people and for the people. 3. Planting of trees on massive scale is done on vacant land community land, roadside railway track and even degraded reserve forest. 4. Trees and shrubs are to be used to harvest multiple products. 5. Social forestry is a short rotation investment. 6. It is primarily a government based program that aims to increase he forest area by rehabilitating wastelands while producing biomass both for industrial and local uses. 7. Benefits of social forestry include: (i) Fuel, fodder, timber, supplementary food and income from surplus forest products and tree derived resources for rural people. (ii) Form villagers into a well-knit community and increased social cohesion. (iii) Reclamation of waste lands and degraded lands along with soil conservation and green cover. (iv) Protection of agricultural fields from winds and dust storms. (v) Check desertification.	rather localized in its concept for managing the unit of land for maximizes production of agricultural crop and forest trees complimentary with each other. 3. Agroforestry is practiced mostly field/own land. 4. It involves integration of two or more than two components in a cultivated land. 5. Agroforestry is also short rotation forestry. 6. Agroforestry involves the rural awakening towards self sufficiency by producing maximum biomass per unit area, fulfilling then needs of food, fodder and fuelwood etc. 7. **Benefits of agroforestry includes:** (i) Maintain soil organic matter and biological activity at levels satisfactory for soil fertility. (ii) Control runoff and soil erosion and maintains required soil moisture. (iii) Maintain more favorable soil physical properties than agriculture, through organic matter maintenance and the effects of tree roots. (iv) More closed nutrient cycling than agriculture and hence to more efficient use of nutrients.

4.2 Constraints in Agro forestry

- ✓ The interference of trees decreases the crop yield which is lower than the monocropping
- ✓ The tree canopy absorbs maximum light and causes competition for light
- ✓ Felling of trees causes damage to the arable crop
- ✓ Competition for moisture between trees and arable crops is maximum when the trees have not deep tap root system
- ✓ Some of the trees serves as host to pest that harm main crop
- ✓ Agroforestry system requires more for its management
- ✓ Longer gestation period for tree delay the returns to the farmer
- ✓ Farmers give more weightage to field crops compare to tree crop
- ✓ Certain tree species produce chemical exudation which affects the growth of agriculture crops

4.3 Status of forests in India

India is one of the 12 mega diversity countries having a vast variety of flora and fauna, commands 7% of world's biodiversity and supports 16 major forest types, varying from the alpine pastures in the Himalayas to temperate, sub-tropical forests, and mangroves in the coastal areas. According to the State of Forest Report, published by the Forest Survey of India (FSI) in 1997, India has a recorded forest **area of 76.5 million hectare or 23.3%** of the total geographic area of the country. But the actual forest cover is **63.34 million ha (19.27% of the country's area)** of which **26.13 million ha are degraded**. There is another **5.72 million ha scrub** in addition to the reported forest cover of 63.34 million ha. Thus, in total, **31.85 million ha forests** in the country are degraded or open.

- ✓ It is the 16th biennial assessment of India's forests by Forest Survey of India, an organisation under the Ministry of Environment, Forest and Climate Change (MoEFCC).
- ✓ FSI undertakes National Forest Inventory to assess the growing stock in forests and TOF (Tree Outside Forest), bamboo resource, carbon stock and to

assess the dependence of the people living in Forest Fringe Villages for fuelwood, fodder, small timber and bamboo.

- ✓ In the current ISFR, a new chapter 'Forest Types and Biodiversity' has been added which presents findings of the forest type mapping based on Champion & Seth classification (1968) and the results of the first ever rapid biodiversity assessment of plant species in the 16 Forest Type Groups.

KEY FINDINGS

- ✓ The Total Forest and Tree cover is 24.56% of the geographical area of the country.
    - o The Total Forest cover is 7,12,249sq km which is 21.67% of the geographical area of the country.
    - o The Tree cover is 2.89% of the geographical area of the country.
- ✓ As compared to ISFR 2017 the current assessment shows an increase of
    - o 0.65% of forest and tree cover put together, at the national level
    - o 0.56% of forest cover
    - o 1.29% of tree cover
- ✓ Change in Recorded forest Area/Green Wash (RFA/GW) as compared to previous assessment of 2017.
    - o Forest cover within the RFA/GW: a slight decrease of 330 sq km (0.05%)
    - o Forest cover outside the RFA/GW: there is an increase of 4,306 sq km.
- ✓ The top five States (UT) in terms of increase in forest cover: Karnataka>Andhra Pradesh>Kerala>Jammu & Kashmir>Himachal Pradesh.
- ✓ Forest cover in the hill districts is 40.30% of the total geographical area of these districts. An increase of 544 sq km (0.19%) in 140 hill districts of the country.
- ✓ The total forest cover in the tribal districts is 37.54% of the geographical area of these districts.
- ✓ Total forest cover in the North Eastern region is 65.05% of its geographical area. The current assessment shows a decrease of forest cover to the extent

of 765 sq km (0.45%) in the region. Except Assam and Tripura, all the States in the region show decrease in forest cover.

- ✓ Mangrove cover in the country has increased by 1.10% as compared to the previous assessment.
- ✓ Wetlands cover 3.83% of the area within the RFA/GW of the country. Amongst the States, Gujarat has the largest area of wetlands within RFA in the country followed by West Bengal.
- ✓ Dependence of fuelwood on forests is highest in the State of Maharashtra, whereas, for fodder, small timber and bamboo, dependence is highest in Madhya Pradesh.
- ✓ It has been assessed that the annual removal of the small timber by the people living in forest fringe villages is nearly 7% of the average annual yield of forests in the country.

II) The Standing Committee on Science & Technology, Environment & Forests (Chair: Mr. Anand Sharma) submitted its report on the 'Status of Forests in India' on February 12, 2019. Key observations and recommendations of the Committee include:

- ✓ **Definition of Forest:** The Committee examined the Draft National Forest Draft Policy 2018 which was circulated for public feedback during April 2018. The Committee noted that the word 'Forest' is not defined in the Draft Policy. It noted that the Ministry uses the definition of the term as provided by the Supreme Court. The Court defined forests to include all forests statutorily recognised under the Forest (Conservation) Act, 1980. The Committee noted that certain stakeholders had expressed concerns that that this definition did not include ecosystems which don't have forest-like attributes, such as wetlands or grasslands. Therefore, it recommended that Ministry of Environment, Forest & Climate Change (MoEF) come out with a comprehensive and clear definition of the term 'Forest'.
- ✓ **Forest cover:** The Committee expressed concern about the decline in the forest cover in the North-Eastern States, which constitute 65.34% of its geographical area in comparison to the national forest cover of 21.54%. It recommended that the concerned state governments and the MoEF take all

necessary steps to ensure that the decline in forest cover in these states is stopped at the earliest.

- ✓ The Committee noted that no action plan has been prepared by the MoEF for controlling the illegal cutting of trees in forests. It stated that MoEF must take cognizance of the illegal felling of trees in different parts of the country and prepare an action plan for tackling this menace, in coordination with state governments.
- ✓ **Deforestation:** The Committee noted that the budget allocation to National Afforestation Programme has been insufficient. This has affected the achievement of the annual targeted area of afforestation during the last few years. The Committee recommended that the MoEF ensure that adequate allocation is made to the National Afforestation Programme and the targets under the Programme are achieved. Further, the Committee noted that the funding pattern for the Programme changed in 2015-16 from a 100% centrally sponsored scheme to a 60-40 sharing scheme between the centre and state. Therefore, the Committee recommended that the concerned state governments provide their share of the changed funding pattern to ensure the success of the Programme.
- ✓ **Evaluation of afforestation:** The Committee noted that the mid-term evaluation study on National Afforestation Programme conducted by the Indian Council of Forestry Research and Education in 2008 had highlighted the successful implementation of the programme. However, the Committee stated that nearly ten years have passed since the ICFRE evaluation. Therefore, it recommended that the MoEF should undertake a study to assess the impact of National Afforestation Programme and the Green India Mission so that their actual impact on the forest cover is known and further strategies in this regard could be formulated accordingly.
- ✓ The Committee observed that the MoEF has not undertaken any field survey to determine the total land available in the country for afforestation. It recommended that necessary action in this regard should be taken at the earliest so that state governments can formulate necessary strategies for taking up the afforestation activities in their respective states.

- ✓ **Concerns of exploitation:** The Committee observed that the general perception of the public is that the Draft Policy emphasizes the commercialization of forests and curtails the ownership of rights of tribals, tribal communities, and traditional forest-dwellers. Concerns were also expressed that the Draft Policy aims to take away the rights of Gram Sabhas for management of forests and instead hands it over to the proposed centrally controlled Corporations. The Committee felt that if too much emphasis is given to the private partnership model in management of forests in the Draft Policy, forest lands may be lost. It recommended that adequate safeguards be taken after stakeholder consultations to protect the forests from over-exploitation by private parties.

UNIT 5: Agroforestry Systems

Unit Structure

5.0 Learning Objectives

After completing this unit you shall be able to:

- Know about different agroforestry systems, subsystem, practices,
- Classification of different agro forestry systems

5.1 Introduction

Different types of agroforestry systems exist in different parts of the world. These systems are highly diverse and complex in character and function. Classification of agroforestry system is necessary in order to provide a framework for evaluating the system and developing action plan for their improvement. Several criteria can be used in classifying them but most common includes the system structure, function, socioeconomic scale of management, ecological spread etc. According to the potential, there are many different systems of agroforestry. In agroforestry the terms like system, sub-system and practices are commonly used.

System

- ✓ System refers to a group of physical components, i.e. an assemblage of objects connected or related in such a manner so as to form and/or act as a unit; e.g. ecosystem which consists of living organism and their non-living environment with which they areinseparably interrelated.
- ✓ In land use terms, a system refers to a type of land use specific to an area and described according to its biotechnical composition and arrangement, level of technical management of socio-economic features; e.g. rice production system, plantation crop systems.

Sub-system

- ✓ Sub-system indicates a lower order hierarchy of the system.
- ✓ It refers to a part of system, with more or less restricted role, content and complexity than the system itself.
- ✓ A sub-system produces a defined 'basic needs' as its major output, so that there can be a food sub-system, an energy production sub-system and cash sub-system.

Practices

- ✓ Practices in agroforestry denote specific land management operations of any nature, carried out on a farm or other management unit.
- ✓ Such practices are involved in the constitution and maintenance of an agroforestry system; e.g. alley cropping, boundary plantations of trees and shrubs, shelterbelts and windbreaks, etc.

Why classification

- ✓ It include logical way of grouping the major factors on which production of the system will depend
- ✓ It indicate how system is managed
- ✓ It offer flexibility for regrouping the information
- ✓ We usually understood and readily handled

5.2 Criteria / Basis for Agroforestry System Classification

Combe (1982) proposed 24 agroforestry systems based on three type of association of the trees with crops, with pastures and with both crops and pastures); two major functions of the tree components (production and protection); two spatial arrangements (regular and irregular); and two types of temporal association (temporary and permanent).

The most obvious and easy-to-use criteria for classifying agroforestry systems are the spatial and temporal arrangement of components, the importance and role of components, the production aims or outputs from the system, and the social and economic features. They correspond to the systems' structure, function (output), socioeconomic nature, or ecological (environmental) spread. These characteristics also represent the main purpose of a

classification scheme. Therefore agroforestry systems can be categorized according to these sets of criteria:

- Structural basis
- Functional basis
- Socioeconomic basis
- Ecological basis

	Agrosilviculture	Silvopastoral	Agrosilvopastoral	Agrosilviculture	Silvopastoral	Agrosilvopastoral	
Permanent							**Production**
							Protection
Temporary							**Production**
							Protection
	Regular			**Irregular**			

Fig. 3.1(a) Agroforestry systems classification, Combe (1982)

- Vergera (1982) considered the relative allocation of land, trees, crops, pastures in various agroforestry systems.
- Tejwani (1987) suggested a classification which among the other things also took into account relative dominance of trees or crops/pastures

5.3 Classification of Agroforestry Systems (Nair, 1985)

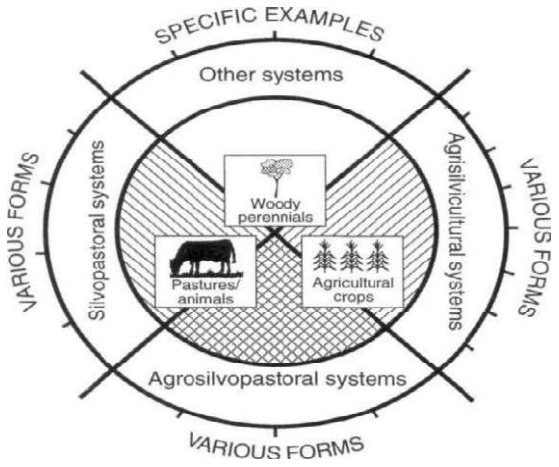
5.3.1 Structural basis

It refers to the composition of the components, including spatial arrangement of the woody component, vertical stratification of all the components, and temporal arrangement of the different components. Hence on the basis of structure agroforestry system can be grouped into two categories.

- Nature of components
- Arrangement of components

A) Nature of components: Based on nature of component agroforestry systems can be classified into following categories

- ✓ Agrisilviculture systems/ silviagriculture/ agrosilviculture
- ✓ Silvopastoral systems/ silvipastoral
- ✓ Agrosilvopastoral systems/ agrisilvipastoral
- ✓ Other systems



3.1b Classification of agroforestry systems on the basis of nature of components

Note: Nomenclature of the system depends upon the prime importance of the component and the component given lot of space placed first in any agroforestry system for eg. Agrisilviculture in which prime component is agriculture crop.

- ✓ Agrosilviculture has a wide applicability and it covers in its scope integration of different components of farming system for eg. Vegetables, pulses, oil seed crops, cereals etc.
- ✓ Whereas agrisilviculture restricted only to integration of cereals with the tree crop

I. Agrisilviculture/Silviagriculture/Agrosilviculture: This system involves the conscious and deliberate use of land for the concurrent production of agricultural crops including tree, crops and forest crops. Based on the nature of the components this system can be grouped into various forms:

a) Improved fallow species in shifting cultivation

b) Taungya system

c) Multispecies tree gardens

d) Alley cropping (Hedgerow intercropping)

e) Multipurpose trees and shrubs on farmlands

f) Crops combinations with plantation crops

g) Agroforestry for fuelwood production

h) Shelter belts

i) Wind breaks

j) Soil conservation hedges etc.

a) Improved fallow species in shifting cultivation:

Shifting cultivation: It is prevalent in many parts of Africa, Latin America, South-East Asia and Indian subcontinent.

- In India it is prevalent in Assam, Meghalaya, Jharkhand, Manipur, Orissa, Nagaland, Chattisgarh, M.P., Arunanchal Pradesh, Andhra Pradesh, Mizoram, Tripura, Kerala, West Bengal, Sikkim.

- It is known as 'jhuming' in North-east, 'khallu / kurwa' in Jharkhand and 'dahiya' or 'podo' in Orissa, Andhra Pradesh.
- In this system, forest patch is selected and cleared felled. The herbs, shrubs and twigs and branches (slashed vegetation) are burnt .Cultivation of crops is done for a few years until soil fertility declines. The site is than abandoned (fallow period) and new patch is selected for cultivation of crops. The site is again cultivated after giving rest for few years.
- Earlier the fallow cycle was of 20–30 year. However, due to increasing requirement for cultivation of land due to population pressure, fallow period has reduced from 25–30 years to 2–3 years which has broken down the resilience of ecosystem and the land is increasingly deteriorating. Thus now shifting cultivation has become source of ecological degradation, soil erosion and converting good forests into wastelands.

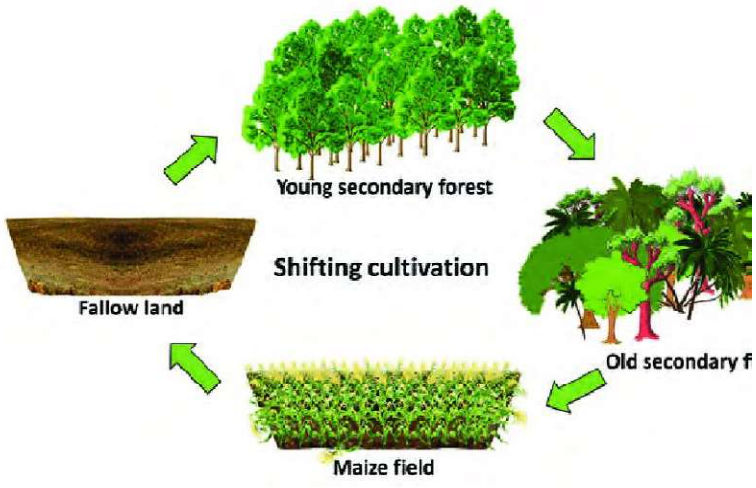


Figure 3.2 Shifting cultivation

Effect of shifting cultivation

- Deforestation and denudation of hill slopes-in secondary succession, area is occupied by weeds, useless shrubs etc
- Soil erosion which leads to soil and nutrient losses, silting of reservoirs and streams, reduction in water-yield and landslips and landslides

- Shifting cultivation adversely affects cation exchange capacity and physical properties of soil. It leads to lowering of organic matter and lowering the total quantity ofsesquioxides, iron, aluminum, calcium, potassium, phosphorus, etc.
- Increases soil pH and reducing microbial activity
- More weed growth and lower crop yield
- No opportunity for infrastructural development

Controlling shifting cultivation

- Motivate public for permanent agriculture by opening demonstration centers for improved agricultural practices, good quality seed, manuring, irrigation, weeding use of improved tools, terracing etc.
- Earning goodwill of local people: By engaging them in forest work and training them to undertake shifting cultivation on scientific lines.
- Arable land can be provided to the tribals for carrying out agriculture and also to settle in the area; a few schemes are being implemented under integrated tribal development programme
- Legal measures: on steep slopes, near to roadside etc
- Using land according to its capability
- Provision of alternative management
- Development of animal husbandry and dairy farming
- Training of artisans and development of handicrafts
- Employment in forest works and other industries
- Providing communication facilities
- Providing economic assistance for houses and agriculture operations

Improved fallow species in shifting cultivation:

- Fallows are crop land left without crops for periods ranging from one season to several years.
- The objective of improved fallow species in shifting cultivation is to recover depleted soil nutrients. Once the soil has recovered, crops are reintroduced for one or more season.

- The best species for the fallow system should induce good nitrogen fixation in the soil.
- The main aim of the fallow is to maintain or restore soil fertility and reduce erosion; some plants can be introduced primarily for their economic value.
- Plants included in improved fallows should be compatible with future crops, free of any negative physical or chemical effects on the soil and not in competition with the crops to be planted later on the same site.

b) Taungya System of cultivation

- The taungya system was used primarily as an inexpensive means of establishing timber plantations but is finally a recognized AF system.
- The taungya (taung = hill, ya = cultivation) is a Burmese word coined in Burma in 1850. The system was introduced to India by Brandis in 1890 and the first taungya plantations were raised in 1896 in North Bengal.
- It was introduced to S Africa in 1887 and was taken to Chittagong and Sylhat (Now in Bangladesh) in 1870.
- In India it started in 1896 in North Bengal. In 1890, it was introduced to Coorg in Karnataka. Regular plantation however started in North Bengal in 1911 for raising Sal plantations and in 1912, extended for raising Teak. In 1923 it was adopted in UP for raising Sal plantations.
- It is still practiced in the states of Kerala, West Bengal, Orissa, Karnataka and the north- eastern hill region.
- This is a modified form of shifting cultivation in which the labour is permitted to raise agri-crops in an area but only side by side with the forest species planted by it. The practice consists of land preparation, tree planting, growing agricultural crops for 1-3 years, until shade becomes too dense, and then moving on to repeat the cycle in a different area. A large variety of crops and trees, depending on the soil and climatic conditions, are grown in India. In fact this system was introduced to raise forest plantations, but finally became recognized agroforestry system.

Types of Taungya

- **Departmental Taungya:** Under this, agricultural crops and plantation are raised by the forest department by employing a number of labourers on daily wages. The main aim of raising crops along with the plantation is to keep down weed growth.
- **Leased Taungya:** The plantation land is given on lease to the person who offers the highest money for raising crops for a specified number of years and ensures care of tree plantation.
- **Village Taungya:** This is the most successful of the three taungya systems. In this crops are raised by the people who have settled down in a village inside the forest for this purpose. Usually each family has about 0.8 to 1.7 ha of land to raise trees and cultivate crops for 3 to 4 years.

Table 3.1: Trees and crops grown in Taungya

State	Tree crop	Associated agricultural crops
U.P.	*Shorea robusta, Tectona grandis Acacia catechu, Dalbergia sisso, Eucalyptus spp. Populus spp.*	Maize, paddy, sorghum, pigeon-pea, soyabean, wheat, barley, chick-pea, rape-see and miscellaneous
Andhra Pradesh (AP)	*Anacardium occidentale, Tectona grandis, Bombax ceiba, Bamboo, Eucalyptus spp.*	Hill paddy, groundnut, sweet potato
Kerala	*Tectona grandis Bombax ceiba Eucalyptus spp.*	Paddy, tapioca, ginger, turmeric, etc.
Assam	*Shorea robusta, S assamica*	Paddy
Tamil Nadu	*Tectona grandis, Santalum album Tamarindus indica, Acacia nilotica Acacia mearnsii ,Ceiba pentandra Cashew, Rubber, Bamboo*	Millet, pulses, groundnut, cotton
Andaman and Nicoba Islands	*Pterocarpus dalbergioides*	Sugar-cane, maize
Maharashtra	*Tectona grandis, Acacia nilotica*	Sunhemp, jute, mesta, sunflower, castor etc.
Tripura	*Shorea spp., Schima spp., Michelia spp.*	Paddy, maize etc
West Bengal	*Tectona grandis, Shorea robusta Schima wallichii, Cryptomeria japonica, Quercus spp. Michelia doltsopa*	Paddy, maize, millets, turmeric, ginger, lady's, finger, pineapple, sunhemp
Karnataka	*Tectona grandis, Santalum album, Cassia siamea*	Paddy, tapioca, etc.

Advantages of Taungya

- Artificial regeneration of the forest is obtained cheaply;
- Problems of unemployment are solved;
- Helps towards maximum utilization of the site;
- Low cost method of forest plantation establishment;
- In every case, highly remunerative to the forest departments;
- Provision of food crops from forest land; and
- Weed, climber growth, etc. is eliminated.

Disadvantage of Taungya

- Loss of soil fertility and exposure of soil;
- Danger of epidemics;
- Legal problems created;
- Susceptibility of land to accelerated erosion increases; and,
- It is a form of exploitation of human labour

c) Multi-species tree Gardens:

- In this system of agroforestry, various kinds of tree species are grown mixed.
- The major function of this system is production of food, fodder and wood products for home consumption and sale.

d) Alley cropping (Hedge row intercropping):

- Alley cropping, also known as hedgerow intercropping,
- In this perennial, preferably leguminous trees or shrubs are grown simultaneously with an arable crop.
- The trees, managed as hedgerows, are grown in wide rows and the crop is planted in the interspace or 'alley' between the tree rows.

Figure 3.2 Alley cropping

- During the cropping phase the trees are pruned and leaves and twigs are used as mulch on the cropped alleys in order to reduce evaporation from the soil surface, suppress weeds and/or add nutrients and organic matter to the top soil.
- The primary purpose of alley cropping is to maintain or increase crop yields by improvement of the soil and microclimate and weed control. Farmers may also obtain
- tree products from the hedgerows, including fuelwood, building poles, food, medicine and fodder, etc.

Layout of Alley

- The position and spacing of hedgerow and crop plants in an alley cropping system depend on plant species, climate, slope, soil conditions and the space required for the movement of people.
- Ideally, hedgerows should be positioned in an east to west direction so that plants on both sides receive full sunlight during the day.
- The spacing used in fields is usually 4 to 8 meters between rows and 25 cm to 2 meters between trees within rows. The closer spacing is generally used in humid areas and the wider spacing in sub-humid or semi-arid regions.

Characteristics of species for hedgerow intercropping: Alley cropping usually includes leguminous trees to improve soil fertility through nitrogen fixation; hence an ideal alley cropping tree or shrub species should have following characteristics:

- It should have a sparse, small crown to permit sunlight penetration into the cropped area
- It should re-sprout rapidly after pruning, coppicing, pollarding or lopping.
- It should form a deep taproot system so that it takes moisture and nutrient from deeper layers and will not compete with agricultural crops
- It should have shallow lateral roots that are easily ‘pruned’ by ploughing along the hedgerow, without serious damage to the plants.
- Fast decomposition rate of leaf litter.
- Ideally, trees and shrubs used for alley cropping should fix nitrogen.

- Trees/shrubs should be non-exacting in nature.

Promising species

Gliricidia sepium, Flemingia macrophylla, Leucaena, Calliandra calothyrsus, Erythrina subumbrans, Albizia saman, Pithecellobium dulce, Paraserianthes falcataria, Acacia spp., *Paraserianthes falcataria* and *Cajanus cajan*.

Advantages

- Improved crop performance due to the addition of nutrients and organic matter into the soil/plant system,
- Reduction of the use of chemical fertilisers,
- Improvement in the physical nature of the soil environment.
- Reductions in erosion losses.
- Provision of additional products such as forage, firewood or stakes when a multipurpose tree legume is used as the hedgerow, and
- Improvement in weed control.

f) Multipurpose trees and shrubs on farmlands:

- In this system various multipurpose tree species are scattered haphazardly or according to some systematic patterns on bunds.
- The major components of this system are multipurpose trees and other fruit trees and common agricultural crops.
- The primary role of this system is production of various trees products and the protective function is fencing and plot demarcation. Examples of multipurpose trees employed in agroforestry are: *Leucaena leucocephala, Acacia albida, Cassia siamea, Casuarina equisetifolia, Azadirachta indica, Acacia senegal, Cocos nucifera,* etc.

g) Crop combinations with plantation crops:

(i) Perennial trees and shrubs such as coffee, tea, coconut and cocoa are combined into intercropping systems in numerous ways, including:

(ii) Integrated multistory mixture of plantation crops;

(iii) Mixture of plantation crops in alternate or other crop arrangement;

(iv) Shade trees for plantation crops

(v) Intercropping with agricultural crops.

- Tea (*Camilia sinensis*) is grown under shade of *A. chinensis*, *A. odoratissim*, *A. lebbek, A. procera, Acacia lenticularis, Derris robusta, Grevillea robusta, Acacia spp., Erythrina lithosperma, Indigofera tesmanii.*
- Coffee (*Coffea arabica*) is grown under the shade of *Erythrina lithosperma* as temporary shade while, permanent shade trees include *Ficus glomerata, F. nervosa, Albizia chinensis, A. lebbek, A moluccana, A. sumatrana, Dalbergia latifolia, Artocarpus integrifolius, Bischofia javanica, Grevillea robusta*.
- Cacao (*Theobroma cacao*) is grown under the shade of coconut and areca nut, and *Dipterocarpus macrocarpa* (in forest).
- Black pepper (*Piper nigrum*) is grown with support from *Erithrina indica*, *Garuga pinnata, Spondias, Mangifera, Gliricidia maculate and Grevillea robusta*.
- Small cardamom (*Elettaria cardamomum*) and large cardamom (*Ammomum subulatum; A. aromaticum*) grow in forests under temporary shade tree of Mesopsis emini..
- Large cardamom is grown under the shade of natural forest as well under planted shade treesviz., *Alnus nepalensis, Schima wallichii; Cinchona spp.; Lagerstroemia spp., Albizia lebbek; Castanopsis tribuloides; C. hystrix; C. indica; Terminalia myriocarpa; Bischofia javanica.*

h) Agroforestry for fuelwood production

- In this system, various multipurpose fuelwood/firewood species are inter-planted on or around agricultural lands.
- The protective role is to act as fencing, shelter belts and boundary demarcation.
- Tree species commonly used as fuelwood are: Acacia nilotica, Albizia lebbek, Cassia siamea, Casuarina equisetifolia, Dalbergia sissoo, Prosopis juliflora, Eucalyptus tereticornis, etc.

i) Shelterbelt

- Shelterbelt is a wide belt of trees, shrubs and grasses, planted in rows which goes right across the land at right-angle to the direction of the prevailing winds to deflect air current, to reduce wind velocity and to give general protection to cultivated areas against wind erosion and desiccating effect of the hot winds in lee-ward side.
- A typical shelterbelt has a triangular cross-section which can be achieved by planting tall trees in the centre, flanked on both sides successively by shorter trees, tall shrubs and then low spreading shrubs and grasses.
- A certain amount of penetrability is desirable in shelterbelts as a result of which the zone of influence is very much greater and the velocity curve shows a smooth, slowly declining trend.
- The width of shelterbelt depends upon local climatic conditions, wind velocity, and the soil type.
- Shelterbelt should be oriented as nearly as possible, at right angles to the prevailing wind In case, where winds blow from different directions, shelterbelt should be raised in quadrangles.

Height and spacing—

- Height of shelterbelt is very important
- As it affects the distance to which protection will be afforded on the lee-ward side.
- Higher the trees forming the shelterbelt, the greater is the zone of influence on the leeward side.
- This affects the spacing of the shelterbelts also. If wind erosion has to be completely controlled, the second belt should be located a little before the place where the wind on the lee-ward side often first shelterbelt assumes damaging velocity.
- Taking 20% reduction in wind velocity as the basis of usefulness of a shelterbelt, effective protection zone extends up to 15 to 20 times the height of the belt.

- In Rajasthan, taking the height of shelterbelt to be about 7.5 m, spacing recommended is 10 times the height, i.e., 75 meters.

Length

- The length of shelterbelt is an important consideration because at the ends of the shelterbelt eddies are produced resulting in increasing the wind velocity at these places.
- It is because of this that road is not ordinarily allowed to cross a shelterbelt.
- In some of the western countries, shelterbelts have been raised right across the country for the protection they afford
- For shorter shelterbelt, the minimum length of shelterbelt to be most effective is 24 times its height.

Soil Preparation

- Soil preparation should be done at least a year in advance to build up sufficient reserve of soil moisture
- It may be done either mechanically or by manual labour
- Leguminous crops may be raised for the first few years in between the rows of trees and shrubs for improving the fertility of the soil.

Choice of species

- The choice of species to be raised in shelterbelt is governed by the climate, soil and topography of the area.
- It is better to raise local species because of their easy establishment.
- Exotics may also be used to improve the efficiency of the shelterbelts.

Characteristics of tree spp. used for shelterbelt are as follows:

- The species selected should be non-exacting;
- Fast-growing;
- Wind-firm;
- Drought-resistant;

- Unpalatable to animals;
- It should have a dense crown and low branching habit;
- It should not be leafless at a time when protection is required;
- It should be economically a multipurpose species, i.e., fit for firewood, timber and fodder.

The following species are recommended for creation of shelter belt:

Grasses:*Cenchrus barbatus, Saccharum spontaneum, Saccharum munja, Panicum turgidum, Panicum antidotale*.

Shrubs: *Calotropis procera, Crotolaria burhia, Calligonum polygonoides, Clerodendron phlomoides, Cassia auriculata, Dodonaea viscosa, Jatropha curcas, Leptadenia spartivm, Agave spp. , Sesbania aculeata*.

Small trees:*Acacia jacquemontii, Acacia leucophloea, Balanites aegyptiaca, Capparis aphylla, Salvadora oleoides.*

Trees:*Acacia arabica, Acacia senegal, Acacia cyanophylla, Albizzia lebbek, Azadirachta indica, Dalbergia sissoo, Lannea coromendelica, Parkinsonia aculeata, Prosopis cineraria, Prosopis juliflora, Pongamia pinnata, Tecoma undulata, Tamarix articulatat Eucalyptus spp., Acacia tortilis.*

Method of raising the plants:

- It is better to sow the seeds in polythene bags and plant out the plants so raised.
- For this purpose nurseries should be maintained at site.
- The plant should be regularly watered for one or two years.
- Properly fenced to protect them from browsing cattle.

Advantages of Shelterbelts

- Very little research work has been done in our country.
- to find out the benefits of the shelter-belts on yields of agricultural crops, horticultural crops and grasses.

- However, on the basis of research work done in CAZRI, TNAU and abroad, the following advantages of the shelterbelts may be mentioned:

Moderating effect on temperature

- Shelterbelt has a moderating effect on air and soil temperature by lowering the maximum and raising the minimum.
- Temperature during day time inside the forest is lower evaporation.
- Temperature during night is higher inside the forest than open.

Increase in humidity

- Shelterbelts increase relative humidity from 1 to 50%.
- There is distinctly perceptible increase in the average relative humidity in the agricultural land protected by shelterbelts

Reduction in evapo-transpiration

- Shelterbelts reduce evapo-transpiration sufficiently in the zone of their influence.
- Increase in soil moisture:
- Shelterbelts increase the moisture content of the soil on the leeward side and delay it's drying up during summer.
- They also increase the underground water supplies by promoting infiltration in the soil.

Reduction in wind velocity and wind erosion:

- Shelterbelts deflect the wind upwards
- Cause considerable reduction in the wind velocity on the leeward side upto a distance of 15 to 20 times the height of the trees forming the shelterbelt.
- As there is considerable reduction in the wind velocity on the leeward side of a shelterbelt, wind erosion is very much reduced.

Increase in agricultural and horticultural crops

- Shelterbelts increase production of agricultural and horticultural crops.

- Study made in 8 cotton fields in distinctly semi-arid areas of U.S.A. revealed an increase of 17.4% in cotton yield when protection against hot winds was provided by shelterbelts.
- Similar increase in crop yields has been reported from Russia where a shelterbelt of 5 rows increased the oat yield by 25% to 28%.
- Protection of orchards by shelterbelt reduces wind damage and increases fruit yield.
- Studies revealed that even if 0.4 hectare out of 4 hectare orchard is devoted to creation of shelterbelt, the remaining protected 3.6 hectare of orchard yielded about 13.00% more than the unprotected 4 Hectare orchard.
- Similarly, the increase in fodder yield is reported to be as high as 300 - 400%.

Protection of damage to public and private property

- The shelterbelts hold up the movement of shifting sand
- Save the roads and railway tracks from being covered and otherwise damaged by moving sand dunes.
- They prevent deposition of silt in canals and agricultural fields.

j) Windbreaks

- Wind break is a protective planting around a garden, a farm or a field to protect it against strong winds.
- It usually consists of 2-3 rows of trees or shrubs, spaced at 0.5 m to 2.5 m apart, depending on the species.

Figure 3.4: Windbreaks

a) Soil conservation hedges

In this system the major groups of components are: multipurpose and/or fruit trees and common agricultural species.

The primary role of multipurpose fruit trees and agricultural species is soil conservation and provision of various tree products.

The following tree species are used for soil conservation: *Grevillea robusta, Acacia catechu, Pinus roxburghii, Acacia modesta, Prosopis juliflora, Alnus nepalensis, Leucaena leucocephala,* etc.

Horti silviculture

It is deliberately integration of horticultural trees with timber trees in order to harvest fruits and timber concurrently from single unit of land. Timber trees are planted on bunds of the orchards acts as windbreak thus protect orchard from high winds.

Horti silvopastoral

In this system various improved leguminous grasses are grown in orchard in order to provide forage to livestock. Trees are planted on the bunds of the orchards. These trees acts as windbreaks and protect horticulture plants from high wind; also provides multiple products.

Silvi-Pastoral System (Trees + Pasture and /Or Animals)

- The production of woody plants combined with pasture is referred to as a silvi-pastoral system.
- The trees and shrubs may be used primarily to produce fodder for livestock or they may be grown for timber, fuelwood, and fruit or to improve the soil.
- A silvi-pastroal system is needed in dry areas, in order to meet out the demands of wood and fodder throughout the year. There are three main categories of silvicultural system
    - Protein bank
    - Live fence of fodder trees and hedges
    - Trees and shrubs on pasture land

A. Protein bank

(i) In this system various multipurpose trees (protein rich trees) are planted on or around farmlands and rangelands

(ii) For cut and carry fodder production to meet the fodder requirements of livestock during the fodder deficit period in winter.

(iii) These trees are rich in protein.

(iv) The trees planted in protein banks are *Grewia optiva, Bauhinia variegata, Morus alba*, *Artocarpus* spp., *Anogeissus latifolia, Cordia dichotoma, Dalbergia sissoo, Eutralobium saman, Zizyphus jujube,* etc.

B. Live fence of fodder trees and hedges

(v) In this system, various fodder trees and shrubs are planted as live fences to protect the property from stray animals

(vi) To protect the farm property from biotic influences.

(vii) The following trees are generally used: *Sesbania grandiflora, Gliricidia sepium, Erythrina abyssinica, Euphorbia* spp., *Acacia* spp. etc.

C. Trees and Shrubs on Pasture Land

(viii) In this system various tree and shrub species are scattered irregularly or arranged according to some systematic pattern,

Agrisilvopastoral/Agrosilvopastoral System (Crops + Tree + Grasses/Animals)

This system has been grouped into two subgroups:

(i) Home gardens

(ii) Woody hedge rows for browsing, mulching, green manuring and soil conservation.

A. Home gardens

(i) It is deliberate integration of trees, crop and animals in a same unit of land in some form of spatial and temporal sequence.

(ii) This is one of the oldest agroforestry practices found in high rainfall area of South and South-East Asia.

(iii) In India it is prevalent in Southern states like Kerala, Tamilnadu.

(iv) Aso common in North Eastern states like Tripura, Assom, West Bengal and part of Islands of Andaman and Nicobar.

(v) In India it is a common practice to plant trees around the habitation.

(vi) It is also known as multilayered AFS

(vii) Area of homestead varies from 0.2-0.5ha

(viii) Tall tree/timber tree occupy the top most layer followed by fruit tree.

(ix) Small shrubs also form the parts of home garden.

(x) Shade loving vegetables find their place in the ground layer.

(xi) Trees provide timber, fruits and also support climber such as pepper, cucurbits, clove,yam, sweet potato, colocasia etc.

(xii) Pineapple is a common fruit grown in home garden

(xiii) In hills, the common spp. for home gardens is *Grewia optiva, Ficus glomerata, Juglansregia* and *Punica granatum*.

(xiv) In rural areas, fruit trees and commercial tree spp., such as Acacia and Neem are ofcommon occurrence in most of the country.

(xv) Cattle and poultry are the main component of homesteads.

(xvi) Forage spp. like Stylo, Guinea grass, Guatemala, Napier and *Setaria cephalis* variety

(xvii) Kazungula also find their place in home garden.

B. Woody Hedges for Browsing, Green Manuring, Mulching and Soil Conservation

(i) In this system various woody hedges especially

(ii) Fast growing

(iii) Good coppicing capacity planted in order to

(iv) Browse the animals

(v) Mulching purpose

(vi) Green manuring purpose

(vii) Soil conservation purpose

(viii) Aim is production of food, fodder, fuel-wood and soil conservation

Other Specified Systems

I) Apiculture with Tree

(i) In this system nectar and pollen rich tree/shrubs are planted on the bunds of the farm.

(ii) Some agriculture/oil seed crops are also grown.

(iii) *Mangifera indica, Vitex negundo, Melia azedarach, Azadirachta indica, Prunus salicina,Prunus armeniaca, Rubus ellipticus, Eucalyptus spp., Callistemon lanceolatus, Berberislycium, Toona ciliata*, etc.

(iv) Main purpose of this system is production of honey.

II) Aqua-forestry

(i) Aqua-forestry is very common in coastal regions (more evident along Andhra coast).

(ii) Farmers are cultivating fish and prawn in saline water and growing coconut and othertrees on bunds of ponds.

(iii) These trees help in producing litter-feed to fishery and generate extra income to farmers.

(iv) Now fish culture in mangroves is also advocated which forms a rich source of nutrition toaquatic life and breeding ground for juvenile fish, prawn and mussels.

(v) A well-balanced system of animal husbandry including goatry, poultry, duck-farming, turtlesand fishes in the small ponds in home-gardens make a balanced system of high moisture,energy and nutrient-use efficiency per unit area.

(vi) The leaves of many leguminous trees viz. *Gliricidia sepium, Leucaena, Moringa oleifera, Acacia nilotica* etc. have been found to serve as good fish feed when offered as pellets andimproved its productivity.

(vii) Area is enclosed with earth embakements.

(viii) Inside the embakement, system of ridges and canals is created. Rain water is collected bymaking bunds which helps in growing of tree species.

III) Multipurpose Wood Lots: In this system special location-specific MPTs are grown mixed or separately planted for variouspurposes such as wood, fodder, soil protection, soil reclamation, etc.

B) Agroforestry Systems Based Arrangement of Components

Arrangement of component refers to the plant component of the system even in agroforestrysystem involving animal the management of such animal according to definite plan such asrotational grazing scheme is in consideration more of the plant than animal. Such plantarrangement in multi species combination can involve dimension, space and time.

(i) Spatial arrangement of plant in agroforestry mixture can result

– Mixed dense, e.g., homegardens

– Mixed sparse, e.g. most systems of trees in pastures

– Zonal-microzonal, macrozonal

Spatial or zonal agroforestry varies from microzonal (such as alternate rows of plantcomponents) to macrozonal arrangements. An extreme form of the zonal arrangement isthe boundary planting of trees on edges of plots for fruits, fodder, fuel wood, fencing, soilprotection and windbreak.

(ii) Temporal arrangement of plant in agroforestry systems can take various forms such as

Coincident: When two component woody and non woody components occupy the land together as coffee under shade tree and pasture under shade trees

Concomitant: When two component woody or non woody stays together for some partof life as in taungya

Intermittent(Space dominated): When annual crops are grown with perennial crops such aspaddy with coconut

Interpolated(Space and time dominated): When different components occupy space duringdifferent time as in home garden

Overlapping Black and rubber

Separate (time dominated): When component occupy space during separate timesuch as improved fallow species in shifting cultivation

5.3.2 Functional basis

It refers to the major function or role of the system, usually furnished by thewoody components (these can be of a service or protective nature, e.g., windbreak, shelterbelt,soil conservation).

(i) **Production:** This system refers to the production of essential commodities (food, fodder, fuelwood,minor forest products, etc.), required to meet the basic needs of the society. It includes intercropping oftrees, home gardens, production of animals and fishes in association with trees etc.

(ii) **Protective agroforestry system:** This system primarily aims at ameliorating the land to improve climateresilient, reduce soil erosion, moisture conservation, provide shelter, shade, etc. e.g. wind breaks.

(iii) **Multipurpose agroforestry system:** Multipurpose agroforestry system ensures multipurpose productionthrough optimizing both productive and protective functions, e.g. hedge row intercropping.

5.3.3 Ecological classification

The agroforestry system is related to various ecological factors *viz*., climatic, edaphic and physiographic ones.On the basis of ecological parameters, it can be classified as:

(i) **Tropical:** Vegetation in extreme climate such as high temperature, low humidity, and scarcity of water *etc*.,e.g. Tropical silvopasture.

(ii) **Sub-tropical:** Agroforestry system in optimal climatic condition, *e.g*. agroforestry in sub-tropical regions

(iii) **Temperate:** Agroforestry system in low temperature regions.

(iv) **Sub-Alpine:** Agroforestry systems in low and medium mountainous regions.

(v) **Alpine:** Agroforestry system in high mountainous regions.

5.3.4 Socio-economic classification

Based on socio-economic consideration, the agroforestry systems are classified based on cost / benefitrelations, management options and technology used.

a) On the basis of cost / benefit relations

(i) **Subsistence agroforestry system:** This system aims at meeting the basis needs of small family having less holding and very little capacity foran investment. They may be some marginal surplus production for sale, e.g., shifting cultivation, scatteredtrees in the farms, homestead agroforestry.

(ii) **Commercial agroforestry system:** This system refers to large scale production on commercial basis. The main consideration is to sale theproducts, e.g., tea/coffee/cocoa plantations under shade trees. This system is managed by individuals,companies, industries, corporate bodies or government.

(iii) **Intermediate agroforestry systems:** This system is an intermediate between commercial and subsistence systems. It is practiced on small mediumsized farms. The system aims at production of sufficient food, wood, fodder and other beneficial products,which are not enough to meet the needs of the family, but to earn money the surplus can be sold.e.g. fruit trees with agricultural crops.

5.4 Agro forestry systems of India

In general, the common agroforestry systems being practised in different agro-ecological regions ofIndia are, agri-silviculture, Boundary plantation, block plantation, energy plantation (trees + cropsduring initial years), alley cropping (hedges + crops), agri-horticulture (fruit trees + crops), Agrisilvi-horticulture (trees +fruit trees + crops), agri-silvi-pasture (trees + crops + pasture or animals), silvi-olericulture (tree +vegetables), horti-pasture (fruit trees + pasture or animals), horti-olericulture (fruit tree + vegetables),silvi- pasture (trees + pasture/ animals), forage forestry (forage trees + pasture), Shelter belts (trees +crops), wind breaks (trees + crops), live fence (shrubs and under- trees on boundary), silvi or hortisericulture(trees or fruit trees + sericulture), horti-apiculture (fruit trees + honeybee), aqua-forestry(trees + fishes) and homestead (multiple combinations of timber/ fruit/ fodder trees, vegetable andanimals).

5.5 Kinds of agro forestry systems

Nair (1987) has classified the agroforestry systems based on the following fourcriteria.

- Structural Basis
- Functional basis

- Socio economic Basis
- Ecological basis

A. Classification Based on Structure

- Nature of Components
- Arrangements of Components

a) Based on Nature of Components

1. Agricultural systems
2. Silvopastoral systems
3. Agrosilvopastoral systems
4. Other systems

1. Agricultural systems

(i) Improved fallow species in shifting cultivation
(ii) The taungia system
(iii) Multispecies tree gardens
(iv) Alley cropping
(v) Multipurpose trees and shrubs on farmlands
(vi) Crop combinations with plantation crops
(vii) Agroforestry fuel wood plantations
(viii) Shelter belt s
(ix) Wind breaks
(x) Soil conservation hedges

2. Silvopastoral systems

(i) Protein bank
(ii) Live fence of fodder trees and hedges
(iii) Trees and shrubs on pastures

3. Agrosilvopastoral systems

(i) Home gardens
(ii) woody perennials for browse, mulch, green manure, soil conservation

4. Other systems

(i) Apiculture with trees
(ii) Aquaforestry

(iii) Multipurpose wood lots

b) Based on Arrangement of components

1. Spatial arrangement
2. Temporal arrangement

B. Classification Based on Function

- Productive functions
- Protective functions
- Productive functions

a). Productive functions

(i) Food
(ii) Fodder
(iii) Fuel wood
(iv) Cloths
(v) Shelter
(vi) NTFPs

b). Protective functions

(i) Wind breaks
(ii) Shelterbelts
(iii) Soil conservation Soil
(iv) improvement Shade

C. Socio-economic Classification

i) Commercial systems
ii) Intermediate systems
iii) Subsistence systems

D. Ecological Classification

i) Humid / sub humid
ii) Semiarid / arid
iii) Highlands

Suggested Reading

[1] P.K. Ramachandran Nair, *An Introduction to Agroforestry*. The Netherlands: Kluwer Academic Publishers, 1993.

UNIT 6: Crop interactions in agroforestry

Unit Structure

6.0 Learning Objectives

After completing this unit, you will be able to:

- Discuss the various positive and negative tree-crop interactions
- Illustrate how these interactions can be quantified from a bio-physical point of view
- Demonstrate how these common principles can be applied in a wide array of situations dependent agroforestry systems, rather than using blueprint models.

6.1 Introduction

In agroforestry systems trees can share space and time (simultaneous systems), or crop and treephases can be sequential (fallow systems). In simultaneous agroforestry systems, trees and foodcrops interact in many ways, leading to positive and negative impacts on the growth of both tree and crop (Figure 1).

6.2 Tree-crop interactions

Interactions can be positive, neutral or negative. Figure 2 shows schematically the relationships between two agroforestry components according to the type of interactions between them.

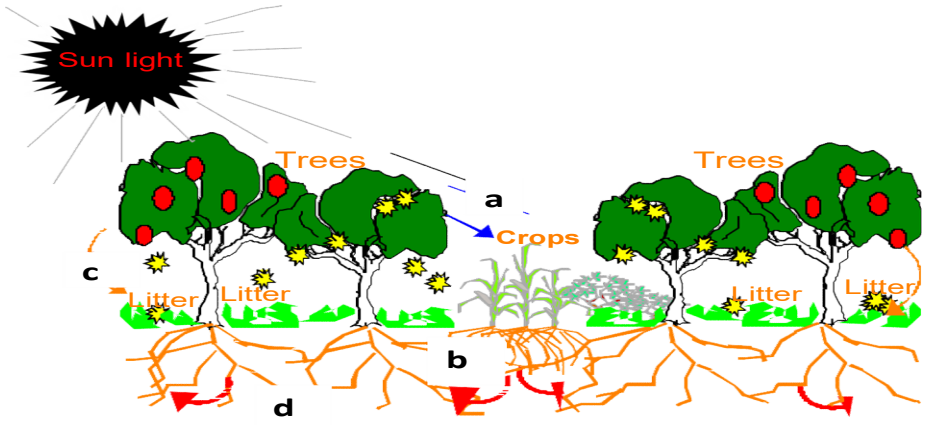


Figure 1. Interaction between trees and crops in a simultaneous agroforestry system.(a = shading; b= competition for water and nutrient; c = litter fall of trees increases C, N, P and other nutrients; d = deep rooted trees play a role as a 'safety-net' for leached nutrient in the deeper layer)

When the interaction is positive, there is complementarily between the components, while there is competition if interaction is negative. This leads to subdivision of interactions as shown in Table 1. Existing agroforestry practices and technologies give examples of the different possibilities and are also shown in Table 1. Fast growing plants need a lot of light, water and nutrients. The past focus on 'fast growing trees' for agroforestry has often underestimated competition effects.

Table1. Analysis of interactions between two populations A and B (modified from Torquebiau, 1994). (0: No significant interaction; + : Advantage for the population in question (growth, survival, reproduction etc.); disadvantage for the population in question)

Type of interaction	Effect of the interaction the population		Nature of the interaction	Agroforestry example
	A	B		
Mutualism	+	+	Interaction favorable to the two populations	Mycorrhizae, Rhizobium-legume
Facilitation	+	0	Interaction favorable for A but not obligatory; B not affected	Windbreaks,shade trees Alley cropping (well managed)

Commensalism	+	0	Interaction obligatory for A and B not affected	Supporttreesfor vines;Improved fallows
Neutralism	0	0	None of the populations affects the other in crop land	Scatteredtrees
Parasitism/predation	+	-	Interaction obligator for A; B is inhibited	Pestanddisease
Amensalism	-		A inhibited; B not affected	Allelopathy
Competition and interference	-	0	Each population is inhibited by the others use of (above- or below ground) growth resources	Alleycropping (poorlymanaged)

6.3 Tree-soil-crop interactions

A more elaborate list of **positive** and **negative** interactions:

6.3.1 Negative interaction (Interference)

a) ***Shading*** by the trees, reducing light intensity at the crop level

b) ***Root competition*** between tree and crop for water and nutrients in the top soil. Here by the tree root architecture is important. Shallow tree root systems are likely to compete more with the crop for scarce nutrients, while deep tree roots can act as a' nutrient pump ‘or 'safety net', where nutrients are so deep that they are out of reach for the crop roots

c) Trees and crops can be a ***host*** of each other’s pests and diseases.

6.3.2 Positive interaction (Facilitation)

a) ***Nutrient recycling*** can be based on:

- Nutrients taken up in the topsoil by tree roots in competition with crops,
- Nutrients taken up while leaching down to a deeper layer with tree roots acting as a 'safety net'.
- Nutrients taken up from weathered minerals in deeper layer, with deep tree roots acting as ‘nutrient pump'.

b) **Litter production**: If litter is high quality(low C/N ratio, low lignin and polyphenolic content), it will decompose rapidly and make nutrients available to the crop and the trees.

c) **Mulch**: Litter of low quality(high C/N ratio, high lignin and polyphenolic content) decomposes slowly and is suitable as mulch. Mulch maintains soil moisture during the dry season. Especially on sandy soils, where water supply for the crops could be a problem, mulch is important.

d) ***Nitrogen supply*** by tree roots to crop roots, either due to root decay or root death following tree pruning or by direct transfer if nodulated roots are in close contact with crop roots,

   i) Tree and crop effects ***reducing weeds*** (by shading in relevant parts of the year) and reducing dry-season fire risks.

   ii) Tree and crop effects ***reducing pest*** and disease pressure by facilitating biological control agents.

   iii) Tree effects on ***micro climate*** (reducing wind speed, increasing air humidity, providing partial shade)

   iv) Long term effects on reducing ***erosion***, maintaining soil organic matter content and soil structure.

6.3.4 How to quantify tree-crop interactions?

The success of any intercropping depends on the balance of ***positive*** and ***negative*** interactions between the components. A simple equation is:

Equation1:

$$Y_{system} = Y_{tree} + Y_{crop} = Y_{tree} + Y_{crop,0} + F - C$$

With

Y_{system} =yield of tree + crop system

Y_{tree}=yield of tree products

Y_{crop}=yield of crop products

$Y_{crop,0}$ =crop yield in a monoculture on the same soil

F = Positive effects of trees on crop growth via soil fertility improvement

C = Negative effects via competition forlight, water and nutrients.

The question whether agroforestry has any advantage over separate crop fields and woodlots, can now be rephrased as:

Positive interaction, if **F > C Negative interaction**, if **F < C**

6.3.5 Synthesis model

1) Mulch + shade model

Fast growing trees produce a lot of mulch material, but also cast a lot of shade. Van Noordwijk(1996a) presented explicit algebraic solutions for an agroforestry model, which links both the *mulch production* and its ensuing soil fertility effect and the *shading* which is assumed to have a negative effect on crop yields to the biomass production of the tree. The model leads to a simple mulch/shade ratio as a basis for comparing tree species. The model also predicts that at low soil fertility, where the soil fertility improvement due to mulch can be pronounced, there is more chance that an agroforestry system improves crop yields than at higher fertility where the negative effects of shading will dominate.

The mulch/shade model, however, does not incorporate the dynamic interactions between *water availability, N dynamics, and crop and tree growth.* Incorporating these elements on the basis of a daily time step extends the model beyond what can be solved explicitly. It leads into the realm of dynamic simulation models, which keep track of resource stocks outside and inside the plants and use these to calculate daily resource flows and daily resource capture.

2) WaNulCas (Water Nutrient Light Capture) model.

The WaNuLCAS simulation model provides a synthesis of current understanding of the processes in ***water, nutrient*** and ***light capture*** in a range of agroforestry systems, as influenced by soil properties and climate. Agroforestry models have to include a two-plant

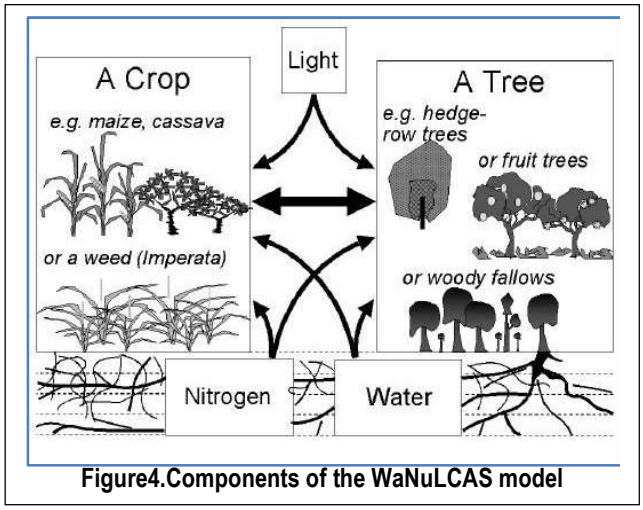


Figure4.Components of the WaNuLCAS model

interaction as illustrated in Figure 4, similar to intercropping and crop-weed models, but differs as one of theplants is a perennial species. The model makes use of the **STELLA II (r)**- modeling environment and represents a 4-layer soil profile with water and N balance. Water and nutrientuptake by crop and atree is based ontheir root length densitiesand current demand. The model allows for the evaluation of different pruning regimes, hedgerow spacing, and choice of species or provenance and fertilizer application rates. It includes various tree characteristics such as root distribution, canopy shape, litter quality, maximum growth rate and speed of recovery after pruning. The model also can be used for both simultaneous and sequential agroforestry systems and may help researchers understand the continuum of options from improved fallow relay planting of tree fallows to rotational and simultaneous forms of hedgerow inter cropping. The tree – soil – crop interaction equation can be further analyzed by:

- Differentiating between ***short*** and ***long*** term fertility effects (F_1 and F_{II}, respectively)
- separating the competition term in an *above*-and a ***below*** *ground* component (C_I and C_{n+w},respectively)

The total balance for below ground resources (water or nutrients) inputs into an agroforestry system is formulated inequation 2:

Equation2

$$\Delta Stored = Input + \mathrm{Re}cycle - Upt_{cro} - Up_{tree,com} - Upt_{tree,noncom} - Los$$

The terms used in the above equation are presented in Table 2, where the term Upt tree, non competitive represents the ‘safety net’ function of tree roots for nutrients and water leaching and percolating below the zone of crop roots and/or outside of the crop growing season, as well as a nutrient pump role for resources stored in the sub soil for longer periods of time (Young, 1997).

Table 4. Representation of resource capture (equation 1) in a simple tree-crop agroforestry system.The crop roots are confined to the 'topsoil' and the tree roots explore the 'subsoil' as well; the subscripts 1, 2 and3 refer tocrop zones with increasing distance to the tree

Termineq.2	Water	Nitrogen	Light
Input	Rainfall,irrigation run-on-runoff	Fertilizer & organic import	Sumofdaily radiation
Recycle	Hydraulic lift into crop rootzone	Litter fall,treepruning, Crop residues	-
Up take Crop	W_ Uptake crop	N fix(Crop)+ N _ Uptake crop	Light cap _ crop
UptakeTree, Competitive	WUptaketree	Top N _ Uptake tree	Lightcap_tree$_{1,2}$
Uptake Tree, Non comp	W _ Uptake tree	N _ fix (Tree)+ N Uptake tree	Lightcap_tree$_3$
Losses	Percolation from Lowest zone	Leaching from lowest zone	1-Lightcap
storage	Water content	(N min & SOM)	-

6.3.6 Management options

To what extent can these research results now be translated into management recommendations? That is what ultimately matters for the farmer.

a) Fast growing trees usually have a broad distributed canopy; **pruning** can reduce the above ground competition (shading!), but this is labour-intensive

b) **Frequency and height of** above ground **pruning** affect depth distribution of tree root systems. More frequent and low level tree pruning stimulate superficial tree roots, increasing competition for water and nutrients.

c) **Fallowing** the land can be beneficial where residual effects of the trees benefit the crops in subsequent years.

d) **Choice of tree species** is crucial with regard to shading effects, root competition or production of useful products for the farmer. As trees generally have a long lifetime, a good choice is a far-reaching decision, which has effects on the longer term.

e) **Mulching** crops with prunings from the trees area possible way to improves oil fertility. Decomposition of organic residues have a direct effect on crop growth, by mineralization of N and other nutrients, and an indirect one, by build-up soil organic residues which may increase future efficiency of nutrient use. Rapidly

decomposing organic residues of low C/N ratio contributes mainly by N-mineralization and slowly decomposing organic residues contribute especially to build up of the soil organic matter pool. Slowly decomposed organic residues are also suitable for mulching. What quality criteria of organic residues were used? Organic residues have a low quality if they have a C/N ratio >25, a lignin content > 20% and a polyphenolic content > 2%, usually found in thick and shiny leafs and woody biomass.

6.4 Selected Tree Seed

(Improved Returns in the Short-Term, Viable Populations for the Long Run)

For generations, people all over the world have unwittingly been depleting the gene pool of many important trees by cutting down trees with the best characteristics, and leaving behind the inferior ones. Hundreds of forestry and agroforestry tree species have also suffered from severe genetic loss due to indiscriminant deforestation.

It is crucial that reforestation, forestry and agroforestry projects make strides to improve the gene pool by propagating seed from carefully selected trees. By utilizing the highest quality selected seed and plant material available, you can begin to reverse the trends of genetic degradation while improving the productivity and health of your plantings.

The genetic quality of tree seed used in plantings is a major factor in the economic success and productivity of a project. Select seed will produce plants that are more productive, better adapted to local site conditions, and better suited to achieve the results planned for the project. The long-term ecological viability and future contribution of a planting is also at stake, as projects should contain enough diversity to reproduce healthy and productive offspring for future generations, while remaining resilient to environmental stresses. The short and long term impacts of genetic seed quality warrant careful consideration and planning when collecting or purchasing seeds.

6.4.1 Five Main Criteria In Selection (Or, What Are We Selecting For?)

There are five main criteria in selecting tree seed for a particular species:

1) **Characteristics of the tree products/services:** Tree characteristics such as form, wood quality, or biochemical traits are likely to be passed on to the offspring

of a tree. Select trees that are representative of the qualities that are desirable for your project.

2) **Adaptation to site conditions such as soils, wind, elevation and rainfall**: Different populations of a species have varying tolerances to environmental conditions and stresses. Select from populations that are adapted to conditions similar to yours.

3) **Tree growth rate**: Studies have shown that you can readily achieve a 20-100% increase in overall growth rate for a species by selecting seed from trees that are the best performers.

4) **Resistance to pests and diseases:** Minimize collections from trees that are obviously prone to harmful pests and diseases.

5) **Genetic diversity of the seed:** Diversity is an important factor. Create a local population with sufficient diversity and vigor in the gene pool to allow for viable populations and offspring into the future as well protect against loss to unforeseen biological and environmental stresses in the near term.

6.4.2 Three Tips for Collecting Select Seed

Here are three important standards to keep in mind when collecting seeds. If you're purchasing seeds collected by someone else, ask if they follow these standards too.

1) Collect from trees with the best form, vigor, and health--the offspring of such trees will tend to have similar qualities. When you are out collecting, keep in mind that seed selection is definitely an area where "quality over quantity" has to be the standard. Distressed and stunted trees tend to produce the most abundant seed, and usually low to the ground where it is easier to access. AVOID collecting from such trees, as you will pass on their undesirable traits. Often the trees with the most desirable characteristics are also the most challenging to collect seed from because they are the tallest and most difficult to access. Rise to the challenge! The extra effort you make now will pay off many times over, for your purposes and for the future.

2) At a minimum, be sure to collect from at least 30 individual trees. To reduce the chance of collecting from closely related individuals, take seed from trees separated by 70 meters (200 feet) or more. If you can pick from more than 30

trees, do so. Pick from throughout the canopy of each tree to ensure that a range of pollinators is represented in the seeds. Pick similar quantities of seeds from each tree so that no one tree is over represented. This can help prevent inbreeding in future generations.

3) Collect from wild stands and within the native range wherever possible. Many plantings done by people have too narrow a genetic base to be a viable source of seed, and the offspring of such populations may be inbred. (Also, be sure to leave enough seed in the wild to allow that population to regenerate naturally.)

By collecting from a broad diversity of specimens selected for superior qualities, your will improve the productivity of your planting now, and its ecological viability into the future.

6.4.3 Multipurpose Tree Species (MPTs)

The multipurpose tree species (MPTs) is a plant species that are purpose fully grown so as to provide two or more than two products and also a service functions like shelter, shade, land sustainability of the land-use system. Many woody perennial species may be 'multipurpose' in one kind of system but 'single purpose' in another. The MPTs are beneficial in a number of ways. They are briefly summarized as follows:

A) Food Related Benefits

1) Human food from trees (fruits, nuts, leaves, cereal substitutes, etc).
2) Livestock feed from trees (one step down the tropic chain).
3) Fertilizer trees for improving the nutritional status of food and feed crops through:
    a) Nitrogen fixation
    b) Access to greater volume of soil nutrients through deep rooting trees
    c) Improved availability of nutrients associated with higher cation exchange capacity and organic matter levels.
4) Soil and water conservation.
5) Environment amelioration.

B) Water Related Benefits

1) Improvement of soil moisture-retention in rain-fed cropping systems and pastures through improved soil structure and microclimate effects of trees.

2) Regulation of stream flow for reduction of flood hazard and more even supply of water, through reduction of run-off and improvement of interception and storage in infiltration galleries, through various watershed protection practices involving trees.
3) Protection of irrigation works by hedgerows of trees.
4) Improvement of drainage from waterlogged or saline soils by phreatophytic trees.
5) Increased biomass storage of water for animal consumption in forage and fodder trees (higher water content of tree fodder in dry season).

C) Energy Related Benefits

1) Firewood for direct combustion
2) Pyrolytic conversion products (charcoal, oil, gas).
3) Produces gas from wood or charcoal feedstocks.
4) Ethanol from fermentation of high-carbohydrate fruits.
5) Methanol from destructive distillation or catalytic synthesis processes using woody feedstock.
6) Oils, latex, other combustible saps and resins.
7) Augmentation of wind power using appropriate arrangements of trees to create venturi effects (wind power is proportional to the cube of wind velocity).

D) Shelter Related Benefits

1) Building materials for shelter construction
2) Shade trees for humans, livestock and shade-loving crops.
3) Wind-breaks and shelter-belts for protection of settlements, cropland
4) And pasture.
5) Living fences.

E) Raw Materials for Processing

1) Woodforavarietyofcraftpurposes.
2) Fiber for weaving industries.
3) Fruits,nutsetc.fordryingorotherfood-processingindustries.
4) Tannins,essentialoil,medicinalingredientsetc.

F) Cash Benefits

1) Direct cash benefits from sale of above-listed products
2) Indirect cash benefits from productivity increases (or input savings)

3) Via associated crops or livestock

G) Savings Investment

1) Addition of a viable emergency saving or investment enterprise to farms now lacking one.
2) Improvement of exiting savings/investment enterprise (e.g., fodder for cattleassavings on thehoof).

H) Social Production

1) Production of goods for socially motivated exchange (e.g. cattle for bride price, ceremonial foods etc.)
2) Increased cash for social purposes (ritual expenses, development levels, politicalcontributions etc.)

Characteristics of MPTs

Multipurpose trees species should fulfill the following criteria:

- Wider adaptability to local climatic conditions.
- Thin and sparse crown that allows sunlight enter into the system
- Capacity to withstand various management practices like coppicing, lopping and pollarding etc.
- Quick sprouting habit.
- Productive capacity that includes poles, wood, food, fodder, medicinal and other products.
- Good leaf litter making nutrients available at appropriate times in the crop cycle.
- Few and shallow lateral roots (or prunable).
- Ability to assist in nitrogen fixation.
- Resistance to drought, flooding, soil variability and other climatic hazards.
- Deep thrusting taproot system.
- Easy to manage
- Cheap to establish
- Higher demand and better value for the produce.

Summary

Agroforestry systems are only beneficiary - from a biophysical point of view -, if there is at least some complementarily in resource capture. Direct empirical approaches to quantify complementarily are possible for aboveground processes, but are more complex below ground. Resources that are stored over a longer period of time make it more difficult to judge whether or not resources could have been used outside an

agroforestry context. Models of tree-soil-crop interactions have to pay specific attention to the depth from which each component is capturing water and nutrients on a daily basis, in order to derive overall complementarily on a seasonal basis.

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UNIT 7: Agroforestry and Human Welfare

Unit Structure

7.0 Learning Objectives

After completing this unit you shall be able to:

- Define agroforestry and human welfare
- Explain ecological aspects of Agro forestry and
- Explain economic aspects of Agro forestry

7.1 Introduction

Agroforestry is an ideal land use option as it optimizes trade-offs between increased food production, poverty alleviation and environmental conservation [18]. This system is adopted in a large hectare of boundaries, bunds and wasteland area and permits the growing of suitable tree species in the field where most annual crops are growing well. Agroforestry assures permanent sources of higher income even in extreme adverse conditions. The role and scope of agroforestry are also studied in way of biodiversity conservation, yield of goods and services to society, augmentation of the carbon storages in agro ecosystems, enhancing the fertility of the soil and providing social and economic well-being to people [19]. Since agroforestry is a land use management

system without deterioration of its fertility that results in more output, this adds to the national economy. Thus, a bright future of agroforestry in India is inevitable.

Agroforestry contributes a vital role in Indian economy and has potential to satisfy three objectives, viz. to protect and ameliorate the environment, enhance sustainable production of economic goods on a long-term basis and improve socioeconomic condition of rural people. It has many contributions like rehabilitation of degraded land, increased farm productivity and capability of conserving natural resource and it is an option to increase the forest cover to 33 % in the country. Besides meeting the subsistence need of food, fruits, fiber and medicines, this farming practice meets almost half of the demand of the fuel wood, two-thirds of the small timber, 70–80 % wood for plywood, 60 % raw material for paper pulp and 9–11 % of green fodder requirement of livestock. Also, agroforestry practices have enhanced overall biomass productivity from 2 to 10 t ha-1y-1 in rain fed areas in general and the arid and semiarid regions in particular [1]. Agroforestry is also providing livelihood opportunities through lac, apiculture and sericulture cultivation, and suitable trees for gum and resin have been identified for development under agroforestry [33]. Under agroforestry system, tree cultivation on agricultural land improves biomass productivity per unit area and also uses nutrients from different soil layers. Further, land such as bund and avenues that are hitherto not cultivated would increase the tree cover of the landscape [34]. Agroforestry is also an attractive option for climate change mitigation as it sequesters carbon in vegetation and soil, produces wood, serves as substitute for similar products that are unsustainably harvested from natural forests and also contributes to farmer's income [37]. As per Alavalapati and Nair [38], agroforestry is widely considered as a potential way and low-cost method to sequester atmospheric carbon and recognized as one of the strategies for climate change mitigation.

7.3 Economic and ecological aspects of agroforestry

7.3.1 Environmental benefits

The environmental impacts of agroforestry practices on farmers are discussed individually as under.

- **Biomass production:** There is significant increase in biomass production viz. fodder, fuel, timber etc. with the adoption of agroforestry. Fodder species like *Glyricidia maculata, Sesbania, Luecaena sp*. (Subabul) and other species like *Tectona grandis, acacia, Azdirachta indica* (Neem), *Cassia siamea, Melia dubia, Casurina sp.* (Casuarina) were grown in agroforestry. This combination not only meets the fodder needs of the cattle and timber needs for agricultural implements but also add organic matter to the soil.

- **Groundwater recharge:** The findings explicitly indicated that there is a significant improvement in the ground water availability due to tree based farming interventions. Farm pond was one such major intervention made to harvest excess runoff rainwater in agroforestry plots. These farm ponds were located in the upper/ middle catchment of the land, which enhanced the percolation which intern recharges the groundwater table.

- **Dependency on natural forest:** Reduction of dependency on the natural forest was observed because agroforestry met the fuel, fodder, fruits, fibre and timber needs of the farmers.

- **Incidence of pest and diseases**: The incidence of pests like mealy bugs, termites, shoot and stem borer were reduced as they were preyed upon by birds, who have made their nests in trees and some birds were also attracted by the fruits in the agroforestry plots.

- **Climate changes:** There was significant difference in atmospheric temperature, rainfall pattern and celaphic characters before and after the adoption of agroforestry. Possible reason is that tree species might have acted with regard to the modification of micro climatic parameters. Also the tap-root system of various trees acted as a barrier to soil erosion by holding soil particles tightly.

- **Utilizing Wasteland:** Wastelands are degraded lands that lack their life-sustaining potential as a result of inherent or imposed disabilities such as by

location, environment, chemical and physical properties of the soil or financial or management constraints [60]. It includes area affected by water logging, ravine, sheet and gully erosion, riverine lands, shifting cultivation, salinity, wind erosion, extreme moisture deficiency, etc. Due to complete loss of top soil, these degraded lands are ecologically unstable and are unsuitable for cultivation. The main causes responsible for development of wasteland include deforestation, shifting cultivation, overgrazing, unskilled irrigation, industrialization activities, etc. Deforestation on a vast scale has increased soil erosion, disturbed water regimes and resulted in scarce supply of fuelwood, fodder and small timber on which the vast majority of India's rural population has been dependent for centuries. The degradation of wasteland can be overcome by participatory approach like social forestry, joint forest management, community forestry, etc., with the help of local people in the planning and management of lands [61] through afforestation of suitable species like Jatropha, Neem [25-26], *Acacias* species, etc. Further, these degraded, and wasteland are reclaimed and restored through a scientific plantation technique, either sole tree plantation under afforestation scheme or practices of different agroforestry models based on specific location. Agroforestry models for fodder production, viz. silvopasture, hortipasture, hortisilvipasture and agrisilviculture system, are usually established in degraded cultivable lands. The wastelands could be effectively utilized for fodder production parallel to livestock production through agroforestry system, which is also an environmentally safe system of land use

- **Nutrient cycling in agroforestry:** Generally, agroforestry practices increase the soil organic matter through leaf litter addition. It increases the population of beneficial microorganism and improves biological nitrogen fixation in soil. All microbiological activity in soil contributes to cycling of nutrient and other ecosystem functions, and all soil functions contribute to ecosystem services. Recycling in natural system is one of the many ecosystem services that sustain and contribute to the well-being of human society [69]. Low soil fertility

is one of the greatest biophysical constraints of production of agroforestry crops across the world [70].

- **Water stress in relation with growth and productivity in agroforestry:** Water stress in plant is developed during periods of water deficiency because plants are unable to absorb adequate water to match the transpiration rate. A water deficiency exists when the amount of rainfall is less than potential evapo-transpiration. Water stress may be either due to water shortage or due to excess of water. Water deficit is one of the key limiting factors for plant growth, productivity and survival and often adversely affects agroforestry practices in arid and semiarid areas [75]. However, plants can normally acclimate to water stress through physiological and morphological responses [76]. However, critical water stress leads to death of plants. Agroforestry has the potential to improve water productivity in two ways. Trees can increase the quantity of water used in farms for tree or crop transpiration and may also improve the productivity of the water that is used by increasing the biomass of trees or crops produced per unit of water used [77]. The rate of depletion of land and surface water in our country is indeed alarming. So the rational approach is required, like by developing the suitable agroforestry model and/or integrating with the rain water harvesting unit for overcoming the water crisis in the country [78]. So water stress in agroforestry can be minimized by developing the appropriate models in general and growing site-specific species.

- Reduction of pressure on natural forests.
- More efficient recycling of nutrients by deep rooted trees on the site
- Better protection of ecological systems
- Reduction of surface run-off, nutrient leaching and soil erosion through impeding effect of tree roots and stems on these processes

- Improvement of microclimate, such as lowering of soil surface temperature and reduction of evaporation of soil moisture through a combination of mulching and shading

- Increment in soil nutrients through addition and decomposition of litter fall.

- Improvement of soil structure through the constant addition of organic matter from decomposed litter.

7.3.2 Economic benefits

The economic impacts of agro forestry practices on farmers are discussed individually as under.

- **Family income:** With the adoption of agroforestry farmers started getting more income by selling the fruits and timber every year. Subsidiary activities like mat weaving, basket making, honey collection, sheep / goat rearing etc. are also taken up as an integral part of agroforestry which also intern contributed to the increased family income.

- **Employment status:** Farmers who used to migrate to other areas in search of employment were reduced to maximum extent as a result of employment generation due to agroforestry which ensure employment throughout the year.

- **Livestock possession:** Agroforestry ensured good and cheap fodder, which intern increased the number of livestock.

- **Supplementary income:** One of the uniqueness of integrated farming system in general and agroforestry in particular is the promotion of traditional subsidiary occupation. This is due to the availability of raw materials for these activities. As a result farmers started many subsidiary ventures like basket making, mat weaving, bamboo crafts etc. These subsidiary occupations, naturally added to the total family income generated from the farmers.

- **Farm expenditure:** The expenditure incurred by the farmers on the farming has increased marginally, but not significantly. Increase in levels of farm income due to improved and sustained productivity

- Increment in an outputs of food, fuel wood , fodder, fertilizer and timber;

- Reduction in incidence of total crop failure, which is common to single cropping or monoculture systems

7.3.3 Social benefits

Social benefits of the agroforestry are discussed under:

- **Festivals:** The farmers have started celebrating their festivals colourfully due to increase in annual income from agroforestry.

- **Food Habits:** The data revealed that there was a variation in food habits before and after adopting of agroforestry. With the adoption of agroforestry, farmers have stopped their traditional profession like hunting, gathering forest produces because they themselves started to produce sufficient food grains.

- **Communication exposure:** Adoption of agroforestry nesseciated them to get in contact with field extension functionaries, radio, newspaper etc to gain more information on agroforestry for better adoption.

- **Migration:** Practicing of agroforestry resulted in increased self-employment opportunities through interventions such as nursery raising, mat weaving, basket making etc. This has resulted in gradual decrease in migration.

- **Nature of occupation:** Farmers were involved in hunting and gathering of minor forest produce in the nearby forests/estates for their livelihood before the introduction of agroforestry. Now they have stopped these occupations and are concentrating only in farming.

- Improvement in rural living standards from sustained employment and higher income
- Improvement in nutrition and health due to increased quality and diversity of food outputs
- Stabilization and improvement of communities through elimination of the need to shift sites of farm activities.

Summary

The overall results of this unit has pointed out that the agroforestry can bring significant social, economic and ecological changes that are desirable for the society and hence agroforestry can achieve effectively social, economic and ecological sustainability. Agroforestry clearly has great potential to improve social and economic conditions in developing countries. Its ability to improve soil quality and mitigate climate change through carbon sequestration should also make it an appealing agricultural method in countries with more significant economic resources or large farm systems. Because of these benefits, agroforestry should continue to be studied and expanded, but with careful considerations. For example, in smaller populations, agroforestry should not be introduced unless it is done so in a way that is compatible with local traditions and practices. Technical knowledge and accurate information should be carefully conveyed so that agroforestry practices can be sustained and to maximize benefits.

UNIT 8: Management and economics of tree cultivation in agro forestry

Unit Structure

8.0 Learning Objectives

After completing this unit, you will be able to:

- Define the economics of cultivation of some important species and
- Nursery and various planting techniques

8.1 Introduction

In this unit we will have species specific economics. In this unit we will discuss ten important species i.e. *Acacia catechu, Dalbergia sissoo, Tectona, Populus, Morus, Grewia, Eucalyptus, Quercus* spp. and bamboo, tamarind, neem etc.

8.2 Economics of cultivation of some species

8.2.1 Economics of cultivation of *Acacia catechu*, Willd

Botanical name: *Acacia catechu* Willd.

Common name: Khair, Kath tree, Cutch tree

Family: Leguminosae

Sub Family: Mimosoideae

Tree Leaves Pods and Leaves

Figure 1 ***Acacia catechu***

Description: A moderate sized deciduous tree with light feathery crown with crooked brown bole, Bark dark brown and red inside. Branches are glabrous armed with recurved thorns. The species is distinguished into three distinct varieties viz. *Acacia catechu*, variety catechuoides, variety sundra and variety catechu.

Distribution: It is found throughout India except in humid and temperate region. It is widely distributed between 900-1200 m from Jammu to Assam. Variety catechu is found in Sikkim, Tarai, West Begal, Assam and upper Mynmar. Variety sundra is found in Indian Peninsular region and parts of Burma.

Climate: Temperature - Maximum 40°C -50°C; Minimum 1°C; Rainfall - 500mm to 2000mm; Altitude - 1200m

Soil: *Acacia catechu* grows on wide variety of soils such as sandy, gravelly alluviam, loam with varying proportions of sand and clay and black cotton soils.It is capable of growing on shallow soils with murram or kankar on which few other species can grow.

Phenology: Leaf-fall - January-February

Leaf renewal - April-May

Flowering - April to August

Fruiting - September-October

Seed collection – October-November, December

Silvicultural characters: Strong light demander, frost and fire hardy, wind firm, browsed by animals.

Regeneration:

a) Natural regeneration:

- *Acacia catechu* reproduces naturally through coppice as well as from seed.
- The coppicing power of the trees depends upon their age, vigour, season of cutting and site conditions.
- In its stands of normal growth and stocking, coppicing can be relied upon to regenerate this species. Such stands are worked under coppice system.
- The stocking of the coppice crop, which depends upon the stocking of the natural crop coppiced and the coppicing power of the trees, is generally irregular.
- Coppice regeneration has therefore to be supplemented by artificial regeneration.
- Coppicing cannot be relied upon in selection stands where *Acacia catechu* grows mixed with other species as the light sufficient for the development of coppice shoots dose not reach the ground in such forests.
- Under heavy shade the stools normally do not coppice.
- The stand having over mature trees also cannot be regenerated through coppice because of the weak coppicing power of such tree.
- It has, however, been observed in some areas that the size of the stump does not affect the coppicing power and the stumps up to 60 cm diameter not only coppice well but also produce healthy coppice shoots.
- The growth of crop is faster than that of the seedlings crop; an average girth of about 20 cm and an average height of about 3.4 m can be expected for nine years old coppice.
- Coppice crop, however, requires thinning of stool to reduce the competition which may otherwise very adversely affect the growth rate of coppice shoots.
- Natural regeneration through seed can be expected under favourable conditions only.

- Seeds, are disseminated by wind. Germination takes place with the onset of monsoon rains and the seedlings get established where conditions are favourable for their growth.
- Soil type, drainage, weed competition, shade and grazing are important factors determining the success of natural regeneration through seed.
- Poor drainage coupled with shade results in heavy mortality of the seedlings because such conditions encourage damping-off. Tall and gregarious weeds compete out the seedlings.
- Grazing does not permit any natural regeneration to establish as the seedlings are browsed and killed. Profuse natural regeneration may be expected in areas kept free of grazing.
- It may be totally absent in grazed areas.
- The growth of seedlings in naturally regenerated crops is slow and they often die-back in winter

Artificial regeneration: *Acacia catechu* can be propagated by one of the three methods, namely (1) direct sowing, (2) planting out nursery raised seedlings and (3) stump planting. Direct sowing is better than stump planting, which is preferred to planting out of entire plants without containers.

i) Line/strip sowing in lines 60 to 90 cm apart, strips 2.5 to 3 cm apart.

ii) Broadcast sowing in weed free area.

iii) Patch sowing by dibbling 2.5 to 3 cm apart.

iv) Potted plants or with ball of earth.

Seed collection and storage:

- The seed ripens in November-December or early January
- Seeds are very susceptible to insect attack even when on the trees and the pods should, therefore be collected shortly before the seeds are fully ripe as otherwise most of seed crop may be destroyed by insects.
- The pods are dried in the sun and then thrashed to separate the seed which is properly cleaned, dried in the sun and stored in airtight tin containers. The

seed should preferably not be stored for more than 6 to 8 months under ordinary conditions;

- The seed should preferably be sown during the year of its collection. As Acacia catechu is a good seeder, there should be no problem in the collection of sufficient fresh seeds every year.
- About 30 to 40 seeds weigh one gram.
- Seed yield per tree is about 0.5 to 2.0 Kg.

Nursery technique:

- Sowing is done in February-March in well prepared nursery beds.
- The spacing adopted is 20 cm between the lines and 2 cm between the seeds in the lines.

Planting technique:-

a) Polybag plants:

- A pit of 30cm3 is prepared with a spacing of 3m × 3m about 2 months in advance
- Planting is done in the month of July
- Polythene container must be removed at the time of planting

b) Ball of the earth planting:

- The taproot is cut at a depth of 25-30cm at the time of uprooting of seedling
- Splitting or bruising tap root is avoided
- Transplanting of seedling is done in rainy season as winter entire transplant are failure

Stump planting:

- Stumps are prepared from 12-15 month old seedling
- The root and shoot portion should be 23-31cm and 2.5 to 5.0cm respectively.
- Stump less than 1cm collar diameter give poor survival
- Stump can be stored for 3 days
- Planting of stump should be done in the onset of monsoon

Silviculture system for management:

The best system under which khair is managed is the clear felling followed by artificial regeneration.

Disease:

Ganoderma lucidum causes root rot disease with considerable mortality in khair plantation raised after clear felling.

Economic importance:-

- Heartwood is mainly used for katha extraction
- Timber is mainly used for agriculture implements
- Small branches for fuel-wood
- Leaves as fodder for goats
- Gum is also important product obtained from Acacia catechu and regarded as the best substitute for the gum-arabic

8.2.2 Economics of cultivation of *Dalbergia sissoo*

Scientific Name: *Dalbergia sissoo* Roxb.

Common Name: Shisham, Sissu

Family: Leguminosae

Sub Family: Papilionoideae

Description

- It is a large deciduous tree with light crown having thick, rough, grey bark with shallow broad longitudinal fissures exfoliating in irregular woody strips and scales.
- It attains a height up to 30 m and a girth of 2.4 m.

Distribution

- The spp. occurs throughout the sub-Himalayan tract and outer Himalayan valleys from the Indus to Assam; usually upto 900 m, but occasionally ascending upto 1500 m.
- Grow gregariously on alluvial soil along stream bank, beds and islands, and on freshly exposed soil along roads and landscapes along with Khair

Figure 2a: *Dalbergia sissoo* tree **Figure 2b:** *Dalbergia sissoo* leaves

Climate

It grows from tropical to sub tropical climate.

- Temperature - Maximum 40°C to 50°C, Minimum 4°C
- Rainfall - 760 mm to 4600 mm
- Altitude - Upto 1500 m.

Phenology

Leaf-fall - November to December

- Leaf renewal - January-February
- Flowering - March/April
- Fruiting - May – July
- Fruit ripe - November-December
- Seed collection - November-December
- Seed viability - 12 - 18 months.
- Seed weight - 530 / gm.
- Germination - 80 per cent.

Silvicultural characters

- *Dalbergia sissoo* is a strong light demander
- It is very frost and drought hardy spp.
- It is wind firm in nature and sensitive to fire and browsing

Regeneration

A) Natural Regeneration

- Seeds germinated during rainy season give good survival,
- Seeds regenerate on newly exposed soil, along water channel, riverine tract.

B) Artificial Regeneration

- It is one of the easiest species to propagate through almost all the common methods viz. direct sowing, entire transplanting, stump planting.

C) Seed collection and storage

- The seeds are plentiful every year, and keep viability for one year.
- Fertile seeds are produced at the age of 3-4 years, but it is advisable to collect seeds from the middle aged vigorously growing trees having straight and clean boles; on an average a medium sized tree produces 12-15 kg pods (4-5 kg clean seed).
- Time of collection varies from December to mid-February in Assam; West Bengal, Punjab and from November to March in Bihar and Orissa.
- The seed can be collected by ascending the tree or beating off with sticks.
- The pods are dried in the sun for 3-4 days and stored after removing dead leaves, foreign matter, etc.

D) Germination capacity and plant percent:

- Germination capacity and plant percent in Dalbergia sissoo are about 90 and 45 per cent respectively.

E) Nursery technique

- Soaked seeds germinate after 7 to 15 days.
- Pricking by end of first season (18-20 cm height). 56 kg seeds are sufficient for one ha area.

F) Planting technique

a) Direct sowing

- Direct sowing is the easiest method to raise shisham plantations; in fact, most of the seeds are sown in lines at the break of rains.

- Distance between lines varying from 3 to 4m.

b) Entire planting

- The planting of entire seedlings being much more laborious and costly, is adopted only in special cases such as arid areas, areas infested with tall grasses, wet sides or along the roadsides.
- Planting is generally done when the summer rains have properly set in, while the pits may be dug sometimes earlier.

c) Stump planting

- Stump planting has clear advantages over either entire planting or direct sowing.
- Cost of stump planting is low; planting period is extendable from July to September.
- The season of stump planting would depend upon the local rainfall and availability of artificial irrigation.
- Best time for planting is the rainy season.
- Stumps are spaced 1.8 m apart in lines on trenches which are 3 m apart from row to row.

Economic importance

- Furniture and house construction
- Fuel and charcoal
- Leaf fodder
- Anti-erosion works

8.2.3 Economics of cultivation of *Tectona grandis* L.

Botanical Name: *Tectona grandis* L.

Common Name: Teak, Sagwan

Family: Verbenaceae

Figure3. *Tectona grandis* L. tree

Description

- Large deciduous tree up to 30 m high and 100 cm or more dbh
- Long straight cylindrical bole up to 2/3 of the height of tree.
- Deep tap root system
- Bark pale brown, grey, striate, fibrous, peeling off in thin strips
- Branch-lets are quadrangular and channelled

Distribution

- Indigenous in peninsula of India, in North-Eastern drier part of Java and other islands of Indian Archipelago
- The Nilambur in Kerala, manmade teak forest are known to foresters throughout world.
- Natural habitat is between 10°N and 25°N on Indian subcontinent, in South-East Aisa especially in India, Burma, Thailand, Laos, Combodia, Vitenam and Indonesia.
- It does not occur naturally in Malaysia

Site factors

Climate

- Teak naturally occurs only in monsoon climate
- Temperature - Maximum 48°C, Minimum 2°C
- Rainfall - 700mm to 2200 mm
- Altitude - 600m to 1200 msl.

Soil

- It grows on variety of geological formations notably trap, limestone, granite, gneiss, mica schist, sandstone, quartzite and clay
- Well drained, well ventilated soils with high oxygen content are best
- Generally prefer soil between pH 6.0-8.5H

Phenology

- Leaf-fall - Dry area- November to January

  Wet area- March
- Leaf renewal - May
- Flowering - June to September
- Fruiting - November to January
- Seed collection - January/February
- Seed viability - more than 1 year
- Seed weight - 125 to 176 per 100 gm.
- Germination - 60 to 80 per cent.

Silvicultural characters

- Strong light demander
- Frost tender
- Drought and wind sensitive
- Fire resistant
- Not browsed
- Good coppice

Natural

- Seeds abundantly
- Requires warmth and light for germination
- In cool shady places the seeds may lie dormant for years
- Establishment of seedlings largely depends on light
- Frost sensitive nature hence seedlings are killed by frost
- Light burning is beneficial
- Weed growth and ground vegetation is obstacles
- Especially Lantana camera discourages its regeneration.

Artificial

- First ever plantation is carried out in Nilambur in 1842 under Conolly.
- Seeds, coppice shoots, stump etc.

Seed collection and storage

- Viable seeds obtained from the age of 5-6years
- Twenty year old plantation regenerates naturally
- Nine year old coppice raised plantation produce healthy seedlings
- Seeds should be collected underneath the trees during January-March
- Seeds cleaned and dried are collected in gunny bags and stored in dry areas
- 35 Kg seeds are required to produce stumps for one hectare area

Pre-sowing treatment

- Necessary to break dormancy of the seed
- Seed germination in the untreated seeds is totally absent or very insignificant
- Following treatments are required to break dormancy of the seed

Natural Weathering

- Seeds are spread over raised platform in the middle of August during rains seeds get
- soaked and then with sun they get dried thus getting natural weathering

Artificial weathering

- Freshly collected seeds are put in gunny bags which are then submerged under flowing water for four days. The gunny bags are taken out and spread over in strong sun for four days. It is again submerged in water for 3-4 days following drying. It is repeated for 3-4 times until endocarp and mesocarp get easily cracked
- **Pit method:** Seeds are put in alternate layers of seeds and straw and daily watered for seven days then dried and stored till the time of sowing
- **Soaking in water:** Immersion of seeds in water for number of days has hastens germination
- **Biological method:** Burying the seeds for one year near the ant hill is reported to give better results

Chemical treatment

- Soaking the seed in concentrated H_2SO_4 for 20 minutes and thorough washing in running water hastens germination

Scorching

- Scorching the seeds in light running fire of leaves of grass or alternatively seed picked from plantation after a light ground leaf-fire is useful method

Cow dung

- Soaking the seeds in the mixture of cow dung and water enhance germination

Nursery technique

- Nursery beds are prepared one year in advance of planting
- Beds of 12 m × 1.2 m size are prepared
- In moist localities raised beds are prepared while in dry localities sunken beds are helpful for germination
- Seeds are sown in the nursery bed from February-June
- 2.5-3 Kg seeds are required per bed
- About 1200-1500 seedlings are expected

Preparation of stumps

- Stumps with 1cm to 2cm diameter at collar level with about 25cm root portion and 2.5cm stem portion are most suitable

Plantation technique

Direct sowing

- It is practiced on very limited scale due to heavy causality

Entire transplanting

- Dona plants are preferred in place of pre-sprouted or normal teak stumps
- The soil in dona retains moisture for comparatively longer period and keep the plant alive
- Dona plants are 4-6 months old at time of planting

Stump planting

- This is the most useful and economical method for teak plantation
- Stumps are plated in crow bar holes and generally buried up to the collar
- In Odisha and drier part of Tamil Nadu stumps are buried up to the tip
- In Madhya Pradesh, in hard soil, stumps are planted in 15cm diameter hole and about 30cm deep
- While planting the stumps the collar is flushed with ground level

Pre-sprouted teak stumps

- In very dry locality pre-sprouted stump planting give satisfactory results
- The stumps are planted 4-6 month in advance and put in container raised on a platform in shade and watered daily
- These stumps after sprouting are planted at the onset of monsoon
- The planting of sprouts is done with the ball of Earth intact in cylindrical holes

Polythene bag

- Planting of seedling raised in polythene bags have also been tried in such cases treated seeds are sown directly in polythene bags filled with manured soil
- The bags are watered daily and planted out when seedling attains a height of 15cm

Vegetative propagation

- Teak can be propagated by grafting, layering and rooting branch cutting
- Among the grafting method used bud grafting is preferred as it is easy, economical and more suitable for grafting on stumps
- Grafting success depends upon age of mother plant, time of grafting and method used

Economic importance

- Furniture and house construction
- Ship and railway coach
- Wood oil for decreasing durability of timbers

8.2.4 Economics of cultivation of *Populus deltoids* Bartr

- **Botanical Name:** *Populus deltoides* Bartr.
- **Family:** Salicaceae
- **Local Name:** Poplar, Pharipipal

Figure 4a*Populus deltoides* tree **Figure 4b**.*Populus deltoides* leaf

Introduction

- Poplars are amongst the fastest growing tree species under appropriate agro climatic conditions.
- Poplars can be harvested at short rotations of 8 to 10 years.
- Wood obtained from poplars is eminently suitable for manufacture of match splints, veneering products, artificial limbs, interior paneling, cheap furniture and packing cases etc.
- Poplars with straight and cylindrical bole, moderate conical crowns mostly deciduous during winter months,
- Combine well with inter-cultivation of agriculture crops.
- These features combined with good economic returns and availability of long-term bank loans have made versatile poplars the most popular tree species for planting under agro forestry system in the irrigated tracts of north-western plains of India
- Six indigenous species viz Populus ciliata, *P. laurifolia, P. gamblei, P. alba, P. glauca,* are found along water courses in Himalayan region.
- However, success story of poplar plantations in the north-western plains of Uttar-Pradesh, Haryana, and Punjab is based on exotic *P. deltoids* indigenous to United States of America.
- Certain clones of *P. deltoids* have been found to be eminently suitable for a afforestation as well as agro forestry plantation. *P deltoids* clones G-3, G-48 (Australian selections) and D-121 (American selections) constitute bulk of these plantations.
- Additional clones like D-61, D-67, S-7C-8 and S-7C-15 have also been included in the plantation programme. Poplars can attain 90 cms girth at breast height and mean annual increment of 20m3/ ha at 8 years rotation under good care.

Description

- *Populus deltoids* is a fast growing tall tree with a fairly straight and slim trunk, rather open crown composed of a few large branches and attaining a height of 30 m and girth of 2 m.

- The branches are more or less angled or almost winged, the side branches borne on large branches are shed early.
- Outer bark forms early, furrowed by cork-like ridges and deep fissures.
- The leaves are fairly large, deltoid on short shoots and very large and cordate on long shoots, light green in colour.
- They are 10-18 cm long, acuminate, crenate-dentate with long petiole.
- The male catkins 7-12 cm long, 40-60 stamens per flower and produce wind-borne pollen. The female catkins are 15-25 cm long.
- The female flowers have single-celled ovary with numerous ovules and at anthesis have 2-4 prominent stigmas.
- Fruit ovoid capsules, hanging in loose clusters, opening by 3-4 valves and seed is small and hairy.

Distribution

- *P. deltoids* clones have been cultivated in a number of countries.
- In fact, *P. deltoids* and their hybrids together make about 90 percent of the total cultivated poplars of the world (FAO, 1979).
- Among the countries in which they have been cultivated are West Punjab in Pakistan, Middle East, New South Wales in South Australia, Parana Delta and north eastern continent part of the province of Buenos Aires, Argentina (Singh, 1982).
- In India, it has been successfully cultivated as a forest crop or agroforestry crop in the Punjab plains and in the Terai region of Uttar Pradesh.
- Poplars have been raised at slightly lower latitudes also, but it is only above 28˚ N, that they had fair success in experimental plantations and on farms.
- On experimental scale, *Populus deltoids* has been successfully cultivated at Jorhat (Assam) at an altitude of 96.5 m (Sharma and Bardoli, 1986).
- In its natural range in the southern part of USA, *P. deltoides* occurs primarily on bottom lands along rivers and other water ways (FAO, 1979).

- In West Punjab (Pakistan) and Middle East, it is cultivated only where irrigation is available.
- In areas where its cultivation has been tried without irrigation, the growth has been very poor.
- In not adequately irrigated plantations in the Middle East, *P. deltoid is* reported to become susceptible to the major wood borer *Melanophila picta* (Singh, 1982).

Soil

- *Populus deltoids* can survive on soils varying from sandy loam to fairly stiff clay, but it makes its best growth on moist, well-drained, deep, medium-textured, alluvial soils that are fertile and well-aerated (Baker and Broadfoot, 1976).
- The nursery plants perform better on clayey soil than on sandy soil (Bonner, 1967). Coarse sands and heavy clayey soils deficient in organic matter are unsuitable.

Artificial Regeneration: Poplars can be raised by the following methods:

(i) By Sexual Reproduction:

- The tree produces seed at intervals but it has low germination percentage.
- The seed of *Populus deltoids* has been germinated under laboratory conditions with germination percentage varying from 5.25 to 19.25%.
- The medium of germination, i.e. two parts soil and one part is of river sand duly sterilized proved most effective and gave higher survival and best shoot development.
- Germination tests conducted about the viability of seed after 6 years of storage showed that -20˚C storage was superior to -50˚C storage in maintaining seed viability (Tauer, 1979).
- Populus deltoides flowered for the first time in May, 1982 in Terai (U.P.).
- Poplar seeds are very minute and 14,000 seeds weigh one kg (Beniwal and Singh, 1989).

- The plant is rarely raised by seeds.

(ii) Vegetative propagation

Cuttings: Cuttings 18-25 cm long and 1-2.5 cm thick having at least four buds are directly planted in the field in well worked soils, keeping one bud above the ground. The soil around the cuttings is thoroughly compacted.

- **Sets:** A set is one year old cut back plant without root or a long stem cutting which consists of one year growth. The root portion left in the nursery can again be used to produce plant/set/cuttings for the next planting season. Sets are planted in 75 cm to 1 m deep pits. The length of set is about 3.5 m or more.
- **Bag plants:** These can be raised in polythene bags of 15cm x 23cm x 150 gauge filled with soil mix and treated with 5% aldrex. Cuttings are planted in these bags in February in the year of planting. Vigorous plants are not obtainable by this method.
- **Stumps (Root-shoot cuttings):** These are prepared from one year old nursery plants keeping 25 cm long root and 3 cm of shoot.
- **Entire transplants (ETPs):** This is the best method for transplanting poplars. These are one or two year old plants raised from cuttings in the nursery. While removing these plants, the root is cut at 25 cm depth and all side roots more than 10 cm long are also trimmed. The plants are taken out with naked root and without foliage.

Nursery Techniques

i) Site Selection

- Soil type and irrigation facility are the two important considerations for the selection of site for nursery.
- Poplar (*Populus deltoids*) needs preferably sandy loam, deep, fertile, well drained, neither alkaline nor too acidic, free from underlying impervious layer and rich in organic matter.
- Coarse sand in areas where the water table drops below in winter and which are subject to summer drought, soils with top-layer removed by erosion and

site with laterite occurring within 60 cm of surface are considered unfit for poplar cultivation.

- Assured irrigation is essential besides other requirements of a good nursery site. As poplars are very sensitive to zinc deficiency, zinc sulphate @ 25 kg/ha should be applied in the area at the time of site preparation (Lal, 1991).

ii) Site Preparation

- A light preparatory irrigation should be given so that the soil has proper moisture at the time of ploughing.
- The field should be leveled after ploughing. One deep ploughing upto 25-30 cm depth is desirable.
- Phosphatic and Potassium fertilizers should be added at this point. After addition of fertilizers, one more harrowing should be arranged.

Clones: A lot of good quality clones have been developed and launched commercially. Some of them are G-48, S7C15, S7C8, L-34, L-49, L-52, Uday, Kranti, WS-39, WSL-22, WSL-27, WSL-32, WSL A-49, and PL-1 to PL-7 etc.

iii) Selection of cuttings

- Cuttings from the main stem of the *Populus deltoids* give better results than those obtained from branches.
- One year old plants from existing nurseries are used for preparation of cuttings for the new nurseries.
- Diseased, dying off-type and suppressed plants must be culled from the beds where stock is reserved for preparation of cuttings for the new nurseries.
- The plants can be cut 2 cms. from ground level and the resultant sets should be graded and formed into bundled and should be transported to the new nursery site immediately and stored there in the storage pits, which should be kept full with fresh water to be replenished every day.
- Cuttings made from ripened one year old wood of the main stem give better results.

- Only well lignified shoots should be used; too tender shoots are not suitable for cuttings.
- Cuttings obtained from young, healthy and vigorous plants perform better.
- The length of cuttings should be 18-25 cm and these should contain four buds.
- When cuttings are taken from the trees, the age of trees and of the parts of trees from which the cuttings are taken markedly affect rooting (Zsuffa, 1976).

Preparation of cuttings

- Cuttings should be prepared with a very sharp and fairly heavy tool to obtain a very clean and smooth cut.
- During the preparation of cuttings, the cut must be given at a point of the set which is fully supported on a log/beam of wood to prevent splitting of cuttings.
- Maximum number of available cuttings from each plant down to one centimeter diameter can be used for planting.
- All cuttings must be submerged under fresh water in drums immediately after preparation of the cuttings.

Treatment of cuttings

- Before planting, cuttings are soaked in water for 24 hours
- Cuttings should be treated with Aldrin (250 ml of Aldex 30 EC in 100 litres of water) and thereafter Emisan (250 g in 100 litres of water) for 10 minutes each and then only planted in the nursery.

Planting of cuttings

- For production of healthy and vigorous entire plants, planting of cuttings at 80 cm x 60 cm is the best spacing (Chaurvedi, 1981).
- To produce one year old plants, spacing of 1-1.4 m between the lines and of not less than 40 cm between the plants is normally

Figure 5 Nursery of Poplar

adopted (FAO, 1965).

- The best time of planting cuttings in the nursery is January to February.
- Cuttings made earlier than January and later than March do not perform well in open conditions (Chaturvedi, 1981).
- Planting rods with the lower ends flattened and sharpened like a screw driver should be used for making the planting holes.
- Each cutting with its thinner end up should be planted in the hole in such a way that the upper portion is just 2 cms above the ground level.
- After planting the soil around each cutting should be compacted gently but firmly without injuring the bark of the cutting in any way.

Irrigation in Nurseries

- Irrigation should be provided as soon as the planting of cuttings in any bed is completed.
- The first irrigation should be medium heavy so that about 5 to 7 cms water is uniformly above ground level at the time of irrigation.
- Soil moisture in the nursery bed should be kept high during rooting of cuttings.
- Subsequent irrigation should be light and the interval may vary between 7 to 10 days depending upon the type of soil.
- Light sandy soils will need frequent irrigations whereas medium to heavy soils will need irrigation at longer intervals.
- The top soil should not be allowed to develop cracks and become absolutely dry.
- Irrigation should be applied at 10 to 15 days interval depending upon the type or soil and need of individual nurseries till onset of monsoons.
- Proper and effective drainage of excess water during rainy reason is essential to prevent lodging and collar rot.
- After the rainy season one to two irrigations per month is adequate.

Fertilizer application

- As the poplar plants grow very fast, the nursery soil has to be enriched frequently. Urea, Super phosphate, Murate of Potash and plentiful supply of Farm Yard Manure are essential for maintaining the growth of cuttings.

- Application of well decomposed compost or farm yard manure @ 200 to 250 quintal per hectare nursery area at the time of soil working is very helpful for the growth of poplar.
- The quantity of fertilizer will depend upon the type of soil.
- Nursery beds are depleted of fertility after producing plants for one year, if no fertilizer is applied.
- After the rains have set in, 2g of urea per plant is given;
- Regular debudding and hoeing will depend upon the incidence of weeds and grasses.
- Singling of collar shoots should be done during April-May when the most vigorous shoot has attained a height 30-35 cm.
- Debudding is done by gently rubbing with gunny bags the newly formed buds upto 2/3 rd height of plant from the base from June to October.
- Sufficient care should be taken to ensure that the young leaves are not damaged.

Planting Entire Transplants (ETPs):

The best time for planting poplar is during the months of January-February before the opening of new buds. One year old ETPs of 3 m length containing 25 cm root portion give most satisfactory results (Chaturvedi, 1981).

- The depth of planting will depend upon the soil type, depth of water table, size of planting stock, etc.
- As poplar is a fast growing species, the soil requires to be incorporated with fertilizers
- A basal dose of 2 kg good FYM, 50 gm super phosphate and 5 gm urea per plant is needed. Nitrogenous fertilizer should be applied in split doses, first dose of nitrogen as 75 g urea should be applied during the first week of June, second dose of 150 g urea during first week of July and third dose of 250 g urea during second and third week of August.
- Application of fertilizer must be followed by light irrigation.

- The best spacing under agro-forestry systems is 5 m x 4 m i.e. 500 plants per hectare.

Application of Manure and Fertilizers

Well decomposed farmyard manure which is rich in macro as well as micro nutrients essential for the plants should be applied to the total area under poplars while preparing the land for inter-cultivation of Rabi and kharif crops. Application of nitrogenous potassic and phosphatic fertilizers as well as micro nutrients will depend on the fertility status of the land. 50 gms of single super phosphate 25 gms muriate of potash is used at the time of planting.

Inter-cultivation of Agricultural Crops

Any traditional crops except paddy can be grown reasonably well in between the lines of poplars during the first 2 years. Subsequently shade tolerant crops like ginger, turmeric and colocasia can be raised as less sunlight penetrate to the ground during active growth period of poplars because the crowns cover most of the canopy. Short duration winter vegetables or rabi crops like wheat lentils toria etc. can also be raised as most poplar clones are leafless during autumn. However intercrop yield decreases with the increase in age of poplars. Care should be taken to avoid physical injuries to the stem of poplars during inter-cultivation operations.

Inter-cropping

It is desirable to grow field crops as inter crops in block plantations of poplar. All rabi and kharif crops can be grown during the first three years except paddy. However, inter-cultivation of sugarcane be preferred for first two years as it is more profitable. Third year onwards cultivation of wheat, cabbage, chilly, tomato, barley, coriander, turmeric, ginger, strawberry, oats, berseem, sarson etc. can be raised throughout the rotation.

Plant Protection Measures

Certain insects and pathogens are known to damage the poplars. Among the important ones are the following:

- **Leaf defoliator:** These are active during the rainy season particularly Pygaera species. The caterpillar of these moths feed on leaves. The insect can be controlled by collecting and destroying the infested leaves. Spray of

Monocrotophos 36 SL @ 600 ml (Monocil / Monolik / Nuvacron / Corophos / Luphos) per acre.

- **Termites:** The risk of termite damage is likely where irrigation and inter cultivation operations are inadequate. The soil should be treated with Aldrin or Gammexene (BHC) (0.15%) and frequent irrigation arranged.
- **Stem and shoot borer:** These can be controlled by pushing a small wick of cotton dipped in any liquid fumigant in the holes through which frass is being pushed out by the borer. All holes must be closed with mud paste after such treatment.
- **Leaf Webber:** The young larvae scrap the leaf surface along with veins and feed on epidermis of leaves by webbing 2 and 3 leaves with silken threads. The pest is active from April to November with peak period from July to October. For controlling the same measures as indicated under leaf defoliators can be adopted.
- **Bark Eating Caterpillar:** Nocturnal feeding larvae make L-shaped holes and wet silken threads entangled with fecal pallets. Pest is active throughout the year. Prune severely infested branches and spray suspension of 100 g Carbaryl 50 WP (Sevin / Hexavin) in 10 litres of water during September to October at feeding sites.
- **Case Worm:** The pest is active throughout the year. The caterpillars feed on bark from December to March, on leaf buds during March and April and on leaves from April to November. For controlling this a spray of Carbaryl 50 WP (Sevin / Hexavin) @ 1 Kg per acre is recommended.
- **Leaf Hopper:** The leaf hoppers are active from April to November with peak period of their activity from July to October. A spray of Oxydemeton-methyl 25 EC (Metasystox) @ 300 ml or dimethoate 30 EC @ 250 ml per acre is recommended.
- **Rot of cuttings:** Black dots appear on the cuttings at ground level and decay of bark takes place. Dip the cuttings for 15 minutes in 0.5 percent solution of Emisan-6 before planting.

- **Leaf Spots:** Brown to dark brown leaf spots of variable sizes appear on leaves. Severe infections lead to premature defoliation. Spray the crop with 0.25 percent Copper Chloride (Biltox 50) or Indofil M-45 at 15-20 days interval starting with first rain. Two to three sprays may be given.
- **Pink Disease:** Girdling of branches in young plants leads to death of parts. The height of tree is stopped due to repeated death of the leaders. Pink to Salmon colored mycelial growth appears on branches. Use resistant varieties or two to three prophylactic spray of Bordeaux mixture during two to four years of age at the beginning of the summer monsoon.
- **Sunscald canker:** Bark is killed due to insolation by heat and canker develops on the southern side of the stem. Protect from insolation and other injuries by white washing the main stem upto two meters from the ground level.
- **Bark Bursts and Canker:** Water oozes out through the wounds resulting in cankers. Avoid injury and high water table sites. Clean the wounds and apply Bordeaux paste or Emisan-6.

Yield and Returns

- Under reasonably good care poplars can attain 90 cm girth at breast height and mean annual increment of 20m3/ha (under bark) at 8 years rotation.

Utilization

- *Populus deltoides* has a medium hardwood, light, free from knots, easy to saw and work.
- The wood has good nail holding power and strength coefficient of *Populus deltoides* is comparable to well-known woods used in packing cases and hence can be used for making cases for fruit and food stuffs.
- High yield pulps (71-80 percent) having excellent strength properties for newsprint could be prepared.
- Young poplars of 2-3 years age group are an excellent source of cellulose fibre for making various grades of fine paper, packing paper, newsprint, etc.
- An experiment conducted at forest Research Institute, Dehradun indicates that *Populus deltoides* wood is suitable for preparation of hardboards, and that

bark to the extent of 20 percent helps in improving the physical and mechanical properties of board compared to boards prepared alone with wood.

- Most of the poplar wood is used in the match and plywood industry.
- The species is suitable for making general purpose plywood, marine plywood, and concrete shuttering plywood. It is also considered suitable for the manufacture of artificial limbs, sports goods and for structural uses such as false ceilings, partition and almirah shelves, etc.
- It has also been found suitable as line supports for overhead power and telecommunication lines.
- The white furniture made out of poplar wood is becoming popular in towns of Punjab.

8.2.5 Economics of cultivation of *Morus alba* L.

Botanical name: *Morus alba L.*

Common names (Hindi): Shahtut, tut, tutri, chinni

Family Name: Moraceae

Figure 6 (a): *M. alba* tree (b): *M. alba* leaves and fruit

Description

A full grown *M. alba* is a moderate sized tree with short clean bole and spreading crown. The bark is smooth in young and rough in old trees. It is a short lived tree and the trunk starts becoming hollow in old trees.

Climate

- *Morus alba* L**.** grows in areas with subtropical or mild temperature climate. Maximum shade temperature seldom exceeds 430C while the minimum temperature may drop below freezing point for a few days in January; the absolute maximum shade temperature touches even 480C in some areas of its cultivation.
- For optimum growth, adequate water supply, particularly during the growing period, is essential. The annual rainfall varies from about 400 mm to 4500 mm and most of it is received during monsoon season.
- In areas with less than about 1200 mm annual rainfall, irrigation is necessary for its good growth.

Distribution

- *Morus alba* is cultivated in Northern India from Jammu and Kashmir to Assam. In the Himalayas, it ascends up to an elevation of about 1200 m.
- In the hills, it is mostly confined to stream beds or such other places where sufficient moisture is available for its growth.
- It does not grow on dry slopes or shallow soils where moisture becomes the limiting factor.

Soil

- *Morus alba* grows on a variety of soils ranging from sandy loam to clayey loam,
- Alluvial, deep, loamy soil with sufficient moisture supply supports its best growth.
- The tree cannot tolerate alkalinity and grows best on soils with pH ranging between 6.0 and 7.5.
- In hills, moisture availability limits the growth and on dry slopes, the trees remain stunted.

Phenology

- Leaf-fall - November - December

- Leaf renewal - March - April
- Flowering - March -April
- Fruit ripe - April-June
- The fruits are white or red and sweet in taste.
- Trees of about five years age start producing viable seed.

Silvicultural characteristics

- *M. alba* is a shade bearing tree and it can with advantage be grown as an under-storey with other light demanding species.
- It coppices and pollards very well.
- The coppicing power of trees bigger than 30 cm diameter is generally poor.
- It can withstand light frost.
- Its water requirement is high
- It suffers from droughts as may be expected from its being a surface feeder.
- It is susceptible to fire and browsing.

Natural Reproduction

- *M. alba* regenerates either through seed or coppice.
- The seed is dispersed either by water or by birds.
- Such seed as it gets lodged at suitable places, germinates readily.
- For germination, the seed requires moist and well-drained soil.
- Light shade is favourable for germination and seedling establishment,
- Thick shade is harmful.
- The seedlings can establish under canopy of trees having light crowns.

Factors considered favourable for seedling establishment are:

- Adequate shade,
- Soil free from tall and thick weeds,
- Adequate soil moisture,

- Soil should be free from salinity,
- Protection against browsing animals,
- M. alba tends to be aggressive in irrigated plantation areas,
- The tree coppices well and can be regenerated through coppice.

Artificial Propagation

- *M. alba* can be propagated either by planting out nursery raised seedlings or through rooted branch cuttings.
- Nursery raised seedlings are planted out either as entire plants or as stumps, the latter give better results than the former.
- Direct sowing does not produce good results.

Seed Collection and Storage

- Ripe fruits should be collected from the trees
- Fruits should never be collected from the ground as the seed in such fruits is generally insect attacked
- The fruits are heaped in the shade, rubbed and washed in water to separate out the seed which is dried in sun for a few days before storage
- The fruits may be pressed in a cloth to extract the juice and the pulp is then dried in sun, rubbed by hand and winnowed to remove the seed
- About 430-460 seeds weigh one gram.
- Seed stored in gunny bags is reported to lose vitality completely after one year's storage.
- Carefully prepared seed can be stored in sealed tins in which it keeps well.
- The seed stratified in layers of fine dry sand or ash keeps well for over two years.

Nursery Techniques

- Sowing in the nursery is done in May-June, soon after seed collection.
- Sowing is done in lines about 20 cm apart.

- Stratification in moist sand at about 50C temperature for about 30-90 days is reported to improve germination.
- Soaking of the seed in cold water for about a week is also reported to hasten and ensure uniform germination.
- Pre-sowing treatment of the seed with kerosene oil is also recommended to protect it from being carried away by ants.
- One bottle of kerosene oil is sufficient to treat about 37 kg seed.

Figure 7 Seedlings of *Morus alba*

- The seed is mixed with ash or sawdust to ensure uniform sowing.
- It is covered only lightly with fine soil.
- Germination commences in about a week and may be complete in another 10 days
- The seedlings are transplanted when about 10 cm tall at a spacing of about 60 x 60 cm.
- Transplanting may be done in winter.
- For the production of stumps, the seedlings may be retained in the nursery for one or two years depending on their growth rate.
- About 2 cm collar diameter is considered to be the most suitable size for stumps.

Planting Technique

- Out of the two common methods namely, planting out of entire plants and stump planting, the latter ensures higher success and is preferred.
- Stumps are prepared out of one or two years old seedlings ensuring that their collar diameter is normally not less than 1 cm.
- Stumps of about 1.5-2 cm collar diameter perform better.
- Stumps with about 22 cm root and 8 cm shoot are prepared with a sharp tool so that these do not spilt during preparation.
- These are wrapped in moist gunny bags during transport.
- Planting is done either in crow bar holes or in 30 cm3 pits.
- Morus alba can be raised by planting branch cuttings also. This method is however, not employed for raising plantations and is employed to multiply clonal material of good varieties.
- The spacing depends upon the objectives of raising the plantations.
- Close spacing may suffice if the trees are to be pollarded for leaf production.
- Wider spacing of 4 x 4 m or 5 x 5 m may be necessary if timber and leaf production are to be combined.

Economic Importance

- Wood is in chief demand for sports industry especially used for hockey sticks, tennis and badminton rackets and cricket bats etc.
- Used for boat-building, house construction, furniture
- It is good fuelwood having calorific value of sapwood and heartwood 4658 and 5003 kcal/kg respectively.
- The leaf fodder of mulberry is of good quality
- The leaves are used for silk worm rearing

8.2.6 Economics of cultivation of *Grewia optiva* Drumm.

Botanical Name: *Grewia optiva* Drumm.

Common Name: Beul, Dhaman

Family: Tiliaceae

Figure 8 *Grewia optiva* tree

Description

- It is a very popular tree of the farmers of the sub-Himalayan tract for its fodder and fibres.
- A full grown tree is moderate sized with spreading crown, reaching a height up to 12 m with a clear bole of 3-4 m and a girth of about 80 cm.
- Bark is smooth and whitish-grey.
- Flowers 1-8, solitary and axillary, petals yellow or white.
- The fruit is a fleshy drupe, 2-4 lobed, olive green when immature and black when ripe, and edible.

Distribution

- It is distributed from the foothills of the Western Himalayas from Jammu and Kashmir to Nepal up to 2000 m elevation.
- It is not a common forest tree and is generally grown on field boundaries or terraces raised by the hill farmers.

Site factors

- It is a tree of sub-tropical climate.
- In its natural habitat, the maximum shade temperature seldom exceeds 38oC and the minimum rarely drops below -2oC.

- Tree is hardy and grows on a variety of soils. Sandy loam soil with adequate moisture supply supports good growth.

Phenology

- Leaf-fall - March-April
- Leaf renewal - April-May
- Flowering - April-May
- Fruiting - June-July
- Fruit ripe - October-November

Silvicultural characteristics

- Strong light demander
- Require complete overhead light
- Seedling suppressed by weed
- It is frost hardy tree
- Young seedling dieback due to severe frost
- It coppice very well
- Susceptible to fire and browsing

Natural Regeneration

- Natural regeneration occurred sporadically
- Seed coat is hard
- Germination take place after the seed get soaked for more than 12 hours
- Long tap root is formed during the first year which is longer than the shoot length

Artificial Regeneration

- *Grewia optiva* can be propagated by seeds, transplanting of nursery raised seeding, by cutting or planting stumps.

Seed collection and storage:

- The fleshy drupes are edible,

- A substantial quantity of fruit crop is devoured by the birds, if seed collection is delayed.
- The fruits are not borne on the current year's shoot, tree lopped completely do not bear fruits.
- Therefore, trees reserved for seed production should either not be lopped at all or if necessary only partially.
- The fruits are rubbed and washed in water to separate out the seeds.
- Each fruit contains 2-4 seeds;
- There are about 12,000 to 15,000 seeds per Kg.
- The seeds have a hard testa and can be stored well for at least a year without any appreciable drop in vitality.

Nursery Technique

- Pre-treatment of seed is necessary as seed coat is hard.
- Sowing should not be done on raised beds as moisture needed for germination.
- The dibbling method of sowing with twice a day irrigation proved to be the best in germination percent.
- The seed is sown in March-April, about 2 cm deep in lines 15 cm apart
- Watering is done regularly till germination is over. Germination starts in about 10 days and takes a month to complete.
- Sowing in March results in prolonged and scattered germination with heterogeneous stock.
- The seedlings are spaced about 10 cm apart in lines.
- The growth of the seedlings is fairly fast and they attain a plantable height of 30 cm or more by July.

Planting Out

- Planting is done at the onset of monsoon, late planting generally fails.

- Seedlings uprooted from the nursery with balls of earth are wrapped in moist gunny bags and transported safely.
- Planting is done in 30 cm3 pits at a spacing of 4x4 m for block planting and 4-5 m for single row planting along the field bunds. For stump planting 15 month aged seedlings are used.

Vegetative Propagation

- It can be successfully propagated by cuttings, under intermittent mist.
- Soaking the cutting base for 20 hrs in 100 mg/litre IAA gave a maximum rooting of 77.5 % in June.
- The technique used for mass multiplication of cuttings for plantation and seed orchard establishment.
- It can also be propagated by air layering.

Economic Importance

i) Small timber

- The wood is white, heavy, hard, elastic, strong and fine-textured.
- It is used for oar-shafts, axe-handles, shoulder poles, cat frames, bows and several other purposes, where strength and elasticity is required.
- The wood is difficult to saw when green but also difficult to work by hand after seasoning. It is reported to be suitable for paper-making.

ii) Fibers

- The bark yields a fibre of inferior quality used for cordage.
- The elastic branches are used for making baskets.

iii) Fuel-wood

- Though used as a fuel wood, not liked very much because of the foul foetid smell it emits on burning.

8.2.7 Economics of cultivation of *Eucalyptus tereticornis, Sm*

Botanical Name: *Eucalyptus tereticornis*

Common Name: Eucalyptus, Safeda, Nilgiri

Family: Myrtaceae

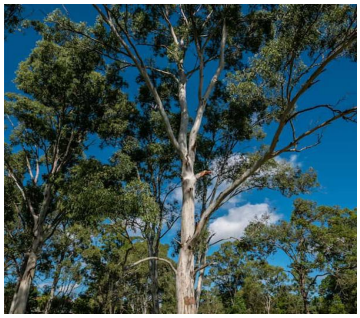

Figure 9a)*Eucalyptus tereticornis tree* b): *Eucalyptus tereticornis* seed

Description

- It is a tall tree upto 40m high
- Bole is straight and clean with whitish mottled bark
- The crown is open
- Juvenile leaves opposite
- Adult leaves alternate
- Inflorescence axillary usually seven flower umbel
- It is distributed/planted all over India except North-eastern states
- In is planted both in the forest and outside in agricultural lands, wasteland, roadsides etc.

Site factor Climate

- Temperature-Maximum 22°C -32°C,Minimum2°C-12°C
- Rainfall -Upto 1500mm
- Altitude -Upto1700m.

Soil

- It can be grown in wide variety of soil such as recent alluvial soil, laterite soils, sand dunes, ravine, murum soil and sandy loam soils etc.

- It can be grown in soil shaving pH more than 10 but grow this poor when pH exceeds 8.5.

Phenology

- It is evergreen species
- Flowering-Twice a year 1st in May-June 2nd in October-November
- High number of fertile seeds was set in first flowering
- Seed collection -July-August

Silviculturalcharacters

- String light demander
- Susceptible to frost because of thin bark and essential oil in the plant tissues
- Good coppice
- It is a wind firm in nature
- Damaged by termites

Natural Regeneration

- Very poor due to destruction of seeds by ants
- Young seedlings smothered by leaf collar
- Leaves are toxic and contain germination inhibitor

Artificial Regeneration Seed collection and storage

- Seeds should be collected from 10year old trees. Although fertile seed is available from young tree
- In a year two collection 1st - February-March and 2nd – October-November
- Capsules should be dries in shade for one day
- Gently shaken to clean the shells
- Dry and stored in a tins at cool dry places
- 3,67,400 seeds weigh one Kg

Nursery techniques

- Seed should be sown in raised nursery bed in the month of October-November or February-March
- Soil should be sterilized with Aldrex or BHC against termites
- Seed should be sown 20gm/m2 of bed in lines 10cm apart and 2.5mm deep
- Germination takes place within 5-15 days of sowing
- 60-75 seedlings are obtained from one gram of seeds
- Seedlings are pricked out when they attain a height of 4-8cm
- Pricking of seedling should be done in to polythene bag.

Spacing

- Spacing depends upon the objective of plantation
- Spacing varies 1.8m × 1.8m – 3m × 3m
- For firewood/fuelwood = 1m × 1m or 1.5m × 1.5m
- For pulpwood/poles = 2m × 2m or 3m × 2m
- For saw log = 3m × 3m
- For Windbreaks and shelterbelts= 1.5m × 1.5m or 2m × 1m

8.2.8 Economics of cultivation of *Quercus leucotrichophora* A Camus

Botanical Name: *Quercus leucotrichophora* A.Camus

Common Name: Ban oak

Family: Fagaceae

Figure10 *Quercus leucotrichophora* a)tree b) seed

Description

- It is moderate sized to large evergreen tree with almost rounded crown
- It attains a height of 20m and diameter of 60cm,
- The bole is irregular and short.
- The bark is greyish brown, rough with cracks and fissures exfoliating in irregular oblong.
- Young leaves are pinkish and woolly all over mature dark green and glabrous above.
- Male spikes slender, drooping 5-10cm long
- Male flower axillary
- Acorn generally solitary usually born on current year shoot
- Ripe nuts ovoid conical brown when ripe 2.5cm long

Distribution

- Occurs in the moist and cooler aspects in Western Himalayas between altitudes 800m to 2300m on southern aspects,
- The limits are lower by 200 to 300 m on the northern aspects.
- In Kangra valley, it is reported to occur even at 600m elevation.
- It is principal species of ban oak forest of lower West Himalayan Temperate Forest
- It is associated with *Quercus dilatata, Cedrus deodara, Pinus wallichiana* however, at lower elevation with *Pinus roxburghi, Quercus glauca* and *Quercus lanuginose*.

Site Factors

Climate

- It is a tree of sub-temperate to temperate climate
- In its natural zone maximum shade temperature never exceeds 35°C while in lower limit in subtropical zone temperature may reach 38°C

- During January most of the area in its upper limit of its distribution receives snowfall but it make small part of precipitation, the major part is received in the form of rainfall during June to September.
- The total annual rainfall varies from 1000-1800mm

Soil

- It grows on wide variety of geological formations and soils such as shale, gneiss, schist, quartzite and limestone rocks and mostly sandy or clayey loam soils.
- It grows best on cool Northern aspect with deep moist shale soils

Phenology

- It is an evergreen tree, old leaves falls after the appearance of new leaves and thus trees are never leafless
- New leaves appear in the month of March-April
- Shading of old leaves and appearance of new leaves first starts at lower elevation of its occurrence
- Male catkins and female spikes appear on new shoots in April-May
- The fruit ripens in December-January after 19-21 month of flowering
- Seeding starts comparatively at early age and coppice of ten year age have been reported bearing fruit

Silvicultural characters

- It is moderate light demander,
- It can withstand fair amount of shade in early age,
- Trees growing under shade develop restricted crown while those grown in the open have well developed crown
- Tree are resistant to ordinary frost but severe frost kills seedling and sapling
- Seedlings are sensitive to drought particular in first two years,
- Due to massive root system tress are wind firm,
- Trees are susceptible to fire
- It coppice well in young age and it declines with age.

Regeneration

A) Natural

- With favourable conditions germination takes place after early showers.
- Germination takes place in June to July after receiving of first showers.
- Germination may take in heavy or moderate shade but seeds fail to germinate in places expose to direct sun.
- Drought is the most adverse factor causing seedling mortality.
- The growth of seedling under natural condition is slow and they attain height of 10cm in first season and about 25cm in four years.
- Seedling develops a long tap root and the growth of root is generally more than that of shoot during the first few years

B) Artificial

- It can be raised easily through direct sowing and planting out of nursery raised seedlings.
- Air layering is also possible and with application of auxins encourages rooting.
- On dry slope transplanting ensures more survival.

Seed collection and storage

- Good seed years are frequent
- Acorns are collected in December to January preferably from tress
- Acorns are dried under shade only and stored in cool place protected against insect-pest
- The seeds can be stored for one year
- About 400-800 acorns weigh one Kg
- Storage of acorns at low temperature and high humidity is advocated

Direct sowing

- Ban oak can be successfully raised by direct sowing either dibbling the seed in cultivated line or patches

- The seeds are sown about 2cm deep during December to January or before the onset of the rains
- About 5 Kg of acorns are sufficient for one hectare area
- Fresh seed registered 60-70% germination
- Sown area should be protected against grazing and fire

Nursery technique

- Seeds are sown in February-March in well manured and raised beds.
- Seeds are sown in lines about 20cm and seeds are spaced at 5cm in the lines at a depth of 2cm.
- Deep sowing delays the germination and also reduces germination percentage.
- Beds should be prepared under light shade, not under direct sunlight.
- Germination starts in about 10-12 days and takes to 4-5 days to complete.
- Regular weeding also required.
- Seedlings are spaced at 10cm in lines in the second rainy season after pruning the roots
- The growth of seedlings is fast and they attains a height of 50-60cm in two year

Planting technique

- Seedlings of about 15-20cm height are suitable for planting out as taller seedlings are difficult to handle due to their massive roots.
- Rainy season gives better results than winter planting.
- Planting is preferably completed by July as later planting brings out poor survival.

Tending

- Species is slow growing and it needs weeding and cleaning for several years.
- Planting should be guarded against cattle browsing and forest fires.
- Improvement fellings and thinning in natural seedlings is to be done at 10years intervals.

Economic importance

- The major use of ban oak is for fuelwood and charcoal making, for which it is in great demand.
- Calorific value of fuelwood is 4600 k cal/Kg.
- Charcoal conversion factor is about 16-20%.
- Tree is lopped for fodder and a mature tree can yield 20-25Kg leaves annually.

8.2.9. Economics of cultivation of *Dendrocalamus hamiltonii*

Botanical Name: *Dendrocalamus hamiltonii* Nees.

Common Name: Magar bans

Family: Poaceae/Graminae

Sub Family: Bambusoideae

Figure:11 *Dendrocalamus hamiltoni*

Description

- It is a large bamboo, culms growing at an angle
- Culm are greyish white when young and dull green when old
- About 12-25m height and 10-19cm diameter
- Internodes are 30-50cm long
- Culm sheath is glabrous, rough with brown hairs on outer side

Distribution

- Found throughout in North-West Himalayas, Sikkim, Bhutan, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura
- Cultivated in Himachal Pradesh between altitude 350-1400 m at Chamba, Mandi and Bilaspur

Site factor

Climate

- Rainfall varies from 750-5000mm in its natural range
- Temperature maximum 46°C and minimum -5°C

Soil

- It grows on wide variety of soils having good drainage
- Sandy loam soils underlain by boulders are most suitable
- It is rarely found on heavy soils such as clay or black cotton soils

Phenology

- Flower sporadically or gregariously
- New culms arise from buds on the rhizome during July-August
- New culms attain their full length by November-December

Natural regeneration

- Reproduction of bamboos is through rhizomes
- Rhizome is underground portion of the stem, closely similar in structure to the above ground portion of the stem i.e. culms and branches
- The buds on rhizomes, which usually develop are generally one year old
- It is affected by careless fellings, non observance of cutting and grazing rules are the other causes which lead to congestion, reduce the yield as well as deteriorate the quality of bamboos

Artificial regeneration

A) Rhizome planting

- Separated out rhizomes can be planted in the rainy season
- Traditional method of planting is by offsets at the onset of rainy season in June-July and about 50% survival rate is expected
- Culm is cut at a height of 1-1.5 m just above the joint and rhizome severed at the desired oldest narrow point
- A pit of 60 cm3 and spacing of 6 m × 6 m and 7 m × 7 m is desirable

- The established plants yield culms of exploitable size in 4-5years

B) Single node cutting

- One node cuttings, each with major length of its basal and minor of distal internode are taken from the under one year old culms and planted in March
- Before planting the cuttings, their branches are trimmed above third to fifth node beyond the condensed basal portion
- The cuttings are planted horizontally with the branch or bud upward, 10-15 cm deep in rows and covered with soil having well decomposed farm yard manure

C) Mass production

- A new technology for mass production of seedling developed by the FRI
- Sowing seed in July in the germination trays, when the seedlings reach 3-4 leave stage they are planted in polybags containing equal proportion of soil, sand and FYM
- At the age of eight month seedlings are removed from polybags in April
- Proliferated tillers of these seedlings are separated by cutting rhizome to act as propagules
- Each propagules consists of a tiller along with rhizome and roots

Economic importance

- Multiple use
- It is used for rafters, house posts, ladders, tent poles, shafts of tongas, scaffoldings etc.
- Young shoots are used as vegetable and pickles
- Important raw material for paper mills

8.2.10 Economics of cultivation of *Tamarindus indica* L.

Botanical Name: *Tamarindus indica* L.

Common Name: Emli, Tamarind

Family: Leguminosae (Caesalpiniodeae)

Figure 12 *Tamarindus indica* L.

Description

- It is a large evergreen tree attaining a height up to 15m
- Spreading crown 9 to 12m in diameter with numerous branches and twigs.
- The trunk is short, the lower branches are borne almost horizontal.
- Bark is moderately thick and dark grey with numerous longitudinal fissures and horizontal cracks.
- Two varieties has been identified: East Indian variety with long pods, 6-12 seeded; West Indian variety with shorter pods, 1-4 seeded

Distribution

- One of the most common tree of Tropical India,
- It is believed to be indigenous to Tropical Africa probably introduced long back to India by Arabs.

It is not tree of forest but is cultivated throughout country except Himalayan region and arid western zone.

Site factor

Climate

- Temperature - Maximum 35°-46°C Minimum 0°-17.5°C
- Rainfall - 750-1900mm
- Altitude - up to 1000m

Soil

- It is non-exacting type tree
- It tolerates slightly saline and alkaline soils

- Best growth is found on deep loamy or alluvial soils with adequate supply of moisture

Phenology

- Leaf-fall - April-May
- Leaf renewal - March-April
- Flowering - April-June
- Fruiting - March-April
- Seed collection - March- April
- Seed weight - 1800-2000 seeds per Kg
- Germination per cent - 75%

Silvicultural characters

- Strong light demander can't grow under shade,
- Frost tender,
- Resistant to drought,
- Produce root suckers and coppice well
- Deep rooted and wind firm in nature
- Not fire hardy but considered best tree for planting along fire lines in Karnataka.

Natural

- It is not adequate in general.
- Scattered seeds may germinate especially in abandoned areas etc.
- Weeds retard the growth of the seedlings.
- The seedlings may attain a height of 0.6m or more in the first season and 1.20 m or more in the second season if they are regularly weeded and watered.

Artificial

- It can be raised easily through direct sowing, planting out of entire plants or stump planting or poly bag container plants.

Seed collection and storage

- Plant begins to yield seed when about 8-10 years of age
- Ripe pods are collected in the month of March-April
- Seed is separated from edible pulp by washing with water then dried and stored
- Fully grown tree produce 2 quintal of fruits per season
- Individual pods contains 3-10 seeds

Nursery technique

- Seeds are sown in March-April in irrigated nursery in lines about 20-25cm apart.
- No pre-treatment of the seed is necessary.
- Germination starts in about a week and takes about a month to complete
- Seedlings attain plantable size by the July when they are about 3-4 months old and attain a height of 30-40cm.

Direct Sowing

- It is done in lines or patches.
- Depth of sowing is about 1.5cm.
- The lines are spaced at 4-5 m apart and the seeds are sown 10cm apart.
- About 20 kg of seed is required to sow one hectare area.
- It gives 80% survival against transplants 60%.

Planting technique

- Planting is done at the commencement of rainy season during July-August.
- The pit size of 30cm3 is recommended for planting
- The plants should be protected through fencing

Stump planting

- It is carried out in 30 cm3 pits in rainy season.
- It gives 42% survival.

Vegetative propagation

- It is done with soft terminal cuttings.
- The cuttings are prepared with current year's shoots and it is collected with new leaves flush early in the morning in turgid condition.
- Cuttings are treated with 1000ppm IBA in 50% Isopropyl alcohol as quick dip for second then transfer to polypropylene tubets

Economic importance

- The chief value of this tree lies in its fruits which are used for various types of food preparations and sherbets.
- The wood is used for carving.
- It makes an ideal avenue tree by virtue of its shade, ornamental flowers and longevity (200years or more).

Source: Report of the task force on greening India for livelihood security and sustainable development. Planning Commission. Government of India. July-2001

UNIT 9: Joint Forest Management

Unit Structure

9.0 Learning Objectives

After studying this unit, you should be able to:

- Critically analyze the role and extent of inter-dependence between the communities and forest resources in sustainability and conservation;
- Explain the concepts of social forestry, Joint Forest Management and Village Eco-development;
- Describe the programmes of the Government for the promotion of people's participation in forest management; and
- Outline the performance of these programmes and the factors associated with them.

9.1 Introduction

Forests constitute one of the important natural resources and provide a number of ecological services to human kind. This is particularly more important when we talk about well-being of rural folks. Over the past few decades due to unplanned development processes has resulted into drastic shrinkage in forest cover and, thus,

overexploitation of forest resources. This has further catalyzed the misery of rural poors as forests help them in meeting many of their day today necessities.

According to a study of Forest Survey of India (FSI), the total requirement of fuel wood, probably the most important forest produce for villages, in the country was about 201 million tons in 1996. Projected demands of fuel wood for 2001 and 2006 were/are 223 and 247 million tons respectively (Planning Commission, 2001). The present availability on a sustainable basis from the existing forests has been estimated at only 17 million tons. It is believed that about 51% of the total demand, much more than is available, is met from forests. Similar pressures exist for timber, fodder and other forest products. Productivity of our forests as estimated is 1.3 cubic meters per ha per year compared to the global average of 2.10 cubic meters per ha per year in terms of timber and firewood. The diversion of forests for various development needs also has contributed to the depletion of these resources.

Many development programmes are operational in rural areas for the upliftment of rural communities. However, most of them does not cover forest resource conservation. IN fact many of such programmes need additional forest land to be diverted for example construction of road. Although most of the programme so implemented had good intention of rural development but unfortunately one of the most important component for rural development of development of forest resources on which livelihood of many rural poor depends. The populations living in the vicinity of forests have many times have shown such examples when they played important roles in better management of forests. This is how the concepts of social forestry and participatory forest management came into existence.

This unit aims at providing you an understanding of the concepts of joint forest management (JFM) and programmes associated with natural resource management for sustainable rural development.

9.2 Joint Forest Management: Concept and Objectives

Degradation of forest resources resulting from more than a century of it's over exploitation and increasing human and livestock pressures has been of great concern to the nation. The degradation of forests affects most the poor rural masses that depend on forest resources for livelihood. The management of the government forests

till recent past was aimed at the production of goods and services like timber, other forest produce and maintenance of soil and water regime. Access of communities to these resources was limited to Rights and Concessions granted for pathways, dry wood for fuel wood to a limited extent and grass and fodder as regulated by the government. In some states, traditional rights for structural timber were also recognized and granted on a periodic basis.

Through the social forestry scheme, the government aimed at community participation, as part of a drive towards afforestation, and rehabilitation of the degraded common lands. A similar programme has been identified for the rehabilitation and conservation of the government forests. Through Joint Forest Management, degraded government forests in the vicinity of villages are being revitalized by the collective efforts of the government and the villagers.

In 1988 the Government of India introduced a new forest policy that radically altered the aims of forest management, shifting it from a commercial and industrial focus to one that stresses environmental functions and meets the basic needs of the people living in or near the forests. For the first time, the rights of people living in and around the forests were recognized as a part of the management of forests, and the demand of the people has been recognized as the first charge on the forest produce.

In support of this new policy, in 1990 the Government of India issued a directive to the states to develop a participatory approach in their efforts to restore nation's degraded forests. This approach has been named Joint Forest Management and is also called Participatory Forest Management. So far 28 states have issued resolutions for Joint Forest Management. By 2003, 17.33 million ha of forestlands were being managed and protected by about 84600 village-level JFM Committees. The aim is to universalize JFM to involve all the 1.73 lakh villages in the vicinity of forests. Based on the experiences gained in the implementation of this programme since 1990, the Government of India modified the related guidelines in 2000 and 2002 and State Governments have been framing their respective rules within the framework of the said guidelines of the Government of India.

The National Afforestation and Eco-development Board (NAEB) was established in 1992 for promoting afforestation and ecological restoration activities in the country. It is the successor of the erstwhile National Wasteland Development Board (NWDB) and is

responsible for providing impetus to the rehabilitation of degraded forests in the states. Under the National Afforestation Programme, the Government of India assists the states in their afforestation efforts. Also, this programme is being used by the Government of India to expand and promote the Joint Forest Management in the states.

9.3 Design of the Programme

Basically, Joint Forest Management empowers the communities to assess, plan and manage the forest resources, which constitute their main life support system. An adequate extent of Government forest area is earmarked for handing over to the village unit of communities for management. Villagers are organized as Joint Forest Management Committees (JFMCs) for this purpose. These committees are given various names like Vana Sanrakshan Samiti (VSS), Forest Protection Committee (FPC), Village Forest Committee (VFC), etc. The State Forest Department organizes and provides motivational, technical and administrative support to the JFMCs, which attract the support of the villagers on the fringes of the degraded forests as its willing members. Generally, two people from each household become members, one of them a woman. The general body of 75 to 150 members, 50 per cent of whom are women, elect a JFM Executive Committee, which in turn elects a chairperson to oversee and manage the affairs of the JFMC. It is prescribed that at least 33% of the seats in the JFM Executive Committee be filled by women members. For a general body meeting, presence of at least 50% of the women members is taken as a prerequisite. Adequate representation is ensured to all the sections of the society. The Forest Department representative acts as the secretary. Interested social and nongovernmental organizations are also involved in building up confidence among the communities.

A memorandum of understanding between the JFMC and the Forest Department formally details the duties, functions, and entitlements of everyone involved. The primary purpose of the JFMC is to protect the forest from encroachment, grazing, theft, fire and to improve the forest in accordance with an approved joint forest management plan, known as a micro-plan. Micro-plans are designed to ensure protection of forests and at the same time they aim at restoring their productive capacity as quickly as possible. As an incentive for managing a particular forest, a JFMC is entitled for a

share from the forest produce grown and available in the area. The income generated from the disposal of forest produce, after meeting the requirement of communities, is distributed equally among the members of the JFMC. At the outset, to help motivate people and to address some of their most pressing social needs, the State Forest Department provides some financial support for the development of the village(s) concerned. The project supports some of these "entry point" activities, with the assistance of other government departments or NGOs to facilitate this broader rural development activity. This enables successful integration of conservation with development aims of the government. It is also prescribed that an appropriate percentage of the income generated from the forest resources be apportioned for activities that are important for ensuring sustainability of the forest(s) managed by the JFMC. The works and funds of the JFMC are handled in a transparent manner jointly by the chairperson of the JFMC and the forester who acts as the secretary. This transparency helps to ensure the quality and cost-effectiveness of all activities. All the decisions related to the implementation of the micro-plan and appropriation of the funds accrued to the JFMC are taken collectively by the JFMC.

9.4 Role of Panchayati Raj Institutions in JFM

One of the basic purposes of Panchayati Raj is to enable people to understand their socio-economic interests and take decisions at their level for their own good. With the notification of the 73rd amendment Act 1992 and its implementation in 1996, Panchayati Raj Institutions have been provided at the village, the intermediate and the district levels. Among the 29 duties entrusted to the PRIs as per the Act, social forestry, farm forestry, minor forest produce, fuel and fodder are some, which are related to the forestry sector. Thus, it empowers the PRIs to take decisions regarding the management of the natural resource at their disposal. However, the management of state forests has been the responsibility of the state government institutions and, therefore, JFM institutions, participating in the management of the government forests are considered to be outside the purview of local self-governments.

This is the reason that the JFM Committees are to be registered under the Societies Registration Act 1860 and function independently. Nevertheless, any activity, including afforestation and management of forests outside state forests, like community lands,

etc. do come within the purview of Panchayats, and JFMC in such case would be associated with the Panchayats concerned.

In this context, the Government of India has suggested formation of a Committee at the district level under the chairmanship of President, Jila Parishad or the Collector, where Jila Parishad is non-functional, with Divisional Forest Officer as the convener and other district level officers as its members. However, it has been advocated that separate non-political identity of the JFM committees as 'guardians of forests' should be maintained.

Panchayats (Extension to the Scheduled Areas) Act 1996 extends panchayats to the tribal areas of Andhra Pradesh, Bihar, Jharkhand, Gujarat, Himachal Pradesh, Maharashtra, Madhya Pradesh, Chhattisgarh, Orissa and Rajasthan with the objective of enabling tribal societies to assume control over their own destiny to preserve and conserve their traditional rights over natural resources.

In this context, as the management of government forests has been retained with state governments, the right over Minor Forest Produce (MFP) in both the Acts has attracted conflicting interpretations of MFP leading to a situation where definite clarifications on this aspect are not forthcoming. Ownership of MFP with PRIs has been accepted only to the extent of making only the residual profits of state forest corporations/federations of co-operatives available to them (i.e. PRIs). This is seen going against the provision of vesting the ownership of MFP with these institutions Planning Commission: 2000, the Ministry of Rural Development: 2003). However, keeping in view the fact that the state forests are kept beyond the domain of PRIs, options of appropriation of MFP by the communities in JFMCs is available under the JFM regime for the state forests while MFP from the community forests and such other forest areas will be at the disposal of PRIs.

In the guidelines issued by the Government of India on JFM, it is suggested that the benefits accrued from Non-Timber Forest Product (NTFP) sales should be shared with all the members of the Gram Sabha including the JFM Committees. Panchayats and State Forest Corporations have been advised to assist the JFMCs for developing skills for handling the NTFP collection, storage and marketing. These guidelines are very general and do not offer a resolution mechanism for conflicts arising out of the

following situations, particularly in the case of major NTFP items involving significant yields.

- In several states, MFP is managed and marketed by State Forest Development Corporations as commercial activities on payment of royalty to the state governments and communities have access for the use of MFP for bona fide purpose only.
- In many states, tribal or other co-operative societies are entrusted with the collection of MFP on payment of royalty or free of cost and the state level federations of these co-operative institutions manage marketing. In many cases MFP is the only activity dealt by these institutions.
- Under the Panchayati Raj Act, MFP has been brought under the mandate of Panchayati Raj Institutions, though the state forests have been kept out of their purview.
- Under JFM arrangements, the JFMC members have a natural right to appropriate the yield, including that of MFP, from the forest area managed by them.

In some states, like MP, the representative of Gram Sabha has been made a member of the executive committee of the JFMC as a measure of conflict resolution. As the micro-planning and major decisions are generally taken in the general meetings, there are few chances of conflicts. However, the relations between JFMCs and PRIs vary from state to state and it is essential to bring harmony between these institutions to avoid any conflicting situations.

9.5 The Impact of Joint Forest Management

The participatory management of forests enables the communities to understand the capability of the forests in catering to their need and thus prompts them to have a realistic resource management plan, based on their requirements and priorities, for the forests entrusted with them. The empowerment of communities in planning and managing the common property resources in their vicinity evolves a sense of ownership of the forests and thus the responsibility of maintaining sustainability becomes a voluntary commitment. As all the villagers are involved in this process, unity and consensus for taking conscious decisions about collective (common

property) resources along with wholehearted co-operation are evolved. These, as we know, are the crucial attributes for an ideal village society. Participatory management also ensures willing inputs from the communities in optimizing/maximizing the productivity of forests. The process of micro planning enables the villagers to understand and appreciate the resource related issues and the importance efforts required for conservation of natural resources.

Most of the states have adopted the JFM concept for the management of degraded forests in the vicinity of villages. States like Madhya Pradesh have entrusted the management of forests within 5 kms of villages to the village communities, irrespective of the degradation status of such forests. Kerala too has adopted the JFM concept for the management of Non-wood Forest products/resources making it possible for the forest and fringe dwellers to take up activities for conserving the resources and appropriate the NWFP on the principles of sustainability. The Government of India has made JFM an integral part of the National Afforestation Scheme in which the Central Government provides funds for afforestation of degraded forests through Forest Development Agencies (FDAs), which are the consortia of JFM Committees with representation from Panchayats, Forest and other line Departments of the State Governments concerned.

9.6 Participation of Communities in Conservation of Biodiversity

9.6.1 Village Eco-development

We have learnt about the forestry management models with participatory approaches adopted for the management of degraded forests for sustainable use, growing of trees as an economic activity and rehabilitation of private and community lands for community use. The typical JFM model is not applicable in situations where the villages are situated in the vicinity of protected areas, i.e. Sanctuaries and National Parks. Protected Areas or PAs, as these conservation area units of forest management are called, are basically the forest areas set apart for the preservation of biodiversity and representative or unique natural habitats in which human interference is sought to be avoided. These areas showcase the wildlife (uncultivated flora and undomesticated faunal diversity) of the country and the objective of management in this case is to

preserve the gene pool by preserving the natural habitats. Forestry operations are avoided and so the removal of forest produces.

In India, at present an area of approximately 1.56 lakh square kms is covered and managed as 500 Sanctuaries and 89 National Parks. Human habitations are situated near these areas also and in many cases within the PAs and there are populations, especially tribal communities, which have lived there for ages. Relocation of human settlements out of the PAs has been one of the operational components of the Protected Area Management, but it is resolved that such relocation should be absolutely voluntary (National Wild Life Action Plan, 2002). However, human interference in

PAs is preferred to be avoided. In such cases, therefore, the village population is deprived of the life support system and perhaps the most important natural resource at its disposal. Besides, these communities face hardships due to loss of employment based on forestry operations, damage of crops and elimination of life by wild animals, etc. This often results in a conflicting situation between the objectives of management and the needs of the society, breaking the bond between the nature and the human inhabitants.

In these situations, instilling the realization of the positive impact of conservation in ecological and economical terms in the communities concerned would be possible by designing rural development programmes which could divert the livelihood pressures from the forests (in terms of their invasive use), and provide improved quality of life to the neighborhood communities by positive ecological impact of the conserved PAs on the village ecosystem. This strategy is known as Village Eco-development.

9.6.2 Concept and Design

Village Eco-development aims at the all-round development of the village as planned by the villagers themselves for sustainable use of all the resources available at their disposal. Dependence of villagers on the forests of a PA is diverted by creating livelihood opportunities outside the PA by optimizing the use of available resources, increasing productivity and value addition based rural enterprises. Non-invasive services generated in the PAs are made available to the deserving members of the community and they are empowered with knowledge and techniques in achieving the

objectives of the management and protection of the PA. Children, for example, are involved in nature education and the appreciation of natural phenomena.

As in Joint Forest Management, Eco-development Committees (EDCs) are formed in villages and they work with NGOs and the PA managers for planning and implementing the appropriate eco-development plans for the village as well as conservation of biodiversity. Development of community resources and generation of gainful employment outside the PA, avoiding invasive and destructive use of PA habitats are the prime considerations in micro planning. Opportunities of seasonal and regular employment in the PA are made available to the villagers recommended by the EDC. Alternatives to the forest based employment are explored and pursued. Modalities of regulating access to the resources (like water and biomass products) in conformity with the prescriptions of the management plan of the PA are also decided by the EDC.

The micro-plan thus prepared takes the shape of an integrated rural development plan that may require investment. There have been instances where such investments have been ensured by various line departments on requests from the PA management, ensuring implementation of site-specific plans beyond the realm of conventional government schemes. In most of the cases so far, investment has been made under the government schemes for the management of PAs.

9.6.3 Village Eco-development as a Government Programme

Village eco-development was adopted as a government effort for the management of PAs during the Ninth Five Year Plan. A pilot project on park management based on participatory Village Eco-development was started during the plan period in seven Project Tiger Areas under the aegis of the Global Environment Facility (GEF) through the World Bank. The Project is in its final stage and has been slated to be one of the successful experiments in winning the co-operation of communities in the conservation of biodiversity. The final results are yet to be compiled in order to develop a universally applicable model of Eco-development Approach. Now the Government of India has prescribed that the village eco-development activities be taken up as a regular PA management activity in all the wildlife park management schemes supported by the Central funds.

Summary

For rehabilitation of degraded forests in the vicinity of inhabited areas, people's institutions have been created to manage government forests in recognition of their first claim on the natural resources as provided in the National Forest Policy 1988. The guidelines of the Government of India for this participatory approach, named the Joint Forest Management, issued in 1990 and improved in 2000 and 2002, provided for the transfer of the responsibility of managing these forests to the communities in terms of planning, management, protection and sharing of benefits. These Guidelines provide for adequate representation of women in decision-making and clarify that the institutions are independent of the purview of Panchayati Raj Institutions for the management of State Forests. However, a clear definition of roles and responsibilities is needed for conflict resolution.

Similar institutional arrangements are evolving for the conservation of biodiversity and the concept of Village Eco-development is emerging as a viable means of ensuring peoples participation in Protected Area Management. It also helps in mitigating conflicts arising out of the denial of forest based subsistence related activities within the Protected Areas.

Thus, community participation in the management of natural resources in the rural development scenario has taken place in the field of forest management. It is expected that the related community institutions would perform this task to bring productivity to the optimum level and the resource character in conformity with their requirements. The ecological functions of the forests can be fulfilled only when the communities ensure optimum productivity in terms of biomass and sustainability in use of forest products.

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