

**Course Title: Forestry and Range Management**

**Course Code: FRW-301**

**Course Credit Hours: 3(2-1)**

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## **THEORY:**

### **Topic 1. Basic concept and Importance and Potential of Forestry.**

A forest is a biotic community of fauna and flora predominated by trees and woody vegetation that covers a large area. Forest have appeared on Earth about 350 million years ago and reached a peak about 270 million to 220 million years ago during the carboniferous period. Today, forests cover about one third of the earth's land surface. Forests played a vital role in the survival, development, and growth of human society. They not only provide industrial wood, fuelwood, shelter and forage for livestock but also improve the quality and quantity of water, reduce erosion and runoff, store carbon, increase soil texture and fertility, provide habitat, reduce air pollution and surrounding temperature and provide several recreational activities to mankind. Pakistan has only 4.8% of its area under forests which is far behind the country need. Pakistan has natural forest cover only 2.2% and losing its forests at the rate of 1.66% per year, all because of increasing population pressure, land clearance for agriculture, timber mafia, over-exploitation of resources and forest fires. There is urgent need of law implementation and adoption of necessary strategies to protect and improve the forests of Pakistan.

### **Significance of Forestry**

Trees are the oldest companion of man, which provided safety, fuel, food, clothing and shelter when man first moved to the Earth from heavenly abode. In fact, quest for wood, which is the principal building material and fuel of the past societies, has triggered large population movements. The discovery of how to keep and use fire, the idea of the wheel, and the concept of lever, are many fundamental civilizing concepts of man that seem to have been developed from wood over a period of many millennia. Actually, wood is indispensable for human existence right from the beginning of life on Earth till to date and associated with human civilization for its multiple uses and properties. With the advent of modern time in mid- sixteenth century and later during industrial revolution in eighteenth century, importance of forests as a source of wood for industries (iron and bronze manufacture), ship building and protection of river catchments for sustained supply of clean water was recognized at a time when forest area began to diminish with increasing population and expansion of agriculture. Wood was used as fuel in locomotives before the discovery of coal: For instance, Changa Manga plantation was established in 1866 to supply fuel for railway engines and some plantations in Punjab and Sindh supplied wood to Indus flotilla at that time. At the close of 20th century, the concept of forest conservation for climatic and environmental stability, sustainable development, control of Desertification and conservation of biological diversity is being highlighted in many international forums. The importance of forests is significant in countries like Pakistan, which has arid and hot climate over more than 70 per cent of its area and where percentage of forest area is very low i.e. 4.8%. In addition to supply of traditional goods and services like wood, fodder, water, wildlife and recreation, forests also protect river catchments in hilly regions and ensure sustained supply of good quality water for irrigation and power generation. Furthermore, sustained agricultural and industrial development in Pakistan is not possible without sustained supply of water in the rivers. Rapid disappearance of forests and reduced tree growth over major part of the country in last two decades has accentuated the problem of aridity, soil degradation, extremes of climate and spread of deserts. There is acute shortage of wood and wood products with concomitant rise in their prices and absence of substantial wood-based industries. It has also adversely

affected the programmes of socioeconomic uplift of large population. Annual expenditure on import of wood products, especially, pulp and paper is very high which could be one of the reasons in overall low literacy rate of the country. Pakistan is one of the countries in Asia and Africa, where forests are too meager to fulfill the needs of the people.

### **Distribution of World's Forest Resources**

Forest can be defined as land with a tree cover of more than 10% or an area of more than 0.5ha under perennial woody vegetation with a minimum height of 5 m at maturity and this land should not be predominantly used for agricultural purposes. Worldwide distribution of forest area, according to FAO (2001, 2003) is given in Table 1.1. Europe which includes the Russian Federation (27% of world's forest area) has the maximum forest area of the region as compared to any other regions. South America has the highest percentage forest cover and the second highest forest area.

Africa has 22% of its land area as forest, which is below the world average of 30%. Africa has the second largest wood biomass (17%) after South America. Asia has a large area of tropical rainforest in the south-eastern mainland: Indonesia and New Guinea. It also has significant areas of drier tropical forest, subtropical forest, temperate forest and even a small occurrence of boreal forest. Asia has the lowest percentage of the forest cover (18%) of any of the regions. However, it has the largest area of forest plantations, particularly in China, India, Japan, Thailand, Turkey and Vietnam. Australia- a prominent region of Oceania is famous for having tropical dry forests predominate. It has moist tropical rainforest in the north, subtropical humid forest in the east and temperate oceanic forest in the south —east and subtropical dry forest in the south- west. New Zealand-another prominent country of the Oceania has subtropical humid (warm temperate) forest in the north island and temperate oceanic forest in the South Island.

North and Central America have all kinds of forest types varying from tropical rainforest to boreal tundra woodlands. The region is dominated in area by the USA and Canada. Both countries have almost equal forest area and both about the same percentage of forest cover (Canada 27% and USA 25%). The forests are mainly subtropical and temperate in the USA, and temperate but mainly boreal in Canada. Consequently, the wood biomass is greater in the USA (24.4 billion tonnes) than Canada (20.2 billion tonnes).

### **Forest Spectrum in Pakistan**

A forest is a biotic community of fauna and flora predominated by trees and woody vegetation that cover a large area. It supports an array of complex flora and fauna, and forms a distinctive microclimate as compared to other land uses. Each forest type has specific species composition, size, diversity, and density, due to specific temperature and precipitation. No matter what type the forest is, the plant sizes, canopy density, litter floor, and root systems are significantly taller, greater, thicker, and deeper respectively than other vegetation types. These characteristics enable forests not only to provide several natural resources, but also to perform a variety of environmental functions.

Forest resources may include timber, water, soil, wildlife, vegetation, minerals, and recreation. Except for minerals, all these resources are greatly affected by forestry activities. Some resources can be destroyed, depending on the intensity and extent of the forestry activity. Environmental functions performed by forests may include control of water and wind erosion, protection of headwater and reservoir watershed and riparian zone, sand dune and stream-bank stabilization, landslide and avalanche prevention, preservation of wildlife habitats and gene pools, mitigation of flood damage and wind speed, and sinks for atmospheric carbon dioxide. Many established forests have been managed to achieve one or more of these environmental functions, while others are preserved to prevent loss in biodiversity and degradation of the ecosystem.

The forests of Pakistan reflect great physiographic, climatic and edaphic contrasts. Pakistan is an oblong stretch of land between the Arabian Sea and Karakoram mountains, lying diagonally between 24° N and

37° N latitudes and 61° E and 75° E longitudes and covering an area of 87.98 million hectares (Siddiqui 1997). Topographically, the country has a continuous massive mountainous tract in the north, the west and the south west and a large fertile plain: the Indus plain. The northern mountain system, comprising of the Karakoram, the great Himalayas, and the Hindu-Kush, has enormous mass of snow and glaciers and 100 peaks of over 5400 m in elevation including K-2 (8, 616 m according to Desio (1988) that is the second highest peak in the world. The mountain system occupies one third area of the country. The western mountain ranges, not as high as in the north, comprise the Sufed Koh and the Sulaiman while the south-western ranges form a high, dry and cold Balochistan plateau. Characteristically, the mountain slopes are steep, even precipitous, making fragile watershed areas and associated forest vegetation extremely important from hydrological point of view. The valleys are narrow. The mountains are continuously undergoing natural process of erosion. The nature of climate with high intensity rainfall in summer and steep slopes in the northern regions are prone to erosion and landslides.

The Indus plain have two distinct features; the alluvial plain and sand dunal desert. The country is drained by five rivers; namely, Indus, Jhelum, Chenab, Ravi and Sutlej. Of these Indus arising in snow covered northern mountain ranges flows towards south through the Punjab and Sindh plains into a wide delta before entering Arabian Sea. Other rivers join it on the way, together feeding one of the largest irrigation systems in the world. The great river system of Indus in Pakistan derives a part of their water supply from sources which lie in the high lands beyond the Himalayas and the western mountains, and part from countless valleys which lie hidden within the mountain folds. Much of the silt of the alluvial plain is from natural geological erosion of mountains in the north brought down by rivers. Thal desert lies between the rivers Indus and Jhelum, while Cholistan and Thar Desert occur on the south-east of the country.

A great variety of parent rock types occur in Pakistan, which exert considerable influence on the properties of soil. The rocks found in Pakistan can be classified into three major groups, viz., the igneous rocks, the sedimentary rocks and the metamorphic rocks. In the Himalayan regions, the common rock types are metamorphic which are gneisses, schists, slates and phyllites with some quartzite and marble. In the northern part of Indus plain, between Sargodha and Shahkot small outcrops of phyllites and quartzites occur. Granite, syenite, diorite, gabbro, dolerite and peridotite are more common types of igneous rocks, which occur in Dir, Swat, Chitral, Gilgit, Zhob, Chagai, Las Bela and Nagarparker.

According to FAO (2010), Pakistan has the natural forest cover of only 2.2% or 1,687,000 ha and losing its forests at the rate of 1.66% or 42,000 ha per year (Data from 1990 to 2010). Pakistan's forests contain about 213 million metric tons of carbon and Pakistan has some 4950 species of vascular plants of which about 7.5% are endemic, meaning they exist in no other country. It is also worth mentioning that major needs for industrial wood (72%) and fuelwood (90%) of the country are fulfilled by the wood from farmland (Rahim and Hasnain 2010). Between 1996 and 2000, the average roundwood production and industrial roundwood production per year in Pakistan was 31.66 million m<sup>3</sup> and 2.35 million m<sup>3</sup> respectively. However, the big bucks were spent to import about 5,32,000 m<sup>3</sup> per year of industrial roundwood (FAO 2002). According to FAO (2002), Pakistan's forests, in spite of having very small forest per capita (only 0.05 ha/capita against world average of 1.0 ha/capita) providing employment to 500,000 workers and contributing 0.3 percent to GNP. Furthermore, Pakistani forests including farm-forests are supplying 32% of Pakistan's total energy needs in the form of fuelwood, providing forage for one third of Pakistan's 86 million head of livestock and saving Pakistan's agriculture, which contribute about 26% of GDP, by ensuring good quality irrigation water in river based gigantic irrigation system.

## **Topic # 2 Forest Products &Utilization.**

Forests have appeared on Earth about 350 million years ago, and reached a peak about 270 million to 220 million years ago during the Carboniferous period. Today, forests cover about one third of the earth's land surface. They are the most distinguished type of vegetation community and provide many

resources and environmental functions that far exceed those of other vegetation covers. Accordingly, forests have always played a vital role in the survival, development, and growth of human society since prehistoric times. Healthy forests always improve the quality of environment. Before discussing the benefits of forest, it is important to understand the four categories of functional forests: Production forests, protection forests, preservation forests, and public forests. The functions for which a forest is managed are directly related with site and environmental conditions. However, the ownership, economic constraints, and prospective value of the forest play an important role in determining management objectives.

**Production forests:** The main purpose of production forests is to obtain financial profit from the forest by producing timber, pulpwood, fuels, wildlife, forest and agricultural by-products, livestock, and recreation services. In rural areas of the tropical regions, a sizeable population lives in and around forests. They grow crops in the forest for food and harvest branch and litter for fuel. India has started a social program in which people plant and grow trees in back yards and community woodlots for fuel and other purposes. Many feasibility studies have shown that power stations could be operated and liquid fuel ethanol could be produced by growing trees in “energy plantations” (Fung 1982). Forest grazing is also a common practice that often damages trees, destroys litter floor, and compacts soils. These exploitive adverse practices interrupt nutrient cycling in the forest, increase soil and water erosion, deplete land productivity, and eventually cause the disappearance of forests or reduction in the forests production. In the pursuit of maximum economic gain from a forest, exploitive uses of its resources should be avoided. Best management practices should be incorporated in all forestry activities so that land productivity can be maintained and water quality should not be impaired.

**Protection forests:** On rough terrain, steep slopes, streambanks, water resource areas, wind prone regions, or potential landslide sites, forests are often established to reduce soil erosion, increase sand stability, improve water quality, retain reservoir capacity, mitigate flood damage, and attenuate air pollution. Forests are also managed to protect habitats for birds, fish and other animals. Protection forests ensure environmental functions; economic income is insignificant or even totally ignored. Since protection forests are there to protect a specific site and environmental condition, species used are more restrictive, and management activities need to assure the sustainability of the forest. Protection forests are usually in areas sensitive to environmental problems; clear cutting, grazing, cropping, and litter harvesting should not be practiced. A clear-cut in these sensitive areas would make artificial regeneration very difficult or too long to establish. It can consequently make the destruction of forests in the protected area devastating. Thus, legal enforcement is required to preserve the protection forests any kind of damage due to cultivation, harvesting, grazing, and other impairing activities. In fact, all forests can be considered protective in view of their function as sinks of atmospheric carbon dioxide, and their effective role to control or reduce global warming. An estimate of potential carbon sequestering in the tropical closed forest landscape is about 1.5 to 3.2 Pg C per year (1 Pg = 10<sup>15</sup> g or 1 Gt) or 31 to 58% of the current CO<sub>2</sub> emission by fossil fuels (Brown and Lugo 1992). A sustainable forest-management plan should be developed that can provide simultaneously both a profitable income from the forest and an inexpensive way to reduce accumulation of CO<sub>2</sub> in the atmosphere.

**Preservation forests:** It has been estimated that about 30% of Earth's surface vegetation has been damaged since farming began. According to another estimate, between 1981 and 1990, about 12% or 168 × 10<sup>6</sup> ha of the highly bio-diversified tropical forests in 62 tropical countries were lost due to deforestation (FAO 1990). Loss of forests leads to the loss of many plant and animal species from the genetic and pharmaceutical pools of the world. The nature and ecosystems of managed forests are different from those of the virgin forests. Impacts on the hydrological cycle, soil and nutrient losses, and climate changes are highly significant and well documented.

**Public forests:** Forests that are developed and managed for the public to provide recreation are referred as public forest. They may include parks, botanic gardens, zoos, and wildlife refuges. Most public forests

have been declared as national, state, and city parks. The national parks are dedicated to preserve vegetation, wildlife, natural wonders, cultural heritages, and historical monuments for people's pleasure and health. They also provide educational and awareness programs through forest trails and on-site boards about environment and biodiversity.

### **Topic # 3. Plant Growth and Environment.**

Trees are complex organisms. They originate either from vegetative propagation or through sexually fertilized egg that matures into a seed encased embryo. On planting, seed give rise to one of the nature's largest living organisms. A tree has three major parts: roots, stem and leaves, which are anatomically different from each other. In this chapter, anatomy of cell, roots, stem and leaves has been described. Related topics like secondary growth, role of cambium, vascular tissues and structure of wood have been discussed. Differences between the wood formation of gymnosperms and angiosperms have been marked out. Water is an important element of life present on the earth. The huge quantity of water loss on every day by trees is a consequence of transpiration that must be reinstated for their growth and survival. In this chapter, importance of water absorption, relation, their interaction with soil and other important aspect of tree physiology like hormonal role and photosynthesis are discussed.

Trees are the tallest self-supporting organisms in the world. A tree is generally defined as a woody plant having the height of 15 ft or more and characterized by a single trunk. They live long and grow superior to any other living organism on the Earth; well-defined stems support a crown. Being perennial in nature, their anatomical features are different from other annuals and/or biennials. Coast redwood *Sequoia sempervirens* (Hyperion) is the world's tallest known living tree, measuring up to 115.61 m (379.3 ft) in height. Tree physiology is the study of natural phenomena operating in the living trees and tree parts. In tree physiology, structure of the cells, tissues and organs are associated with processes and functions. Trees are physiologically alike to other form of plants like biennials/annuals because they are also autotrophic, non mobile, soil dependant for waters and minerals etc. Wood formation and larger heights make trees distinguished from bushes, grasses and/or dwarf plants. Some major physiological phenomena like water absorption, ascent of sap, photosynthesis, transpiration and plant hormones are briefly discussed in this chapter.

#### **Tree**

A tree consists of three major portions: root, stem or trunk and crown. Crown consists of limbs (> wrist thickness), branches (thumb thickness < wrist thickness), twigs ( $\leq$  thumb thickness), leaves, flowers, seeds etc. Trunk supports limbs and limbs carry branches and twigs, which, ultimately, support leaves. Leaves are the food manufacturing factories as they contain chlorophyll and the process of photosynthesis occurs therein. Limbs and branches are woody in nature and useful part of a tree to be used for timber or fuel purpose. Distinguish characteristics of crown parts (leaves and seeds) can also be used for tree classification i.e. depending on leaves; tree can be classified as Hardwoods and Softwoods. Softwoods are the Gymnosperms and the Hardwoods are the Angiosperms.

#### **Tree Anatomy**

##### **Root**

Structurally roots can be divided as monocot roots and dicot roots (here, only dicot roots will be discussed) and they can be further divided into two categories. 1. Primary roots 2. Adventitious roots. The functions of the primary roots are to anchor the plant in the soil, to absorb water and also serve as store house of food materials. Adventitious roots are helpful in support the plant body into soil and absorbing soluble substances from soil. Root cap consists of parenchymatous cells. The function of root cap is to give protection and control the movement of root.

**Epidermis:** This layer is consisted of elongated cells without cuticle and stomata. Most of the epidermal cells extend out in tubular unicellular root hairs. Epidermis is also known as Epiblem, Rhizodermis and

Piliferous layer (Figure 3.2 and Figure 3.3). Beneath the epidermis is one or multilayer exodermis present whose cell walls can suberized.

**Cortex:** It is consisted of polygonal parenchyma cells. These cells contain starch grains. The roots of dicotyledons, sometimes, exhibit secondary growth and shed their cortex. Various idioblasts and secretory structures are found in the root cortex.

**Endodermis:** The inner most distinct layer of the cortex is known as endodermis. It is characterized by the presence of Casparin strips on their anticlinal walls. According to Guttenberg, suberin like materials are found in the strips.

**Pericycle:** The layer next to the endodermis is pericycle. It may be uniseriate or multiseriate. Lateral roots also arise from pericycle cells. It provides outer boundary of the vascular tissues.

**Vascular system:** Phloem strands occur beneath the pericycle. Xylem forms discrete strands alternating with the phloem strands. If xylem is not differentiated in the centre, the centre is occupied by pith. The root shows an exarch xylem, metaxylem occur inward side while proto xylem outward side of vascular cylinder. The phloem is also centripetally differentiated i.e., the protophloem occurring closer to the periphery than the metaphloem. The parenchymatous conjunctive tissue occurs in between xylem and phloem strands. The pith is scanty or absent.

### **Stem**

The close association of the stem with the leaves makes the aerial part of the plant axis that is structurally more complex than the root (Figure 3.4). The term shoot, which refers to the stem and leaves are as one system, serves to express this association. The root and stem make a continuous structure called the Axis of the plant. The vascular bundles are continuous from the root to the stem. But the arrangement of vascular bundles is quite different in the two organs. The stems possess collateral bundles with endarch xylem, where as the root possess radial bundles with exarch xylem.

**Cortex:** The region that lies next to the epidermis is the cortex. The innermost layer of the cortex is endodermis. It consists of a single layer of cells which contain numerous starch grains. The part of the cortex situated between the epidermis and endodermis is generally divided into two regions, an outer zone of collenchymas cells and an inner zone of parenchyma cells.

**Endodermis:** The inner most layer of the cortex is the endodermis. The cells are barrel-shaped, elongated and compact in structure. These cells contain starch grain may be termed as starch sheath.

**Pericycle:** The region between the vascular bundles and the cortex is known as the pericycle. It is generally composed of parenchyma and sclerenchyma cells. Vascular bundles: each vascular bundle consists of 3 parts. Xylem are thick walled and occur nearest the centre of stem, while phloem cells are thin walled and occurred towards the peripheral portion of vascular bundle. Between the xylem and phloem cambium layer is present, which consists of meristematic cells. Cambium cells divided to increase the size of vascular bundles by forming xylem cells on the inner side and phloem cells on the outer side.

**Xylem:** The xylem which is formed by the activity of the cambium is called primary xylem. The xylem formed is nearest the centre of the stem is called protoxylem. The more peripheral part the xylem is known as metaxylem. The xylem is composed of 3 types of cells-Tracheary cells, tracheids and vessels, wood fibers and wood parenchyma. The protoxylem is composed largely of annular and spiral vessels and parenchyma, while the tracheary elements of the secondary xylem are pitted.

### **Leaf**

It is an important component of the plant body. It is engaged in fundamental physiological activities such as respiration, transpiration and photosynthesis. Typically a leaf is a thin, dorsiventral flattened organ, produce above ground. There are two types of leaves (i) isobilateral leaf and (ii) dorsiventral leaf. Leaves are isobilateral if they possess stomata on both surfaces and are dorsiventral if stomata are present only lower surface.

**Epidermis:** It consists of single layered of cells and covered with waxy substance called Cutin. Stomata are found in most abundance in the lower epidermis of the dorsiventral leaf (Figure 3.5). Each stoma remains surrounded by two semi lunar guard cells. The guard cells are living and contain chloroplasts. The guard cells may remain surrounded by two or more accessory cells in addition to epidermis cells. Stomata are found in scattered form.

**Mesophyll cells:** The tissue of the leaf that lie between upper and lower epidermis and between the veins consists of thin walled parenchyma is known as mesophyll. Mesophyll portion consists of two types one is palisade cells and other one is spongy tissues. Both cells contain chlorophylls therefore take part in photosynthesis process. The palisade tissue may consist of a single or more layers and compactly arranged, while spongy tissue occur lower portion of the mesophyll in the leaf. The spongy tissue is usually composed of loose, irregular, thin walled cells having big intercellular spaces among them. Due to the presence of a large air space in the spongy tissue they are more adaptable to the exchange of gases between the cells and the atmosphere. The function of the midrib and the lateral veins are to strength the leaf.

**Collenchyma, Schlerenchyma and Parenchyma:** In the centre of the upper portion of the mid rib, just below the epidermis, there is usually a group of collenchymas cells which are turgid and give strength to the leaf. Schlerenchyma cells are associated with the vascular tissues of the leaves. They occurred surrounded the vascular bundle of leaves. Usually these cells are thick walled, dead and lignified. Parenchyma cells occupy the region between collenchymas cells and the central portion of the midrib. These cells give turgidity and strength to the midrib.

#### **Topic # 4. Principles of Agro Forestry, precise role, extent and magnitude, selection of suitable species.**

1. Precise objective of forestry for specific site.
2. Selection of suitable site.
3. Selection of suitable specie.
4. Establishment of woody vegetation.
5. Cultural operations and protection.
6. Timely felling, proper conversion and skilful marketing.

#### **Topic # 5. Land capability classes (1-V11).**

Capability class is the broadest category in the land capability classification system. Class codes 1, 2, 3, 4, 5, 6, 7, and 8 are used to represent both irrigated and non-irrigated land capability classes.

Class 1 soils have slight limitations that restrict their use.

Class 2 soils have moderate limitations that reduce the choice of plants or require moderate conservation practices.

Class 3 soils have severe limitations that reduce the choice of plants or require special conservation practices, or both.

Class 4 soils have very severe limitations that restrict the choice of plants or require very careful management, or both.

Class 5 soils have little or no hazard of erosion but have other limitations, impractical to remove, that limit their use mainly to pasture, range, forestland, or wildlife food and cover.

Class 6 soils have severe limitations that make them generally unsuited to cultivation and that limit their use mainly to pasture, range, forestland, or wildlife food and cover.

Class 7 soils have very severe limitations that make them unsuited to cultivation and that restrict their use mainly to grazing, forestland, or wildlife.

Class 8 soils and miscellaneous areas have limitations that preclude their use for commercial plant production and limit their use to recreation, wildlife, or water supply or for esthetic purposes.

Capability subclass is the second category in the land capability classification system. Class codes e, w, s, and c are used for land capability subclasses.

Subclass e is made up of soils for which the susceptibility to erosion is the dominant problem or hazard affecting their use. Erosion susceptibility and past erosion damage are the major soil factors that affect soils in this subclass.

Subclass w is made up of soils for which excess water is the dominant hazard or limitation affecting their use. Poor soil drainage, wetness, a high water table, and overflow are the factors that affect soils in this subclass.

Subclass s is made up of soils that have soil limitations within the rooting zone, such as shallowness of the rooting zone, stones, low moisture-holding capacity, low fertility that is difficult to correct, and salinity or sodium content.

Subclass c is made up of soils for which the climate (the temperature or lack of moisture) is the major hazard or limitation affecting their use.

The subclass represents the dominant limitation that determines the capability class. Within a capability class, where the kinds of limitations are essentially equal, the subclasses have the following priority: e, w, s, and c. Subclasses are not assigned to soils or miscellaneous areas in capability classes 1 and 8.

## **Topic # 6 Multipurpose trees.**

### **1. *Acacia nilotica***

**COMMON NAMES:** Kikar, Babul.

**DESCRIPTION:** An evergreen, thorny, moderate-size tree, 20 m tall. Diameters up to 1 m have been recorded. Leaves are compound, 2.5 to 7.5 cm long. The crown form varies from conical to spreading. The flowers are fragrant, yellow to bright yellow growing in bunches and mature year around depending on sub-species and geographical location. The pods are variable 4 to 22 cm long, and also mature year around depending on sub-species and geographic location.

**DISTRIBUTION:** This tree is native to Pakistan and is found in the Sindh, Punjab, Baluchistan and K.P.K. It is wild as well as extensively cultivated throughout the world, usually below 600 m in elevation.

**USES:** Fodder, fuel and charcoal, agricultural implements, pit props, apiculture, gum, lac production, tannin, fencing, land stabilization, nitrogen fixing, and medicinal (bark for diarrhea and dysentery).

### **2. *Albizzia lebbek***

**COMMON NAMES:** Kala Sirin, Black Siris.

**DESCRIPTION:** A fast growing deciduous tree 12 to 30 m tall. Diameter upto 1m are not uncommon. The crown is open flat, and umbrella- . Foliage is feathery-like and the leaves are compound. Leaflets are small 3cm long. The bark is dark gray, rough and irregularly cracked. The fragrant flowers are yellow or greenish-white, in dense clusters, appearing between April and May. The pods are broad, flat and about 25cm long. They are yellowish brown when ripe. The pods mature between June to September.

**DISTRIBUTION:** This tree is native to the sub-Himalayan tract. In Pakistan it grows in a narrow belt from Sialkot to Hazara, Bajaur, Buner and Malakand. It has been planted throughout the plains of Sindh & Punjab.

**USES:** Fodder, fuel, land stabilization, nitrogen fixing, poles, agricultural implements, shade, and apiculture.

### **3. *Albizzia procera***

**COMMON NAMES:** Sufed Sirin, White Siris.



**DESCRIPTION:** A fast growing, deciduous tree 12 to 30 m tall. Diameters to 1 m have been recorded. The crown is open, and umbrella-like. Foliage is feathery-like and the leaves are compound. Leaflets are small, 3 cm long. The bark is smooth, light yellowish or greenish gray. It peels in flakes which are red on the undersides. The fragrant flowers are yellow or greenish-yellow and occur in loose clusters, appearing between June and August. The pods are narrow flat and about 15cm long. They are dark red brown when they ripe. The pods mature in September.

**DISTRIBUTION:** This tree is native to central and southern India, Bangladesh and Burma. In Pakistan it has been planted in the Punjab and K.P.K.

**USES:** Fodder, fuel, nitrogen fixing, poles and construction, agricultural implements, shade, furniture, tannin & apiculture.

#### 4. *Azadirachta indica*

**COMMON NAMES:** Neem, Margosa Tree.

**DESCRIPTION:** A medium to large, usually evergreen tree, 12 to 25 m tall with a diameter of 0.57 to 0.86 m. The crown is broad, dense, spreading & rounded. The leaves are compound; with the leaflets 2.5 to 7 cm long and lance shaped with long points and 4 to 7 pairs of leaflets on each leaf. Edges of the leaflets are toothed. The bark is dark gray, lightly furrowed and broken in irregularly shaped scales. The flowers are small, white and with the fragrance of honey, occur in dense bunches and appear between March and April. The fruit is a fleshy drupe containing one seed enclosed in a hard shell. Each fleshy drupe is greenish, oblong 1.5 to 2 cm long. The drupe is yellow when fully ripe. The fruiting period is June to August.

**DISTRIBUTION:** A native tree to India, Pakistan, Nepal, Afghanistan, Burma, China and Sri Lanka. In Pakistan it is found in the Sindh, southern Punjab, and lower Baluchistan, has been identified as far west as Sarai Alamgir, but has not been recorded west of the Jhelum river.

**USES:** Furniture, fodder, wood carving, medicinal (leaves as a febrifuge extracts as a cure of typhoid), timber, agriculture implements and tannin. Oil (from the seed) is marketed as a pesticide, vermifuge, and a contraceptive.

#### 5. *Cassia fistula*

**COMMON NAMES:** Amaltas, Indian Laburnum.

**DESCRIPTION:** A medium sized deciduous to semi-evergreen tree, with an open crown. The tree may never appear to be entirely leafless. At maturity, height of the tree will range from 5 to 9 m and have a diameter of 0.5 to 1.5 m. Leaves are compound and are divided into between 4 and 6 pairs of larger (12 by 6cm.) oval shaped leaflets. The leaflets are leathery, long pointed and stalked. The bark is greenish-gray on young trees, changing to a reddish brown with age. On old trees the bark peels off in hard scales. The flowers which are bright yellow and appear around April and May. They form in large, hanging, pointed bunches and are arranged along a central axis. The fruit is a long pod (2 to 3 cm in diameter and 30 or more cm long). Usually smooth, hard and dark brown when ripe; they mature between September and February. The pods break open easily to expose the seed.

**DISTRIBUTION:** The tree is native to Pakistan, commonly found east of the Indus in the plains and continuing north into the Himalayas to a elevation of approximately 1200 meters. It is cultivated throughout the plains region.

**USES:** Fuel, ornamental, fine furniture, agricultural implements, tool handles, support posts, cart wheels and axles, tannin, and medicinal (seed pod pulp as a purgative).

## 6. *Cedrus deodara*

**COMMON NAMES:** Diar, Deodar, Himalayan Cedar.

**DESCRIPTION:** A large, evergreen, tree 45 to 60 m tall with a diameter of 0.8 to 1.1 m. The crown extends to the ground with the branches forming a conical shape. The leaves are three, sided needles 2.5 to 4 cm long. The needles occur in groups or dense tufts, sometimes as rosettes. The bark is grayish or reddish-brown forming into irregular shaped scales with age. It is monoecious. The male flowers or cones are solitary on the ends of branches. The female flowers are erect along the tops of the branches, 10 to 15 cm long, and oval to pyramidal in shape. They are blue-green when young. The cones bloom between June and September. The fruit is the female cone. As the cone ripens it turns a brown color. The seed in the cone takes a full year to mature after pollination and a full 2 years for the reproductive cycle to be completed. There are two winged seed beneath each cone scale. Seed is shed in November.

**DISTRIBUTION:** This tree is native to the Himalayas of the subcontinent including Pakistan, Afghanistan and India. In Pakistan it is found at high elevations in Azad Kashmir, Murree Hills, Hazara, Swat, Dir, Tirah and Chitral.

**USES:** Construction, fuel, railway sleepers, watershed protection, packing cases and medicinal (aromatic wood juice is a carminative, diuretic).

## 7. *Cordia myxa*

**COMMON NAMES:** Lasura, Sebasten Plum.

**DESCRIPTION:** A medium sized deciduous tree, 5 to 15 m tall. Leaves are simple, variable in shape, with the base rounded or heart shaped. The leaves are 7 to 13 cm long and 6 to 11 cm wide. The bark is brown and has deep fissures with numerous shallow fissures around the stem. The white yellowish brown flowers hang in bunches. Each flower is between 0.5 to 1 cm across. The fruit, a drupe, is oblong 1 to 3 cm long. The drupe is yellowish brown pink to black when ripe. The drupe is sweet and edible, and matures in July and August.

**DISTRIBUTION:** This tree is native to Pakistan and India. In Pakistan it is found in the sub-Himalayan tract from Rawalpindi eastward. It is also found in the Salt Range.

**USES:** Fuel, fruit, implements, erosion control, and medicinal (fruit for cough, diseases of the chest)

## 8. *Dalbergia sissoo*

**COMMON NAMES:** Shisham, Tahli, Rose wood.

**DESCRIPTION:** A medium size to large, deciduous tree, 30 m in height. The branches are spreading and diameters of 3 m have been recorded. The trunk is usually crooked. The leaves are compound with 3 to 5 leaflets on an 8 cm stalk. The leaflets are between 2.5 to 6 cm in diameter, broadly oval, tough and pointed. The bark is gray, and furrowed longitudinally. On older trees the bark may peel off in strips. Young branches may be covered with a gray down. The flowers occur in groups and are small. The flowers are dull white to yellowish white to pinkish, appearing between March and May. The pods are small, 5 to 8 cm long and papery. The pods ripen from June to February. There are usually 1 to 4 seeds per pod.

**DISTRIBUTION:** The tree is native to the subcontinent along a sub-Himalayan tract. It is common along rivers banks and streams. It is successfully planted in many areas of Pakistan, India and other parts of the world.

**USES:** Fodder, furniture, fuel and charcoal, medicinal (roots and bark), railway carriages, sporting goods, farm implements, and shade.

## 9. *Eucalyptus camaldulensis*

**COMMON NAMES:** Sufeda, Lachi, Red River Gum.

**DESCRIPTION:** A large, evergreen tree, up to 40 m tall with a diameter of 1 to 2 m. The crown is spreading and irregular. The leaves are simple, narrow and lance shaped, 6 to 30 cm long and 0.8 to 2 cm wide. The leaves have a unique eucalyptus smell when crushed. The bark is smooth and stem may be crooked. The bark is whitish, pale gray with mottle reddish patches. Pieces of the bark will shed in long strips or irregular flakes. The flowers, which occur in groups of fives and tens, bloom usually between May and June. The fruit is a capsule containing many small seeds, and is shaped like a half globe 0.7 cm in diameter. The capsules mature between September and October.

**DISTRIBUTION:** The tree is native to Australia. It is widely planted in arid areas throughout the world. In Pakistan it is successfully planted throughout the plains and in the hills.

**USES:** Carriages, fuel, charcoal, furniture, oil (leaves), shelterbelt, apiculture, pulp, and fiber board.

#### 10. *Ficus religiosa*

**COMMON NAME:** Pipal.

**DESCRIPTION:** A large deciduous tree that is leafless or nearly so for a short period during hot seasons. The leaves are simple, large 10 to 15 cm by 6 to 12 cm and are broadly ovate, abruptly lanceolate, and shiny on the top side. The bark is gray and smooth with small irregular scales when old. It flowers in April and May. The fruit (fig) grows in the axil of the lower leaves and are 1.2 cm in diameter. Seeds are very small. Fruit matures from October to November.

**DISTRIBUTION:** The tree is common in the sub-Himalayas but probably is not native. It is cultivated throughout the plains.

**USES:** Ornamental, fodder, food (figs), small timber, and medicinal.

#### 11. *Melia azedarach*

**COMMON NAMES:** Bakain, Persian Lilac.

**DESCRIPTION:** A medium to small sized, deciduous tree, 6 to 12 m tall and with diameters of 0.57 to 0.70 m. The crown is spreading and rounded. The leaves are compound up to 60 cm long. The bark is dark gray with longitudinal ridges. The flowers are small, lilac colored and fragrant. The flowers occur in dense, hanging bunches appearing between March and May. The fruit is a drupe containing 4 to 5 seeds. The fruiting period is June to January.

**DISTRIBUTION:** This is native to the Himalayas including, Pakistan and Nepal. In Pakistan it is extensively planted in the plains of the Punjab and K.P.K. It has been successfully planted in many other parts of the world.

**USES:** Furniture, fodder, ornamental, timber, construction, agricultural implements, boxes and packing crates, sports equipment, veneer and plywood, and medicinal (flowers and leaves as poultice for headaches, juice of leaves as an anthelmintic and diuretic).

#### 12. *Morus alba*

**COMMON NAMES:** Tut, Mulberry.

**DESCRIPTION:** A medium sized deciduous tree, 9 to 15 m tall and diameters of 0.6 to 0.8 m. The crown is spreading and rounded. The leaves are simple, but varied in shape, 5 to 15 cm long and 4 to 12 cm wide. The bark is dark grayish brown with vertical ridges or fissures. It is monoecious. The male flowers are in 1-2 long catkin like to cm bunches. The female flowers are in solitary, rounded heads 0.5 to 1 cm in diameter. The flowers are greenish appearing between February and April. The fruit is a berry containing

5 to 15 small seeds, 0.7 to 1 cm long. The berries are white to pinkish to purple to red to black. The fruiting period is between March and June.

**DISTRIBUTION:** The tree is native to Pakistan, China, Central Asia and Afghanistan. It has been planted in many parts of the other world.

**USES:** Silk worm food, fodder, fruit, carriages, sports equipment, veneer and plywood, furniture, medicinal (Bark is a vermifuge and purgative, fruit is a laxative), and shelterbelts.

### 13. *Pinus roxburghii*

**COMMON NAMES:** Chir pine, Nakhtar.

**DESCRIPTION:** A large tree 21 to 33m tall with an average diameter of 0.6 m. The crown is rounded. The needles are in threes, 20 to 30 cm long. The bole is straight, erect. It is monoecious. The male flowers or cones are many, crowded in head like clusters, 1.3 to 1.8 cm long. The female flowers are erect solitary with 2 to 5 clustered at the end of branches. The cones bloom between January and April. The fruit is the female cone. As it ripens it turns a shiny reddish-brown color. The seed in the cone takes a full year to mature after pollination and 2 years for the reproductive cycle to be completed. There are two, winged seeds beneath each cone scale. Seed is shed September through October.

**DISTRIBUTION:** The tree is native to Pakistan, Bhutan, Nepal, India, and Afghanistan. In Pakistan it is found in the Himalayas specifically in Azad Kashmir, Murree, Ilazara, Swat, Dir, Bajaur, Khyber, Malakand, and Orakzai Agencies. It is easily cultivated in the northern areas of the Punjab and the K.P.K. Large plantations have been raised in Mansehra, Abbottabad and Balakote areas of K.P.K.

**USES:** Construction, fuel, resin, erosion control, sleepers, food (edible seed), various wood products (furniture, match sticks, etc.), tar (roots), and tannin.

### 14. *Syzgium cumini*

**COMMON NAMES:** Jamun, Jaman, Black Plum.

**DESCRIPTION:** A large evergreen tree up to 40 m tall with a diameter of 1 to 2 m. The crown is spreading and dense. The leaves are simple, variable in size and shape, oval to oval-lance like 7 to 15 cm long, dark green, tough and leathery. The bark is smooth and the stem may be crooked. The bark is light to dark gray, with slight depressions. The small white flowers have tassels and a sweet scent. They are arranged in bunches of threes and bloom usually between February and March. The fruit is a smooth, round fleshy berry that is purple black when ripe. The berry contains a single seed. The berries are edible and mature between June and August.

**DISTRIBUTION:** The tree is native to the subcontinent including Pakistan. It has been successfully planted in many areas of the world. In Pakistan it is found in the plains and lower hills of the Punjab, K.P.K, and Azad Kashmir.

**USES:** Construction, fuel, fruit, medicinal (fruit is a carminative, seed for treatment of diabetes), tannin, shelterbelts, apiculture, paper pulp, shade, fodder and roadside planting.

### 15. *Tamarix aphylla*

**COMMON NAMES:** Frash, Ghaz, Khagga, Tamarisk.

**DESCRIPTION:** An erect medium to large sized evergreen tree. It reaches heights of 10 to 18 m with diameters of 1 m, and has a non-spreading crown. The leaves are minute and scale like. The white,

minute flowers are borne in spikes and arranged in panicles. Flowers occur between April and September, while seed matures between December and January.

**DISTRIBUTION:** The tree is native to the Middle East including Pakistan, central Asia, North Africa and Arabia. In Pakistan it is common to the plains of the Punjab, Sind, Baluchistan and K.P.K. extensively planted in the sand dune area of Thal desert.

**USES:** Carpentry, agriculture implements, fuel-wood, shelter belts, charcoal, tannin, erosion control, and sand dune stabilization.

#### **16. Terminalia arjuna**

**COMMON NAMES:** Arjun.

**DESCRIPTION:** A large evergreen tree 21 to 30 m tall with a diameter of 1 to 2.5 m. It has an open, spreading crown with drooping branches. The leaves are simple with smooth margins, and are oblong or elliptic 10 to 15 cm long. The trunk is buttressed with pronounced ridges. The bark is thick, pinkish green to gray and peels off in large thin sheets. The flowers are yellowish white and occur in bunches 3 to 6 cm long between April and May. The fruit is a wood capsule 2.5 to 5 cm long. The cones mature in May and June.

**DISTRIBUTION:** The tree is native to the subcontinent. In Pakistan it has been planted throughout the plains, in gardens and as a roadside tree.

**USES:** Fuel, implements, erosion control, wheels, spokes and axles, fodder, medicinal (bark is a astringent and cardiac stimulant), timber and ornamental.

#### **17. Zizyphus mauritiana**

**COMMON NAMES:** Ber, Chinese date.

**DESCRIPTION:** A spiny deciduous or evergreen shrub or small tree 12 m tall with a diameter of 40 cm. The crown is spreading with drooping branches. The leaves are simple elliptical to rounded 2.5 to 6 cm long and 1.5 to 5 cm wide. The leaf tips are slightly rounded with finely wavy-tooth margins. The leaves are shiny green and hairless on the tops with dense whitish hairs underneath. Spines are curved, brownish, and 3 to 6 mm long. On harsh site-it is a dense shrub 3 to 4 m tall. The bole is straight and the bark is light to dark gray with many deep furrows. The flowers are small 5 mm across in clusters and are quite fragrant, yellow, and densely hairy and bloom between April and October. The fruit is shiny orange-red or reddish-brown and edible, 2 to 2.5 cm long. The seed matures from December through March.

**DISTRIBUTION:** The tree is native to South Asia including Pakistan. It has been successfully cultivated in many parts of the world. It can be seen throughout Pakistan but it grows best at lower elevations in the Punjab, K.P.K, Sind and Baluchistan.

**USES:** Fuel, charcoal, agricultural implements and fruit.

### **Topic # 7. Introduction to various Agro Forestry Systems.**

Forest can play a vital role in improving Pakistan's economy being protective layers for watershed areas, maintaining a sustained supply of wood, wood-based and non wood forest products, conserving and improving soil fertility, erosion control, improving food, fodder and fuelwood production. As the forest area of Pakistan is very low from the standard figure i.e., only 2.5%, there is a dire need for introducing such systems and practices which can increase the forest area meeting the nation's requirements. For this, agroforestry is a better option that cannot only increase forest area but by adopting this system, marginal lands can also be brought under cultivation by incorporating salinity and drought resistant

trees into land use system which can bridge the gap between demand and supply of food and fodder for livestock. This chapter describes in detail the important issues, challenges and solutions associated with agroforestry in the light of various examples, case studies and theories.

### **Introduction and History of Agroforestry**

Trees have an important role to play on earth by fulfilling the basic necessities of all living organisms from micro organisms to animals. The world's population is assumed to reach at 10 billion by the middle of 21st century (UN 1995) if it continues to grow at the present rate. This upcoming challenge reveals a great demand of food, fiber and shelter to cover social, medical and economical demands of human beings. Trees are also essential for the survival of about 200 million people worldwide by providing wood and income (Ansari and Iftikhar 1985).

There is no doubt that agroforestry has been practiced since millennia as an arrangement of traditional land-use systems and practices but in late 1970s, it was evolved as a modern and improved land-use system. It has been a customary practice to grow trees and crops in a combination for getting maximum benefits and intermediate income. Not only in Asia, but it has been practiced in European countries like Finland and Germany as well. Beside this, farmers of tropics and Central America have been regularly involved in growing different tropical trees on their farmlands aiming at obtaining timber benefits, shelter tree crop and windbreaks (Nair 1993). Such examples can also be found in Asia i.e., the farmers practiced agroforestry in Philippine by clearing the forest area for agricultural crop production but leaving a few selected trees to provide a partial canopy or shelter to new crop (Nair 1993). These examples indicate that trees are integral part of cropping system to support agriculture. The change of cropping pattern or the inclusion of tree species into traditional farming system started in 1806 from Burma which was under British Empire at that time. U Pan Hle, a Karen in the Tonze forests of Thararrawaddy Division in Burma, established a plantation of teak through the use of "taungya" (hill cultivation) method and presented it to Sir Dietrich Brandis (Blanford 1958). This system was further spread to other parts of Burma and later it reached South Africa in early times of 1887, India in 1890 and Bengal in 1896 (Raghavan 1960). This is important to mention that teak is not the only species that can be used in agroforestry system, other tree species of multiple benefits can also be used for this purpose. Like the traditional land-use disciplines of agriculture and forestry, agroforestry covers biological, physical and social science disciplines. (Mercer and Miller 1998). Understandably, the biophysical sciences have dominated the first two decades of agroforestry research and development because the interest in agroforestry as a land use emerged from observations of the impacts of non sustainable farming systems on tropical soils and forests (Nair 1996). Concerns over the inadequacy of socioeconomic research in agroforestry began to grow, however, as improved agroforestry systems were transferred from research institutions to rural development projects. As mentioned above, during the 1980s agroforestry became an established focus of international rural development efforts.

For example, in 1988 and 1989 ICRAF identified 166 agroforestry projects supported by developmental organizations and government agencies (Miiller and Scherr 1990), and by the early 1990s the US Agency for International Development alone supported 28 agroforestry and technological advances, agroforestry rural development efforts were frequently unsuccessful (Nair 1996).

More than a decade of discussions on how to protect the world's forests has resulted in substantial changes in the way forests are managed. Policies and programs help to promote sustainable forest management. Forest plantations comprise about 5% of the world's forests. Asia has the largest area of plantations, accounting for 62% of the world's total. China accounts for 24% of that total and India, 18% (FAO 2000). The area of forest plantations was increased by an average of 3 million hectares per year during the 1990s. Half of this increase was the result of afforestation on land previously under non-forest land use, whereas the other half resulted from conversion of natural forest. In Pakistan, at present about 90% fuel wood and 60% timber comes from farmlands. Thus, agroforestry is playing a vital role in fulfilling our wood requirements. It is estimated that 10% area of our farmlands can be easily

brought under tree cover without harming agricultural crops. At present the tree cover on farmlands is only 2%. There are about 300 million trees on farmlands throughout the country with a standing volume of 70 million m<sup>3</sup> (Quraishi 1998).

The significance of wood produced on farmlands has increased sharply during the last two decades. According to FSMP (Forestry Sector Master Plan) the annual growth of forests and trees was 14.4 million m<sup>3</sup> of which 7.7 million m<sup>3</sup> (53%) was put on by the farmland trees. The farmlands of the Punjab have about 200 million trees of which 95% are in irrigated areas. These trees are mainly comprised of *Dalbergia sissoo* (42%), *Acacia modesta* (20%), *Acacia nilotica* (11%), *Melia azedarach* (7%), and Mango (6%). Ber (31%), *Acacia modesta* (20%), *Acacia nilotica* (19%) and *Dalbergia sissoo* (7%) are the predominant species in rainfed areas (Quraishi, 1998). The farmers have long recognized the value of planting trees on fields for sheltering crops, generating wood for self-consumption and commercial sale. Scattered trees have less competition with agricultural crops and they yield tangible benefits at very little cost and efforts.

Figure 9.1 manifested that agroforestry is adopted for various purposes. This figure provides a detailed overview of agriculture-forestry interface based on the socioeconomic need of the community. An agroforestry system possesses three main qualities to obtain maximum benefits i.e., productivity (farm income can be increased by enhanced tree products' output, improvement in crop yield, and optimizing labour efficiency), sustainability (improvement in soil fertility, reclamation of problem soils) and adoptability (introduction of new and improved technologies in agroforestry systems).

#### **Topic # 8. Tree as crop,**

Agroforestry practices mainly consisting of trees and crops growing together are known as agrosilvicultural practices. It includes 'taungya'. In Taungya, the farmers grow their agricultural crops with young trees either on borders or in between. It's a common practice in West Africa and savannas as discussed earlier. In these areas, the farmers retain the native trees present on their farmlands and cultivate their crops amongst those trees with the addition of modern technology as hedgerow intercropping cropping or alley cropping. In such system, fast growing and nitrogen fixing tree species are preferred to retain or grow between crop lines which are periodically pruned, thinned and harvested to provide nutrient-rich mulch as fertilizer to the crop. In sloping areas, tree species are planted on contour especially to control soil erosion, improve water infiltration and reduce run-off effects. In this system, following practices have been used in various parts of the world. Some important practices in this system are elaborated here.

- Improved Fallow: In this practice, fast growing, leguminous trees are grown during a fallow period.
- Taungya: During early stages of plantation, agricultural crops are cultivated among young trees. In this practice, fast growing leguminous trees are used.
- Alley cropping: Fast growing, leguminous or fodder trees are grown between crops or as hedges.
- Multipurpose trees (MPTs) on agriculture land: MPTs Trees which can benefit in terms of timber, fuelwood, fruit and fodder are planted on bunds or terraces.
- Shelterbelts, windbreaks and live fences: tall growing trees are grown along / around agriculture land.

#### **Topic # 8. Social Forestry, Why Social Forestry?**

According to Sheikh (1997) Pakistan is virtually facing a wood famine. Prices of construction timber and fuel wood have increased during the last few years. According to national statistics, (Govt. of Pakistan 2006-07) the country ranks the 7th most populous country with a population of more than 155 million. Their current annual demand of wood will increase at the same rate, if not faster due to an increased standard of living. One possibility to bridge this gap between supply and demand could be to put more area under both the state and as well as the local forests. Currently, it seems rather difficult because of

the paramount claim of agriculture on land and water and also the attendant financial constraints. Another possibility could be to intensify the forest management practices for better yields per unit area but that would also require heavy inputs.

#### **The Scope of Social Forestry in Pakistan**

Approximately 75% of the total geographical area of the country, comprising mountains, watersheds, land and deserts is uncultivated (Hafeez 1998). This area is either underutilized or not in use. Most of it is uncultivable due to steep slopes, waterlogged soils, salinity or the absence of adequate irrigation facilities. This huge land resource has never been put to appropriate use. It is next to impossible to divert any area, water or other resources from crop husbandry to make up the deficiency of forests and trees. In the situation, these wastelands can best be utilized for wood production. Incidentally, the wood production activity will improve the ability of the country's watersheds to produce a sustained supply of water for hydropower production and agriculture. The wastelands include mountainous areas, deserts, plains without irrigation, ravine tracts, "uncommanded" areas in the irrigated plains, saline, sodic and waterlogged lands, all of which have a great potential for raising trees of suitable species for fuel, fodder, fiber, food etc (Khan 2001).

Potential of Social Forestry on Wastelands and Degraded Areas In Pakistan there are large wastelands and degraded areas that for several reasons are not being effectively utilized under agriculture. However, these lands can be gainfully utilized for wood production. Once the area is reclaimed, it ultimately starts improving the soil conditions. Table 1 identifies the most suitable areas for social forestry, including communal lands.

#### **The Most Suitable Areas for Social Forestry in Pakistan**

- 1. *Guzara* forests** Ownership is vested in local people, either as individual property or joint property. *Guzara* literally means "subsistence" and are private forests held either individually (by families), or jointly (by communities).
- 2. Communal forests** It is a sub-category of the *Guzara* forest, where entire village owns the forest. The proper management of such lands through participatory and Joint Forest Management techniques can help enhancing wood supplies for future needs.
- 3. *Shamlats*** It is a very common term used for a piece of lands owned by the state but managed and used by all the villagers for the collective purposes of the community. The village common lands (*shamlats*) are deteriorating due to lack of proper management.
- 4. Village pastures** If these lands are managed on proper scientific lines they can contribute to wood production.
- 5. Public waste lands** These lands are often lying without vegetation and can be used for energy plantations along with crops.
- 6. Linear plantations** All linear plantations present large areas often suitable for plantation of trees for wood fuel production.
- 7. Farm forest areas** These are linear or compact plantings of trees on private farm lands, owned individually or jointly by locals and are not subject to forest department authority.
- 8. Canal side land strips -**
- 9. Roadside land strips; Railside land strips**
- 10. *Auqaf* lands** Large *auqaf* (government) lands are available for growing of trees for wood fuel production.

#### **Topic # 9. Introduction to Range and Wildlife Sciences.**

##### **Range Management**

The present conditions of the rangelands are the result of a protracted evolution of plants and animals, which has also been influenced by human activities for thousands of years. Unfortunately the impact of



humans and their livestock became excessive and negative in the second half of the twentieth century. The removal of vegetation for wood and overgrazing are the main causes of the deterioration. Certain improvements have actually been made in some of the rangelands, but these do not make up for the serious conditions that have developed in more extensive areas. Over 26% of Earth's land is now pasture or grazing land. This area increases to over 70% when only agricultural land is considered. These percentages are predominantly composed of rangelands, plus pastures and other types of grazing land. The area occupied by grazing land is in dynamic equilibrium with that of agricultural land and forests. Approximately 220 million hectares of forest became pasture in the thirty years between 1970 and 2000; this area, added to that of the previously existing rangeland, has brought the level of grazing land up to the present 3423 billion ha. Most of the new pastures emerged from the native forests of Africa, Asia, and America, and only a small part from the noncultivation of unproductive land. The abandonment of cropland has favored the new diffusion of pastures and rangelands, in some parts of Europe as a result of economic diversification, and in parts of Africa after population dispersal caused by both AIDS and war. In the same period, grazing lands have been lost as a result of acidification or salinization in Australia, and in Africa through desertification. On the other hand, the number of livestock has increased by 600 million heads (equivalent to ~250 million livestock units (LU)) over the last thirty years of the twentieth century; the total number is at present ~3,300 million heads, half of which graze in the rangelands. This number is too high when compared to the area of pasture, thus ~30% of the total world production of cereals and pulses is necessarily used to feed some of these animals. Some of the livestock are housed in stables, but nevertheless the rangelands sustain most of the domestic livestock and are also home to the largest number of wild grazers and browsers. Excessive exploitation, due both to direct human intervention and to the unduly high number of animals, has frequently resulted in moderate to severe degradation in the quality and productivity of this ecosystem. Traditionally, the principal parameter taken into consideration when estimating the value of a rangeland was its production of forage; however, its vegetation also contributes in other ways to the economy of the local population. Animal products and by-products, firewood and timber, medicinal plants, wild fruits and honey—these are all part of rangeland-based economies. Moreover some new industries have already identified the economic importance of native forage: small legumes produce estrogens for the pharmaceutical industry, while other species can absorb the heavy and toxic metals produced by industrial activities and mining; genes are being collected to improve certain characteristics of the crops. This biodiversity will presumably be valorized in the future. Rangelands also play a significant role in ecological stability on a global scale, and their importance also comprises landscape diversity over large territories. Biodiversity, landscape diversity, and economic differentiation interact and will influence future changes in the pastoral economies.

### **Principles of Range Management and Range livestock Production.**

1. Objective
2. Selection of site
3. Local people
4. Site Development
5. Site Management
6. Range Vegetation Management
7. Range Vegetation Improvement
8. Range Livestock Management
9. Range Livestock Improvement
10. Sale of Range Products

## PRACTICALS

Identification and description of Farm trees.

1. Aam/Mango	<i>Mangifera indica</i>
2. Amaltas	<i>Cassia fistula</i>
3. Arjun	<i>Terminalia arjuna</i>
4. Bakain	<i>Melia azedarach</i>
5. Ber/Beri	<i>Ziziphus jujuba</i>
6. Neem	<i>Azadirachta indica</i>
7. Shisham/Tali	<i>Dalbergia sissoo</i>
8. Kikar	<i>Acacia nilotica</i>
9. Date Palm/Khajoor	<i>Phoenix dactylifera</i>
10. Sufeda	<i>Eucalyptus camaldulensis</i>
11. Sufeda	<i>Eucalyptus citirotora</i>
12. Sohanjna	<i>Moringa oleifera</i>
13. Tut/Mulberry	<i>Morus alba</i>
14. Pipal	<i>Ficus religiosa</i>
15. Frash	<i>Tamarix aphylla</i>
16. Jaman	<i>Syzygium cumini</i>
17. Botal Brush	<i>Callistemon viminalis</i>
18. White Siris	<i>Albizzia procera</i>
19. Black Siris	<i>Albizzia lebbek</i>
20. Kachnar	<i>Bauhinia purpurea</i>
21. Simal	<i>Bombax cieba</i>
22. Galb	<i>Diospyrus caryoprusterus</i>
23. Rubber Plant	<i>Ficus elastica</i>
24. Jand	<i>Prosopis cineraria</i>
25. Sukh Chain	<i>Pongamia clabera</i>
26. Bohar	<i>Ficus bengalensis</i>
27. Neelum	<i>Jacaranda memosipholia</i>
28. Biri patta	<i>Heterophragma adenophyllum</i>
29. Cheel/Chir	<i>Pinus roxburgii</i>
30. Layee/frash/ghaz	<i>Tamarix aphylla</i>

**Nursery raising Techniques. Seed Collection. Storage, Treatment, Land preparation, Sowing, Trampling and after care.**

Natural regeneration is a very slow process and can be assisted and/or promoted through artificial regeneration. Nursery plays a key role in the success of afforestation and artificial regeneration of forests. Healthy seedlings of nursery can only lead to dense forest with desired features. Objectives of nursery raising can be either the introduction of exotic species or promotion of threatened native species in an area. For some tree species, nursery raising is essential due to their slow growth and severe competition. Afforestation of problematic and marginal lands is impossible without nursery raised seedlings. There are several types of nurseries depending upon type of planting material, size and irrigation. Before establishing a nursery, suitable type should be selected depending upon our objectives. Suitable site selection with ample supply of water is a determinant factor in the successful

establishment of nursery. Care should be provided to nursery plants to protect them from diseases and pests.

### **Introduction**

Nursery is a place where seedlings, cuttings and grafts are raised with care before transplanting (BCFT 1953). It comprises of nursery beds, paths irrigated channels etc. To make afforestation/reforestation successful a well stocked and managed nursery is a prerequisite. Besides all the other biotic and abiotic factors the principle failures reasons can be traced back through these poorly managed nurseries. Ultimately, the planting material produced in these nurseries is not up to the mark and due this reason although millions of plants are planted of the whole, the percentage of survival and success is not satisfactory (Sheikh 2003). Therefore, it is of great importance that maximum attention must be paid to raise nurseries on scientific basis.

### **Objectives of Nursery**

Establishment of forest has got an important place in artificial regeneration (Chaudhry 1994). Following are important objectives for which a forest nursery is generally made:

- 1) Some important species do not produce seed every year. So, the plantations of these species can be raised only by sowing all available seeds in the nursery to prepare seedlings to be planted out each year.
- 2) Some species have slow growth rate and if the seeds of these species are sown directly/naturally, the seedlings are most likely to be suppressed by weeds and ultimately killed. Therefore, slow growing species are generally raised in nursery and ultimately after attaining desirable plant height, planted elsewhere.
- 3) Success of linear plantations heavily depends on planting healthy, tall and sturdy plants which can be obtained only from nursery.
- 4) For some species, raising tree plantations by direct sowing are not so successful when raised by transplanting their seedlings. In such cases, nursery is an essential part of artificial regeneration.
- 5) To introduce exotic species raising nursery is the best option
- 6) Planting of nursery grown plants is the best method of artificial regeneration on problematic sites.
- 7) Failure of plantations have to be replaced either for the year of planting or during the next year. Sowing done in the patches/gaps is liable to be unsuccessful because of suppression from weeds and cannot catch up the growth as from, original sowing. Therefore, replacement of casualties is always done by planting nursery grown plants or stumps.

### **Types of Forest Nursery**

The nurseries may be of several types (Figure 5.1). Some important types of nurseries found in Pakistan are as under:

#### **Based on Use (Time Span)**

On the basis of use or time span, nurseries can be further divided into:

- Temporary Nursery
- Permanent Nursery

#### *Temporary Nursery*

These are the nurseries which are raised to supply planting stock for a shorter period of time, normally near to the area to be regenerated. These nurseries don't have the permanent infrastructure.

Salient Features:

- \_ These nurseries are established near to the regeneration areas
- \_ These are maintained for only a shorter period of time
- \_ These are normally smaller in size and extent
- \_ Generally maintained for only few species
- \_ No permanent infra structure is developed
- \_ Less capital is required for these nurseries.

#### *Temporary Nursery*

## Permanent Nursery

### *Permanent Nursery*

These are the nurseries which are established to supply planting stock for a longer period of time with development of permanent infrastructure.

#### Salient Features

- \_ These nurseries are established/run for a considerable period of time
- \_ These are normally large in size and extent
- \_ Maintained for a large number of tree species
- \_ Permanent infra structure is developed

Large no of Labor is Engaged for a Longer Period of Time, etc. based on Nature of Use

#### **On the basis of nature of beds, nurseries can be further divided into:**

- Seedling Nursery
- Transplant Nursery

### *Seedling Nursery*

It is the nursery in which seedlings are raised and hence no transplanting is done (Figure 5.2).

\_ In these seedlings are raised directly at final destination and hence there is no need to transplant them elsewhere.

- \_ Time and cost effective nurseries.
- \_ Normally raised by consumers themselves

### *Transplant Nursery*

It is the nursery in which seedlings are transplanted in preparation for afforestation of an area. Sometimes these are also called pricking out beds.

#### Seedling Nursery

#### Transplant Nursery

#### **Nurseries division on the base of use.**

- \_ In these nurseries seedlings are raised purely to be transplanted elsewhere.
- \_ Seedlings can be raised in pots or in beds

These can be permanent or temporary in nature

#### **Based on Irrigation**

On the basis of irrigation (Figure 5.3), nurseries can be further divided into:

- Dry Nursery
- Wet Nursery

### *Dry Nursery*

It is the nursery which is managed without any artificial means of irrigation water.

#### Salient Features

- \_ These are established in rain fed areas.
- \_ No proper lay out is carried out for irrigation.
- \_ These are normally temporary in nature

### *Wet Nursery*

It is the nursery which is managed by the artificial means of irrigation water during dry spells.

- \_ These nurseries can be established in any suitable area with proper availability of irrigation water.
- \_ Proper irrigation plan is laid out with the development of permanent infrastructure in these nurseries.
- \_ These are the nurseries found normally throughout the world.
- \_ These are permanent in nature but can be temporary.

#### **Based on Type of Planting Material**

On the basis of planting material (Figure 5.4) nurseries can be further divided into:

- Bed Nursery
- Potted/Polythene bag Nursery

- Bed Nursery

There are two types of bed nursery which are:

- Raised bed nursery

This type of nursery is established when large numbers of plants are required (about ten thousand).

- Trench-berm nursery

This type of nursery is established in irrigated plantations for providing planting stock in Government forests and to provide people and raised on any number of acres. e.g Shisham, Siris etc.

- Potted/Polythene bag Nursery

In this type of nursery, the planting material is raised in pots or in polythene bags of various sizes. e.g., Kikar, Eucalyptus

Before taking up the task of a nursery establishment some important considerations must be taken into account. Following are the few important points:

Bed Nursery

P-Bag Nursery

### **Establishment of Forest Nursery**

Prior Considerations

Before taking up the task of a nursery establishment some important considerations must be considered. Following are the few important points:

#### ***Estimates of Nursery operations and Cost***

- Cost of site clearance
- Demarcation of the nursery area
- After demarcation fencing of the nursery area and leveling
- Basic tools/implements required to carry out various operations
- Preparation of soil mixture
- Collection of seed
- Raising of nursery
- Sowing and planting operations
- Use of the latest technology available

#### ***Basic Requirements***

To execute various nursery operations as mentioned above following basic requirements must be given due consideration:

- It is always recommended to have the exact estimates, availability of labor and expenditure to be incurred to carry out various nursery operations right from the start to the sale of product for the successful nursery business
- It is recommended to have exact idea of basic planting material production in terms of its compatibility and number according to the selected site

There are numerous factors which are to be considered while establishing the forest nursery (Duryea and Landis 1984). Some of the important factors are as under:

1) *Site selection*: Selection of suitable site is a basic requirement for establishing the good nursery. Site should easily accessible for carriage of planting material and irrigation supply should be available as well. Moreover, the area of nursery depends upon:

- Species to be grown
- Quantity of stock
- Availability of labor

2) *Fencing the Nursery*: This practice normally depends upon the type of nursery. For example, cattle and game proof fences along with live fences are used in permanent nurseries. This is one of the most important practice to protect nursery plant from biological pests.

3) *Layout of Nursery*: This is one of the most important steps as far as forest nursery establishment is concerned. For this following key points are taken into account:

- Provision of Irrigation water
- Paths are to be carved
- Provision of a store

4) *Preparation of Beds*: Following operations are done for the preparation of beds:

- Proper size of the beds must be decided according to the area available.
- Type of beds must be decided, depending upon the conditions of the site/area, species to be grown and type of the nursery.
- Preparation of soil in terms of digging up to proper depth, removal of pebbles/stones, roots and other wastes etc.

5) *Miscellaneous Operations*: Other operations include:

- Collected seeds must be healthy and sufficient to raise the required amount of planting stock.
- Timely sowing of seeds in nursery beds/pots.
- Protective measures must be taken at proper time (including weeding, hoeing, pricking, root pruning, shifting, shading, use of pesticides against biological pest and hardening of planting stock before transplanting etc.)
- Proper irrigation at proper time
- Maintaining the fertility of nursery soils

### **Important Nursery Diseases and their Control**

#### **Damping Off**

This disease is caused by soil-inhabiting fungi that are facultative parasites. Most of them cause damage in pines seedling belongs to genera *Pythium*, *Rhizoctonia* and *Fusarium*. Sowing in summer with abundant soil moisture and alkaline in nature helps to favor this disease.

*Symptoms*: Damping off is characterized by early decay and death of seedlings with soft and succulent stem. Hyphae of the fungus spread through the soil and penetrate the tender epidermis of the succulent tissues of the plant stem (Figure 5.5). There are two types of this disease i.e. pre-emergence damping off and post emergence damping off. In pre emergence damping off, the seeds are decayed or killed by the damping off organisms before the emergence from soil. With the post emergence, the seedlings are attacked after they have appeared above ground/germination. The fungi spread rapidly in the tissue, especially, in the roots and the seedlings either wilt completely or suddenly fall over before wilting. A bed of seedlings may be completely wiped out within few days. Pre-emergence Damping off Post-emergence Damping off

*Prevention and Control*: Avoid heavy or excessive watering and keep seed beds well ventilated. The fungi caused damping off reproduce and spread fast under humid conditions.

- Thinning of heavy plants should be made
- Plants should not be under complete shadow.
- Proper weeding of the nursery is essential.
- Proper drainage
- Avoid excessive use of nitrogen fertilizer
- Use of Bordeaux mixtures

#### **Rodents and their Control**

Major rodents have been presented in the Figure 5.6 and describe below:

1) **Porcupine**: Porcupine causes serious damage to nursery and regeneration areas at night and lives in earthen holes (burrows). It damages almost all types of nurseries. Roots and bark of trees are the favorite food of this pest. Fumigation of burrows is normally done with Aluminum Phosphide or Fostoxin tablets at the rate of 5 tablets/burrow and it is plugged with grasses/thorny bushes and soil etc.

**2) Field rats:** These also cause damage to nursery and young plants. Nine types of field rats are found in Pakistan. These make serious damage to the roots of plants due to this plants health is affected and the chances of termite attack are increased to many folds as well. Field rats are controlled by using the fumigation of burrows with Aluminum Phosphide tablets at the rate of 1 tablet/hole and then plugging this with soil and grasses etc. These pests are also controlled by baiting of various rodenticides. For more effective results, the tablets must be rolled in piece of cloth, then dip in water before putting it into the burrow.

**3) Termite:** Termite normally attack on young plants but this also can damage the seedling in the nursery as well. Chloropyrifos is commonly used at the ratio of one liter/acre, through flood irrigation by mixing this pesticide in water, drop by drop at the inlet of water.

**4) Defoliator:** Defoliators usually attack nursery seedlings as well as regeneration areas and causes serious damage to the plants. Organophosphate spray is normally used to control this pest. The doze of 0.5 liter/acre with the ratio of 1:160 is used in water as spray.