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ALLAMA IQBAL OPEN UNIVERSITY, ISLAMABAD

(Department of Agricultural Sciences)

Course: Agroforestry (2510)

Level: M.Sc. Forestry Extension

Semester: Autumn 2026

Assignment No. 2

Total Marks: 100 • Pass Marks: 40 • All questions carry equal marks (20 each).

SOLVED ASSIGNMENT GUIDE — For Study & Reference

Note: This guide is prepared for study and reference purposes only. Students are advised to read the relevant units of the course book, understand the concepts, and then write the assignment in their own words. Do not copy this guide word for word.

Question 1: Establishing an Agroforestry System and Pruning Techniques in Tree Management (20 Marks)

Q.1 What basic points need to be considered before the establishment of an agroforestry system? Discuss various types/techniques of pruning involved in tree management. (20)

Introduction

Most agroforestry failures are decided before a single seedling is planted. A system planted on the wrong site, with the wrong species, for a farmer whose needs, labour and tenure were never examined, will disappoint however well it is afterwards tended — and because trees

occupy land for years, the mistake is long-lived and expensive. Establishment therefore begins with careful consideration of basic points: the objectives of the farmer, the site and its climate, soil and water, the choice and arrangement of components, the availability of planting material, labour, capital and protection, and the markets and rights that will govern the harvest. Once established, the system must be managed, and among management operations none is more characteristic of agroforestry than pruning — the deliberate removal of branches or roots to control tree-crop interaction, shape the tree and obtain useful products. This answer treats the two parts in turn: first the points to settle before establishment, then the main types and techniques of pruning and the principles that make pruning succeed.

Part A — Points to Consider Before Establishment: Objectives and Diagnosis

The first point is to define the objectives clearly with the farmer, not for the farmer. Is the main need fodder for the lean season, fuelwood for the house, timber as long-term savings, fruit for sale, shelter for crops, soil improvement, or a ranked combination of these? Objectives decide everything downstream — species, spacing, rotation length and management — and a system designed for early fodder will differ completely from one designed for quality timber. Closely connected is diagnosis of the farming system as it already exists: its crops, livestock, labour calendar, cash flow, existing trees and the farmer's own knowledge and preferences. The diagnostic approach used in agroforestry development insists that the new system must fit into the farm's real life — filling a genuine gap, using slack labour rather than competing with peak operations, and building on practices the farmer already trusts — instead of arriving as an alien package. A short, honest diagnosis at this stage prevents the commonest failure of all: a technically sound system that nobody actually wants.

Site, Climate, Soil and Water

The second group of points concerns the site itself. Climate — total rainfall and its distribution, length of dry season, temperature extremes, frost, heat and prevailing wind — determines which species can survive and how strong tree-crop competition for water will be. Soil must be examined for depth, texture, drainage, fertility, pH and salinity: a species that flourishes on deep, well-drained loam may fail outright on shallow, saline or waterlogged soil. Water availability needs particular honesty in Pakistan's conditions: is irrigation assured, and how often; is the groundwater fresh or brackish; will the trees depend on rainfall alone? Slope, aspect and erosion risk decide layout, because planting on slopes normally requires contour arrangement and soil-conservation measures. Existing vegetation and problems — salinity patches, wind exposure, grazing pressure — should be mapped. The rule is simple and unforgiving: match the system to the site as it is, not as the planter wishes it to be, because trees cannot be moved once the mismatch appears.

Choice of Species and Design of the System

Third comes the choice of components and their design. Species should be selected for site adaptation first, then for the objectives: growth rate, multipurpose value, fodder quality, timber quality, nitrogen-fixing ability, crown shape and root habit, compatibility with crops, and freedom from serious pests, diseases and allelopathic effects. Proven local species and planting material of known origin are safer than untested exotics. Design then arranges the chosen components: boundary, scattered, strip, alley, block or home-garden layout; spacing and orientation, including east-west tree lines where shade on crops must be minimised; tree

density, which in crop combinations must stay low enough that total production of the combined system exceeds that of the crop alone; and the sequence in time, including what happens as trees mature and after final harvest. The design should be drawn and discussed on the farm itself, and it should start modestly — a farmer can extend a successful small planting, but cannot easily undo a large failed one.

Planting Material, Labour, Capital, Protection and Rights

Fourth, the practical inputs must be secured before planting, not hoped for after it. Quality seedlings of the right species, in the right quantity, ready in the planting season, are decisive: poor, root-bound or wrongly identified nursery stock handicaps the system for life, so nursery arrangements, seed sources and transport need planning months ahead. Labour and capital must be costed honestly — pit digging, planting, watering, weeding, protection and pruning all demand work or cash at particular times, and the plan must state who provides them. Protection is critical in the establishment years: young trees in open farmland face free-grazing livestock, theft, fire and termites, and fencing, tree guards, community grazing agreements or thorn barriers must be arranged before planting day. Finally, rights must be clear: who owns the land, who owns the trees, who may prune and harvest, and what permissions, if any, govern felling and transport of timber? Insecure tenure and ambiguous tree rights are among the strongest known discouragers of planting, especially for tenants, and they must be resolved in advance.

Markets, Knowledge and a Plan for Management

Fifth, look beyond establishment to the life of the system. Market enquiry — who buys this timber, fruit or fodder, at what price, in what form, and how far away — prevents the bitter discovery at harvest that the product cannot be sold profitably. The farmer's knowledge and the extension support available must be assessed: unfamiliar techniques such as pruning regimes or alley management need demonstration and follow-up visits, not a single leaflet. A simple written management plan should record objectives, layout, species, operations by year, expected intermediate yields from prunings and thinnings, and the harvest and replanting intention. Where possible, a small trial or a visit to a successful neighbouring system lets the farmer judge with his own eyes. Establishment done with this preparation — objectives diagnosed, site matched, species and design chosen, inputs and protection secured, rights and markets checked — gives the young system its best possible start.

Part B — Pruning: Meaning and Purposes

Pruning is the selective removal of branches, shoots or roots of a tree, carried out for a defined purpose and in a planned manner. In agroforestry its purposes are distinctive. It controls interaction: reducing crown size lets light reach the crop, and cutting roots limits below-ground competition, so pruning is the main tool by which the tree component is kept compatible with crops year after year. It shapes the tree, producing a straight, clear timber stem, a manageable fodder crown or a safe, balanced fruit tree. It yields products — fodder, fuelwood, mulch and green manure — from material that would otherwise be waste, so alley-cropping shrubs are pruned as a harvest operation. It also improves tree health and safety by removing dead,

diseased, crossing and dangerous branches, stimulates new growth of the desired kind, as in pollarded fodder trees, and regulates fruiting. Pruning is therefore not tidying; it is applied management of the tree's form, growth and relationship with its neighbours.

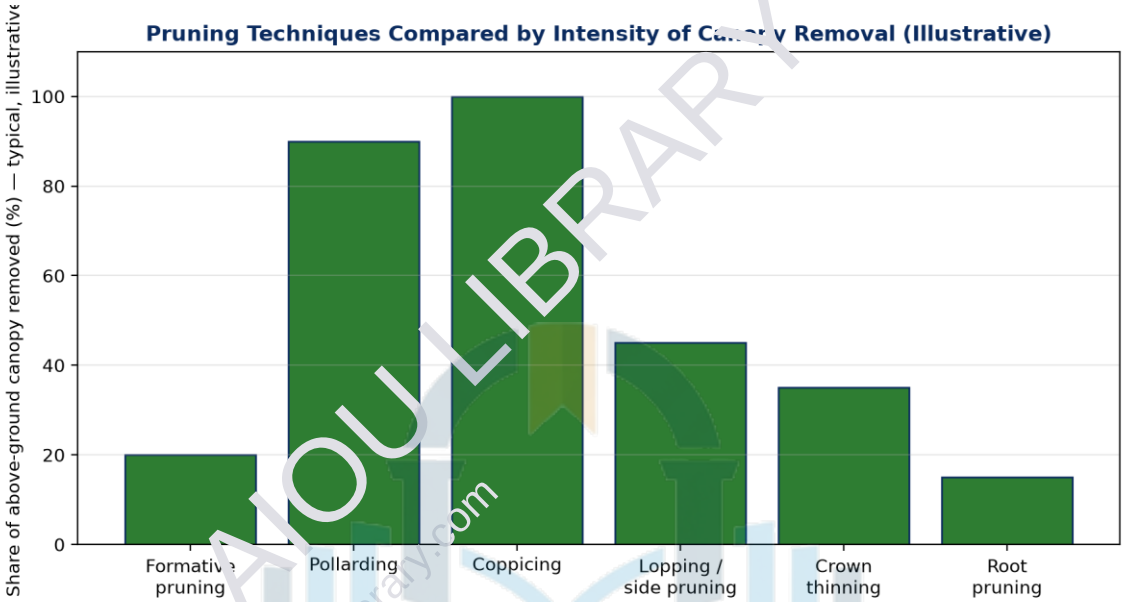

Figure 1: Pruning techniques compared by the typical share of canopy removed — from light formative pruning to complete coppicing (illustrative).

Types and Techniques of Pruning — Crown and Stem Forms

Formative or training pruning is done in the first years to build the tree's framework: removing forks, competing leaders and badly placed branches so that a timber tree develops a single straight stem and a fodder or fruit tree develops a strong, well-spaced crown. Side pruning (also called singling or lateral pruning in farm practice) removes lower or side branches along the stem, raising the crown, producing knot-free timber below and, crucially in agroforestry, lifting shade off the crop and letting light under the canopy. Crown lifting, crown thinning, crown reduction and crown raising describe related operations by their result: thinning removes

selected branches throughout the crown to admit light and air without changing its size; reduction shortens the crown's extent; raising removes the lowest branches. Lopping is the rough cutting of branches, common in traditional fodder collection; done indiscriminately it damages trees, and good practice converts it into planned pruning with clean cuts at proper points. Each technique answers a different need, and the manager chooses by objective: timber quality, fodder yield, shade control or safety.

Pollarding, Coppicing and Root Pruning

Three more specialised techniques are especially important in agroforestry. Pollarding is the repeated cutting of a tree's crown at a fixed height, traditionally above the reach of browsing animals, so that a head of new shoots forms and is harvested in cycles for fodder and fuel; it keeps the tree permanently accessible, controls its shade, and can continue for decades in suitable species such as mulberry and many fodder trees. Coppicing is cutting the stem near ground level and allowing the stump to regenerate from dormant buds, producing multiple shoots harvested in short rotations for poles and fuel; it suits species with strong coppicing ability and converts pruning into a complete harvesting system. Root pruning is the cutting of tree roots along a line between tree and crop — often combined with trenching — to sever shallow lateral roots that compete with the crop for water and nutrients while leaving deep roots to sustain the tree; it is widely used with boundary trees and in alley systems and must be repeated as roots regrow. Together with crown work, root pruning shows that pruning in agroforestry manages the whole tree, above and below ground, as one interaction with the crop.

Table 1: Main pruning types and techniques in agroforestry tree management

Technique	What Is Done	Main Purpose / Use
Formative pruning	Remove forks, competing leaders and bad branches in young trees	Build a strong, well-shaped tree from the start
Side / lateral pruning	Remove lower side branches along the stem	Clear timber stem; lift shade off crops
Crown thinning	Remove selected branches throughout the crown	Admit light and air; reduce shade without reducing crown size much
Lopping (planned)	Cut branches for fodder or fuel at planned points	Harvest fodder/fuel while protecting tree health
Pollarding	Cut crown repeatedly at a fixed height above browsing reach	Regular fodder/fuel harvests; permanent shade control
Coppicing	Cut stem near ground; regenerate from stump	Short-rotation poles and fuelwood
Root pruning	Sever shallow lateral roots along a trench line	Reduce root competition with crops

Principles of Good Pruning Practice

Whatever the technique, sound pruning follows common principles. Cut at the right place — just outside the branch collar, without leaving stubs that rot or cutting flush so that the trunk's protective tissue is torn. Use sharp, suitable tools and clean cuts, and disinfect tools where disease is a risk. Respect proportion: removing too much live crown at once weakens the tree and provokes dense, weak regrowth, so heavy work is staged and the share removed is kept moderate except in coppicing and pollarding systems designed for it. Prune at the right season — generally when growth and the crop calendar make competition control most valuable and wound healing favourable; in alley and boundary systems pruning is deliberately timed just before or during the cropping season so that light reaches the crop at its most sensitive stage. Match the operation to species, because trees differ greatly in coppicing and regrowth ability and in tolerance of heavy cutting; a regime perfect for a fodder shrub can kill a timber tree. Finally, use the prunings — as fodder, mulch, green manure or fuel — because in agroforestry pruned material is a product, and returning it to the soil closes the nutrient loop that makes the system sustainable.

Conclusion

To conclude, successful establishment is planned, not improvised: define the farmer's objectives and diagnose the farm; examine climate, soil, water and site honestly; choose adapted, multipurpose and compatible species and arrange them in a crop-friendly design; secure quality planting material, labour, capital and protection in advance; clarify tenure and tree rights; check markets and extension support; and record a simple management plan.

Thereafter, pruning is the manager's chief instrument: formative and side pruning shape the tree, crown operations control shade and light, pollarding and coppicing turn trees into regular fodder and fuel producers, and root pruning restrains below-ground competition. Systems established on the right points and pruned with knowledge deliver the combined production that agroforestry promises; systems that skip either step demonstrate why the preparation mattered.

Question 2: Major Agroforestry Systems Practised in Pakistan (20 Marks)

Q.2 Write down the major agro-forestry systems that are practiced in Pakistan. (20)

Introduction

Pakistan's agroforestry is not an imported novelty but a living tradition that research and extension are working to improve. From the irrigated plains of Punjab and Sindh to the rainfed Potohar plateau, the deserts of Thal and Cholistan, the dry west and the terraced mountains of the north, farmers have long combined trees with crops and livestock in forms fitted to local water, soil and need. These systems differ greatly in structure and intensity: some are as simple as a line of shisham on a field boundary, others as complex as a multi-storeyed home garden or an irrigated block plantation run almost like a crop. This answer describes the major agroforestry systems practised in Pakistan — boundary and scattered-tree systems, irrigated plantations, alley and hedgerow plantings, home gardens, silvopastoral and rangeland systems, windbreaks and shelterbelts, woodlots, and the special systems of the mountains, canal and

road sides, and shifting and fallow lands — noting for each its form, main species, products and region.

Trees on Farm Boundaries and Field Edges

Boundary planting is the most widespread agroforestry system in Pakistan and the usual first step for a cautious farmer. Trees are planted in single or double lines on field boundaries, bunds and farm edges, where they occupy almost no cultivable land and interfere least with cropping and ploughing. Shisham (Dalbergia sissoo) is the classic boundary timber of the irrigated plains, valued for its high-quality wood; poplar, eucalyptus, mulberry, babul (Acacia nilotica) and beri are also common, chosen by zone and water. Boundary trees yield timber as a long-term saving, fuelwood and fodder from prunings, shade for resting labour and livestock, and some shelter for the crop, while their roots and canopies mark and defend the holding's edge. Managed with side pruning and root pruning where needed, a mature boundary can be worth a substantial sum at harvest without the farmer having surrendered a single cropped acre — the clearest explanation of the system's popularity.

Scattered Trees on Cropland and Parkland-Type Systems

In many areas, especially the rainfed barani tracts, dry plains and older settled farmland, trees stand scattered within the cropped fields themselves rather than on their edges. Species such as kikar and babul, phulai, beri (Ziziphus), dhak and, in suitable areas, mango and other fruit trees are retained or planted at low density among wheat, pulses, fodder and other crops. These trees are working assets: they give fodder loppings in lean seasons, fuel, small timber, fruit and shade, they fix nitrogen where leguminous species are used, and their litter and root

action maintain soil in fields that receive little fertiliser. Density is kept low and crowns are lopped or pruned so that crop loss beneath the canopy stays small and is outweighed by the tree's products and soil benefits. This parkland pattern, evolved by farmers themselves, demonstrates the central agroforestry judgement — total production of tree plus crop, not crop yield alone, is the measure of the land's performance.

Irrigated Plantations and Block Plantings with Crops

Where irrigation is assured, above all in Punjab and parts of Sindh and Khyber Pakhtunkhwa, farmers raise compact block plantations of fast-growing trees, intercropping agricultural crops between the young trees for the first years until shade closes the canopy. Poplar is the leading species of this commercial system, with eucalyptus and shisham also important; crops such as wheat, sugarcane, fodders and vegetables are taken from the inter-rows early in the rotation, so the land produces income while the timber grows. At harvest the blocks supply matchwood, plywood, packaging, poles and fuel to a ready industrial and urban market. This is the most commercially developed agroforestry system in the country and effectively a form of farm forestry combined with initial agroforestry intercropping; its success depends on quality planting material, assured water, correct spacing, timely thinning and pruning, and access to buyers — and it has made farm-grown wood a major share of Pakistan's timber supply.

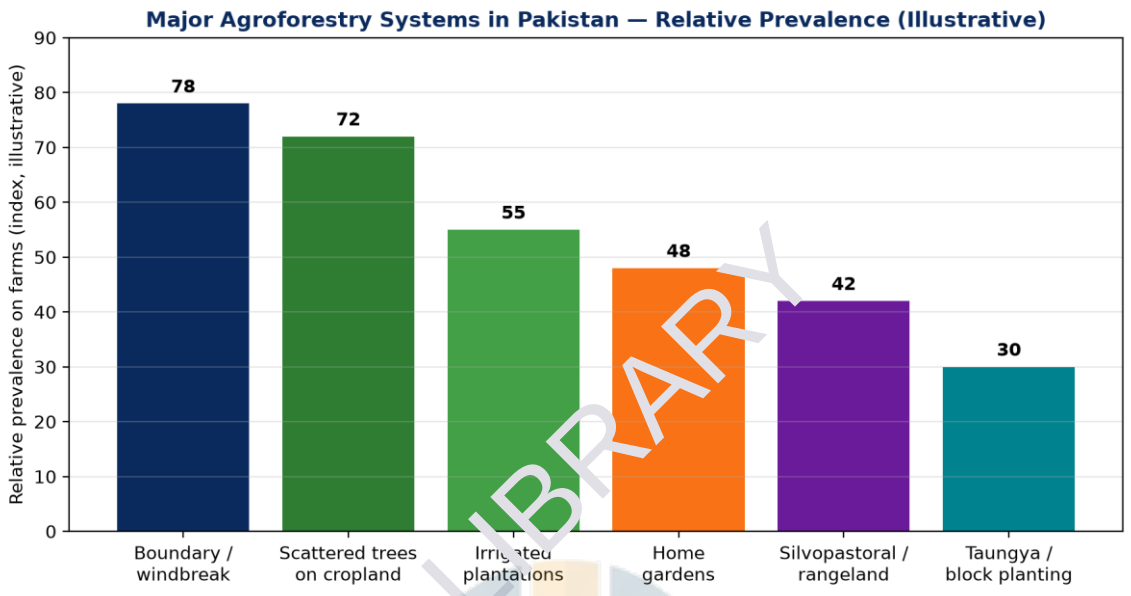

Figure 2: Major agroforestry systems in Pakistan compared by relative prevalence on farms (illustrative index based on the discussion in this answer).

Alley Cropping, Hedgerows and Fodder Plantings

Alley cropping and related hedgerow systems, promoted through research and projects and adopted in pockets especially where fodder and soil fertility are pressing needs, grow crops in alleys between regularly pruned hedgerows of leguminous shrubs or small trees such as sesbania and leucaena in suitable areas. The hedges are cut back at crop planting and during the season; their prunings are fed to livestock or laid as mulch and green manure, returning nitrogen and organic matter to the crop rows while the hedge roots help hold the soil — on sloping land the hedges are set on the contour, where they also act as erosion barriers that gradually build terraces. Related fodder plantings include fodder banks — small, dense, intensively cut plots of fodder shrubs near the homestead — and live fences of thorny or fodder species that protect fields while yielding feed and fuel. These systems are management-

intensive, which limits their spread, but where fodder shortage and declining fertility are severe they answer both problems from the same small piece of land.

Home Gardens and Homestead Planting

Around houses in villages and farmsteads across Pakistan, home gardens combine fruit trees — mango, citrus, guava, ber, pomegranate, mulberry and others by zone — with vegetables, fodders, fuel and timber species, medicinal and ornamental plants, and very often poultry or small livestock, in a dense, multi-layered and continuously harvested unit. The home garden is the most diverse and the most household-centred of all systems: it supplies the family's fruit, vegetables, fodder and fuel through the year, uses household waste, wash water and family labour efficiently, gives women a prominent management role, and provides shade and amenity around the dwelling. Because land around the homestead is secure and closely watched, trees there survive and are tended better than anywhere else on the farm. Intensifying home gardens with improved fruit varieties, better layering of species and integration of fodder and fuel species is one of the lowest-risk improvements available in every zone of the country.

Silvopastoral Systems, Rangelands and Grazing Lands

Where livestock dominate — the rangelands of Balochistan, the dry west, the Thal and Cholistan deserts, Sindh's grazing tracts and the mountain pastures — the characteristic system is silvopastoral: trees and shrubs combined with pasture and browsing animals. Scattered fodder trees and shrubs in grazing lands provide the critical lean-season feed, shade and shelter that pure grassland cannot; species are the hardy, deep-rooted trees of each zone, heavily

lopped under local custom. In better-watered areas, planted pasture with fodder trees, fodder banks and live fences form improved silvopastoral units on farms. The system's central challenge is management of grazing pressure itself: uncontrolled free grazing destroys regeneration and young plantings, so improvement depends on protection, rotational use and community agreement as much as on planting. Done well, silvopasture raises livestock production, halts rangeland degradation and stores carbon over vast areas that can grow little else.

Table 2: Major agroforestry systems in Pakistan — form, typical species and products

System	Typ cal Species / Form	Main Products and Services
Boundary planting	Shisham, poplar, eucalyptus, mulberry on field edges	Timber, fuel, fodder prunings, shelter, land demarcation
Scattered trees on cropland	Kikar / babul, phulai, beri among barani crops	Fodder, fuel, small timber, fruit, soil maintenance
Irrigated block plantations	Poplar, eucalyptus, shisham blocks intercropped when young	Industrial timber, poles, fuel; early intercrop income
Alley cropping / hedgerows	Sesbania, leucaena hedges with crops between	Fodder, mulch, nitrogen, erosion control on contours
Home gardens	Fruit trees, vegetables,	Year-round household food,

	fodder and fuel species at homestead	fodder, fuel, shade
Silvopastoral / rangeland	Hardy fodder trees with pasture and livestock	Lean-season fodder, shade, livestock production
Windbreaks / shelterbelts	Lines of tall trees around fields and settlements	Wind and sand protection, microclimate, timber
Community / farm woodlots	Mixed fast-growing species on a dedicated plot	Fuelwood, poles, timber for household or village use

Windbreaks, Shelterbelts, Woodlots and Linear Plantations

Protective systems form another major group. Windbreaks and shelterbelts — lines or belts of trees around fields, orchards, settlements and along channels in the dry and irrigated plains, including the fringes of Thal and Cholistan — reduce wind speed, cut evaporation and sand movement, protect young crops and fruit blossom, and yield timber and fuel as a by-product; species and layout are chosen for height, density and deep rooting. Farm and community woodlots are dedicated plots of fast-growing fuel and pole species on spare, degraded or village land, supplying the household's or village's wood needs from a managed block instead of from destructive cutting. Linear plantations along canals, roads and railways, traditionally raised by public agencies and communities, are a vast national asset in their own right: they produce timber, shade and shelter over thousands of kilometres and show how much tree cover Pakistan can add without using farmland at all. Orchards combined with intercrops in their early

years, and trees planted for reclamation of saline, waterlogged or eroded patches, complete the list of widely seen forms.

Mountain and Special Systems

In the northern mountains and other hill areas, agroforestry takes forms fitted to steep land and terraced farming: trees on terrace risers and edges, fruit-based systems, fodder trees that carry livestock through snowy winters, and combinations of conifer or broadleaved trees with crops and pasture at different altitudes. Shifting cultivation in its traditional long-fallow form, where a cropped phase alternates with a tree-fallow phase that restores fertility, survives in limited areas and is the ancestor of the improved fallow systems now recommended, in which planted leguminous fallows restore the soil faster and on less land. In the Indus delta and coastal belt, mangrove protection and planting combine tree cover with fisheries and grazing in a distinctive silvo-fishery and pastoral setting. Across all zones the pattern is consistent: the system's form follows water, land and livelihood, which is precisely why a national list must be a family of systems rather than a single model.

Conclusion

In conclusion, the major agroforestry systems practised in Pakistan are boundary planting, scattered trees on cropland, irrigated block plantations intercropped in their early years, alley cropping and hedgerow and fodder plantings, home gardens, silvopastoral and rangeland systems, windbreaks and shelterbelts, farm and community woodlots, linear plantations along canals and roads, and the terraced, fallow and coastal systems of the special zones. They share one logic — trees deliberately combined with farming for greater total and more secure

production — while differing in form because Pakistan's farms differ. Policy and extension succeed when they strengthen these proven systems with better species, layouts, pruning and markets, rather than attempting to replace them wholesale with imported designs.

Question 3: Characteristics of Multipurpose Trees and Shrubs Suitable for Agroforestry (20 Marks)

Q.3 Discuss the characteristics of multi-purpose trees and shrubs suitable for agro-forestry. (20)

Introduction

The tree is the defining component of agroforestry, and the multipurpose tree or shrub — a woody perennial deliberately grown to provide more than one product or service — is its ideal form. A small farmer with little land cannot afford a tree that does only one thing: the same planting must, if possible, feed animals, supply the kitchen fire, improve the soil, shade the homestead and still be standing as saleable timber when money is needed. Yet not every tree combines well with farming. A suitable multipurpose species must fit the site, grow acceptably fast, coexist with crops rather than suppress them, respond to management such as pruning and coppicing, and deliver products the household or market actually wants. This answer discusses the characteristics to look for — ecological adaptation, growth and form, compatibility with crops, soil-improving ability, range and quality of products, ease of propagation and management, and freedom from serious drawbacks — and illustrates them with the qualities expected of an ideal agroforestry tree.

Ecological Adaptation and Hardy, Reliable Growth

The first characteristic is adaptation to the local site. The species must tolerate the zone's rainfall pattern and dry season, its temperature extremes and frost or heat, and the soils on offer — including, where required, drought, salinity, alkalinity, shallow depth or temporary waterlogging. A species outside its adaptation may survive, but it will grow slowly, suffer pests and disappoint the farmer, and disappointment in a long-lived tree costs years. Closely linked is reliability: good seed or planting material should be available, germination and establishment should be dependable under farm conditions, and the young plant should withstand the ordinary hazards of farmland — browsing, trampling, termites and dry spells — with reasonable protection. Fast early growth is valued because it shortens the unproductive establishment period, competes with weeds, reaches safe height above browsing animals quickly and begins repaying the farmer's care; but speed must be balanced against wood quality, longevity and water use, since the very fastest species are not always the most useful or the most welcome neighbours to crops.

Form, Crown and Root Characteristics

The tree's architecture decides much of its behaviour in a farming system. A desirable crown for crop combinations is light and open, or capable of being pruned into such a form, casting shade that is partial and seasonal rather than dense and permanent; species that shed leaves in the season when the companion crop most needs light — as several important species do in the dry or winter season — enjoy a natural advantage, because phenology itself manages the light competition. A straight, clear bole is wanted in timber species, while a spreading, repeatedly

harvestable crown suits fodder species, so form is judged against purpose. Below ground, a deep taproot system with few aggressive shallow lateral roots is the agroforestry ideal: the tree draws water and nutrients from depths the crop does not reach, anchors firmly against wind, and competes little in the topsoil. Species whose roots spread densely and shallowly through the crop's rooting zone, or which sucker invasively into the field, are correspondingly disfavoured unless root pruning can control them.

Compatibility with Crops and Animals

Compatibility is the characteristic that most separates agroforestry species from ordinary forest species. The tree must not suppress its companions chemically — allelopathic species, whose leaves, litter or root exudates inhibit crop germination or growth, are avoided for close combinations, whatever their other merits. It should not be an alternate host for major crop pests and diseases, nor so thorny or awkwardly placed by nature that field operations become difficult, though thorniness is an asset in a live fence. Its litter should decompose at a useful rate, returning nutrients rather than locking them up or forming a smothering mat. For silvopastoral use the foliage must be palatable and nutritious to livestock and free of serious toxicity — or toxic only in circumstances that management can avoid — and the tree must tolerate repeated browsing or lopping without dying. Compatibility is partly manageable, by spacing, pruning and placement, but a species that is fundamentally antagonistic to crops or animals will always be an uphill struggle, and selection should be honest about it.

Soil-Improving and Protective Qualities

A highly prized group of characteristics concerns what the tree does for the site. Nitrogen fixation, in leguminous trees and shrubs and a few non-legume fixers, adds fertility that benefits the whole system and is the single most valuable soil service a tree can offer; it underlies the choice of sesbania, leucaena, gliricidia, babul and many other leading agroforestry species. Beyond fixation, good species pump leached nutrients from deep layers and return them in litter, build soil organic matter, protect the surface from rain impact and erosion, bind soil with their roots on slopes and banks, and shelter crops from wind. Services such as shade for livestock, habitat for pollinators and natural enemies, and carbon storage add further value. A multipurpose tree is therefore judged as an ecological worker as well as a producer: the species that feeds the soil while it feeds the household earns its place twice over.

Table 3: Desirable characteristics of a multipurpose tree or shrub for agroforestry

Group of Characteristics	Desirable Features	Why It Matters
Adaptation	Tolerates local climate and soil, including drought or salinity where needed	Survival and steady growth without costly inputs
Growth	Fast early growth; reliable establishment; long productive life	Quick returns; repays care; serves for many years
Crown and form	Light or prunable crown;	Controls shade; fits the

	useful phenology; straight bole for timber	intended product
Roots	Deep taproot; few shallow competing laterals	Uses deep resources; little competition with crops
Compatibility	No serious allelopathy; not a pest host; palatable foliage for fodder use	Crops and livestock thrive beside it
Soil services	Nitrogen fixation; litter return; erosion control; shelter	Builds the fertility and stability of the whole system
Products	Several useful outputs: fodder, fuel, timber, fruit, fibre or others	Meets many household needs from little land
Management	Coppices and pollards well; responds to pruning; easy to propagate	Farmer can control and harvest it with simple tools

Multiplicity and Quality of Products

The defining characteristic remains multipurpose output. The species should yield at least two, and preferably several, of the products farm families need: nutritious fodder, fuelwood that

burns well, durable or otherwise marketable timber and poles, fruit or other food for people, fibre, gum, tannin, medicine or honey flora, together with the services already described. Quality matters as much as quantity — fodder is judged by protein content, digestibility and seasonal availability; fuel by density and burning behaviour; timber by strength, durability and market acceptance — and timing matters too, because a fodder species that stays green in the dry season, or a fruit that ripens when little else is available, is worth far more than the same yield at a time of plenty. The products should also arrive in a useful sequence: prunings and loppings during the tree's life, fruit in its season, and the final timber harvest as a capital realisation, so that the tree pays its way continuously rather than only at felling.

Ease of Propagation, Management Response and Safety

Practical characteristics decide adoption. The species should propagate easily and cheaply — by seed that is abundant, viable and simple to handle, or vegetatively where that is reliable — so that nurseries and farmers can raise planting stock without specialist facilities. It should respond well to management: coppice vigorously after cutting where fuel or fodder rotations are intended, pollard without dying, accept pruning and shaping, and regrow in a predictable form, because an agroforestry tree is a managed tree and species that resent cutting are poor subjects. It should be reasonably free of serious pests, diseases and dangerous traits; should not be invasive or a troublesome weed in farmland; should not poison livestock through fallen pods or litter in ordinary use; and where it is an introduced species, its behaviour outside cultivation should be known and acceptable. Longevity and wind-firmness complete the picture: the farmer plants for years, and a tree that breaks, uproots or dies just as it becomes valuable wastes the whole investment.

No Perfect Species: Matching Characteristics to Purpose and Place

These characteristics describe an ideal, and the experienced worker knows that no real species possesses them all. The fastest growers are often thirsty or short-lived; the best timber trees are rarely the best fodder; nitrogen fixers may be thorny; a species perfected for the irrigated plains may fail in the dry hills. Selection is therefore an exercise in priorities: list the purposes in the farmer's own order, state the site's hard limits, and choose the species whose strengths match the top purposes and whose weaknesses can be managed by design — wider spacing for a heavy crown, boundary placement for a competitive root system, root pruning where laterals invade the crop. Local and indigenous species deserve first consideration because their adaptation and acceptance are proven and their behaviour is known, with introduced species added where they fill a clear gap and have been tested locally. The characteristics in this answer are best used as a checklist for that matching process, not as a demand for perfection.

Conclusion

In conclusion, a multipurpose tree or shrub suitable for agroforestry is adapted and hardy on the site, grows fast and reliably, has a light or manageable crown and a deep, non-aggressive root system, is compatible with crops and livestock without allelopathy or pest-sharing, improves and protects the soil — ideally by fixing nitrogen and returning litter — yields several good products at useful times, propagates easily, responds to pruning, coppicing and pollarding, and is safe, long-lived and free of serious drawbacks. Because no species is ideal in every respect, the skill lies in matching this checklist of characteristics to the farmer's ranked purposes and the site's limits. When that matching is done well, one planting serves the

household, the livestock, the soil and the market at once — which is the whole idea of a multipurpose tree.

Question 4: Major Approaches in the Classification of Agroforestry Systems (20 Marks)

Q.4 What are the major approaches in the classification of agroforestry systems? (20)

Introduction

Classification can be approached from more than one direction, and agroforestry literature reflects this: instead of a single agreed ladder, the subject uses several major approaches, each organising systems by a different leading idea. One approach classifies by structure — the components present and their arrangement. Another classifies by function — what the system is for. Others proceed by ecological zone, by socio-economic scale and purpose, by the historical development and spread of systems, or by physiognomic and floristic appearance, borrowing a method from vegetation science. The most influential modern treatment, associated with Nair, combines several of these into a multi-basis framework rather than choosing only one. This answer takes each major approach in turn, explaining its basis, its main categories and its strengths and limits, and then shows how the approaches are used together in practice — because understanding the approaches, and not merely memorising one list, is what the question requires.

Approach 1: Structural Classification

The structural approach classifies systems by the nature of their components and by the arrangement of those components in space and time, and it is generally treated as the primary approach because structure is directly observable and stable. By components it gives the three great families: agrisilvicultural systems (trees with crops), silvopastoral systems (trees with pasture and livestock) and agrosilvopastoral systems (trees with crops and livestock), with special categories such as apiculture with trees and aqua-silviculture for other combinations. By spatial arrangement it distinguishes mixed dense and mixed sparse plantings, strip and zonal plantings, boundary plantings and multi-storeyed arrangements; by temporal arrangement it distinguishes simultaneous systems, in which components grow together, from sequential systems, such as rotational fallows and taungya, in which the combination changes over time. The structural approach's strength is clarity: anyone can verify it in the field. Its limit is that structure alone says nothing about purpose, productivity or suitability — two structurally identical plantings may serve entirely different ends — which is why the other approaches exist.

Approach 2: Functional Classification

The functional approach classifies systems by the role of the woody component and the outputs expected from the system. Its main division is between productive functions — the supply of food, fodder, fuelwood, timber, fruit, fibre and other goods — and protective functions — windbreak and shelter, shade, soil and water conservation, erosion control and microclimate improvement — with a large and important class of multipurpose systems in which the same planting is deliberately managed for both. Sub-classification by the main

product is common in practice: fodder systems, fuelwood systems, timber systems and fruit-based systems, for example. Function is the approach closest to the farmer's own thinking, since farmers plant for purposes, and it directly guides management — pruning, rotation and harvesting all follow from the function chosen. Its weakness is overlap: because most real systems serve several functions at once, assigning one class can be arbitrary unless the main function is carefully defined and subsidiary functions are also recorded, as good practice requires.

Approach 3: Ecological Classification

The ecological approach classifies systems according to the environmental conditions to which they are adapted, principally by agro-ecological zone. Its main categories are agroforestry systems of the humid tropics and subtropics, of the sub-humid zone, of the semi-arid and arid zones, and of highland and montane regions, with soils, altitude and water availability refining the groups. This approach is the essential guard against misapplied technology transfer: it insists that every system carries an ecological address, and that recommendations move safely only within comparable environments. It is therefore the approach most used in research reporting and in planning introductions to new areas. Its limitation is breadth — a zone contains many different systems — so ecological classification normally operates as one axis combined with the structural axis, producing descriptions such as 'semi-arid agrisilvicultural boundary systems' that are precise in both respects at once.

Approach 4: Socio-Economic Classification

The socio-economic approach classifies systems by the scale, intensity and economic purpose of their management. Its standard categories are subsistence systems, managed mainly for the household's own consumption with family labour and few purchased inputs; commercial systems, managed mainly for sale with higher inputs, hired labour and attention to markets; and intermediate systems, which combine household use with regular sale, as most smallholder systems in Pakistan do. Correlated distinctions include the level of technology, the size of holding, land and tree tenure, and whether the system arises from traditional practice or from a development intervention. This approach is indispensable for extension and policy, because acceptability, credit, labour and marketing all follow the socio-economic class; a design that is excellent for a commercial grower may be impossible for a subsistence household. Its weakness is fluidity: the same physical system can move between classes as a family's circumstances or markets change, so the classification describes the management of the moment rather than a permanent property of the planting.

Table 4: Major approaches to classifying agroforestry systems compared

Approach	Classifying Basis	Main Categories	Best Used For
Structural	Components and their arrangement in space and time	Agrisilvicultural; silvopastoral; agrosilvopastoral; boundary, strip, multi-storeyed,	Field identification, teaching, research design

		rotational	
Functional	Role of trees and outputs expected	Productive; protective; multipurpose (fodder, fuel, timber, fruit systems)	Management planning; farmer-oriented advice
Ecological	Agro-ecological zone and site conditions	Humid; sub-humid; semi-arid; arid; highland systems	Safe transfer of technology; research reporting
Socio-economic	Scale, inputs and purpose of management	Subsistence; intermediate; commercial	Extension, credit, policy and adoption analysis
Historical / spread	Origin and extent of the practice	Traditional / indigenous; improved / introduced	Development history; respecting local knowledge
Physiognomic / floristic	Appearance, structure and dominant species of vegetation	Named by form and dominant species assemblages	Vegetation description and mapping

Approach 5: Historical and Spread-Based Classification

A further approach classifies systems by their origin, development and extent. It distinguishes traditional or indigenous systems — the practices farmers evolved themselves over generations, such as scattered trees in barani fields and home gardens — from improved and newly introduced systems developed by research and projects, such as alley cropping in its modern form. It may also note how widespread a system is, from localised practices of one valley to nationally important systems such as irrigated poplar plantations. This approach matters developmentally: traditional systems embody tested local adaptation and deserve improvement rather than replacement, while introduced systems require demonstration, adaptation and time before judgement. Recording origin also protects intellectual honesty in research, distinguishing what science created from what it merely documented and refined.

Approach 6: Physiognomic and Floristic Classification

Borrowed from vegetation science, the physiognomic approach classifies by the outward appearance and growth-form structure of the vegetation — its height, layering, density and seasonal aspect — while the floristic approach classifies by species composition, naming systems after their dominant or characteristic species. In agroforestry these approaches appear in descriptions such as multi-storeyed home-garden systems, in inventories that record the dominant tree species of farm plantings, and in mapping work where the visible structure of tree cover is the practical unit. They are useful for survey, mapping and ecological comparison, and floristic naming is genuinely informative because the dominant species determines so many system properties. Their limitation for farm management is that appearance and species

alone do not reveal function, tenure or economics, so these approaches normally supplement rather than replace the structural and functional ones.

The Combined Multi-Basis Framework in Practice

Modern practice, following Nair's synthesis, does not force a choice among these approaches but applies them as successive, complementary criteria — in effect a set of axes on which every system can be located. A system is first placed structurally by its components and arrangement; its arrangement in time and space is specified; its main function is recorded; its ecological zone is stated; and its socio-economic scale is noted. The result is a compact, complete description — for example, an intermediate-scale, multipurpose, agrisilvicultural boundary system of the irrigated semi-arid plains — from which a trained reader learns the system's composition, layout, purpose, home environment and management level at a glance. This multi-basis habit also disciplines research and extension writing, because it exposes missing information: a report that cannot state a system's zone, function and scale has not yet described it adequately. Examination answers and project documents alike benefit from presenting classification in this combined way rather than as one rigid list.

Strengths, Limits and Choice of Approach

Each approach, then, has a proper job. Structure identifies; function explains purpose and guides management; ecology locates and limits transfer; socio-economics predicts adoption and support needs; history respects origins; physiognomy and floristics serve survey and mapping. The limits are the mirror image of the strengths: no single approach answers every question, real systems straddle categories, and classes based on management or function

change as the farm changes. The skill expected of the student and the practitioner is to choose the approach — or the combination — that fits the task in hand, state the basis of classification explicitly, and apply it consistently. Confusion in the literature almost always traces back to mixing bases without saying so; clarity returns the moment each label declares which approach it comes from.

Conclusion

To conclude, the major approaches in the classification of agroforestry systems are the structural approach, based on components and their spatial and temporal arrangement; the functional approach, based on productive, protective and multipurpose roles; the ecological approach, based on agro-ecological zone; the socio-economic approach, based on subsistence, intermediate and commercial scale and management; the historical approach, based on traditional or introduced origin and spread; and the physiognomic-floristic approach, based on appearance and dominant species. None is sufficient alone, and the accepted modern practice combines them into a multi-basis description that identifies a system completely. Mastering the approaches — their bases, categories, strengths and limits — equips the student to read the literature critically, describe any system precisely, and classify new practices sensibly as they appear.

Question 5: Short Notes — Role of Woody Perennials and of Leguminous Woody Perennials (20 Marks)

Q.5 Write short notes on the following: (20) i. Role of woody perennials in agroforestry. ii. Role of leguminous woody perennials for agro-forestry

Introduction

Both parts of this question concern the woody perennial — the tree, shrub, palm or bamboo whose long life distinguishes agroforestry from ordinary cropping. Part (i) asks for the role of woody perennials in general: what their permanence, size and deep rooting enable them to do for production, for the soil and microclimate, and for the farm household. Part (ii) narrows the focus to the most valued subgroup, the leguminous woody perennials, whose partnership with nitrogen-fixing bacteria gives them a fertility role no other trees can fully match. The notes below treat each part separately, as the question requires, while showing how the special role of the legumes grows out of the general role of woody perennials.

Note (i): Role of Woody Perennials in Agroforestry — Productive Roles

Woody perennials are, first, producers of goods that annual crops cannot supply. Because they live for years and grow large, they yield timber, poles and construction wood; fuelwood and charcoal; fodder from leaves, pods and loppings; fruit, nuts and other human foods; and a range of secondary products including fibre, gums, resins, tannins, medicines, honey flora and raw material for rural crafts and industry. These products arrive on a different calendar from crops — fodder in the dry season, fruit in its own season, prunings through the year, timber at

maturity — so the woody component evens out the farm's supply of feed, fuel, food and cash and provides a standing reserve that can be harvested in emergencies. Economically the tree is also capital: a growing asset on land that would otherwise hold none, appreciating biologically year by year. This productive role alone justifies trees on farms, but it is only half of their contribution, because the same standing trees are simultaneously working on the environment in which the crops grow.

Note (i): Role of Woody Perennials — Ecological and Protective Roles

Ecologically, the woody perennial's permanence and depth make it the system's engineer. Its roots exploit soil layers below the crop's reach, pumping leached nutrients back to the surface through litter, prunings and root turnover, tightening the nutrient cycle. Its canopy and litter protect the soil surface from raindrop impact and erosion, its roots bind slopes and banks, and its litter builds the organic matter that governs soil structure, water holding and biological activity. Standing trees moderate the farm microclimate — shade, shelter from wind, reduced temperature extremes and evaporation — protect crops, livestock and homesteads, and in windbreaks defend whole fields. They store carbon in biomass and soil for years to decades, support birds, pollinators and other biodiversity in a cultivated landscape, and by supplying farm-grown fuel and timber they relieve the destructive pressure on natural forests. Their permanence also carries management duties: the same canopy that shelters also shades, and the same roots that pump nutrients also drink, so the woody perennial's role is beneficial on balance only when species, density and pruning are managed — a qualification that belongs in any honest account of its role.

Table 5: Roles of woody perennials in agroforestry at a glance

Role	How the Woody Perennial Performs It	Benefit to the Farm
Production	Yields timber, fuel, fodder, fruit and secondary products over many years	Diversified, year-round income and household supply
Nutrient cycling	Deep roots pump leached nutrients, litter and prunings return them	Maintained soil fertility with fewer external inputs
Soil and water protection	Canopy, litter and roots check erosion; cover improves infiltration	Soil conserved; water used more productively
Microclimate	Shade and wind shelter moderate temperature and evaporation	Less stress on crops and livestock
Risk and capital	Standing, long-lived asset harvestable in need	Security, savings and resilience
Forest protection	Farm supply of wood substitutes for forest cutting	Natural forests and watersheds relieved

Note (ii): Role of Leguminous Woody Perennials — Nitrogen Fixation

Leguminous woody perennials — trees and shrubs of the legume family that form root nodules with Rhizobium and related bacteria — hold a special place because they add new nitrogen to the system from the air itself. Nitrogen is the nutrient crops need most, the one most commonly deficient, and the one whose fertiliser form is costly and easily lost; a legume tree converts atmospheric nitrogen into plant protein continuously and free of cash cost. Through leaf litter, green-manure prunings, root and nodule turnover, and the manure of animals fed on its fodder, that fixed nitrogen passes to companion and following crops. Fixation rates vary widely with species, site and management, and the student should avoid quoting single figures as universal, but the direction and importance of the effect are firmly established in alley cropping, improved fallows and fodder systems worldwide. Species widely used or valued for this role include sesbania, leucaena, gliricidia, and Pakistan's own babul / kikar (Acacia nilotica) and other acacias, together with many indigenous leguminous trees of rangelands and hills — a group whose fertility service is added on top of all the general roles described in part (i).

Note (ii): Other Roles of Leguminous Woody Perennials

Nitrogen is the headline, but leguminous woody perennials earn their place with a full supporting cast. Their foliage and pods are typically protein-rich, making them premier fodder species whose feed value is highest exactly because of the nitrogen they contain; leucaena, sesbania and acacia pods are classic examples, subject in a few species to management of anti-nutritional factors — leucaena's mimosine, for instance, is handled by limiting its share of the ration and by established feeding practice. They grow fast on poor soils where fertility-hungry

species stall, so they are the pioneers of reclamation: planted on degraded, eroded or nitrogen-starved land, in improved fallows and contour hedges, they rebuild fertility and organic matter and prepare the site for other crops and trees. Many give useful fuelwood, poles, gum — gum arabic comes from an acacia — tannin, honey flora and shade, and their deep roots and litter add the standard protective services. In system design they are therefore placed wherever fertility must be manufactured in place: as alley hedges pruned for green manure, as fallow species, as fodder banks, and as nurse and soil-building components in plantations.

Note (ii): Management and Cautions

The legumes' role is maximised by management and bounded by a few cautions that complete the note. Fixation is strongest when the plant is well grown and its prunings are actually returned to the soil or fed and manured back; harvesting and exporting all biomass exports the nitrogen with it. Nodulation requires the right soil conditions — reasonable phosphorus and freedom from extreme acidity or salinity stress — so very degraded sites may need initial care. Some excellent legumes are thorny, some spread vigorously and must be contained, and a few carry the fodder cautions noted above; none of this disqualifies them, but species choice and placement should be deliberate. Finally, legumes fix nitrogen, not phosphorus, potassium or water: they reduce, and in favourable cases can largely replace, nitrogen fertiliser for companion crops, but a complete fertility programme still accounts for the other nutrients the harvest removes.

Conclusion

In conclusion, woody perennials are the productive and ecological foundation of agroforestry: they produce timber, fuel, fodder, fruit and secondary goods on a calendar that complements crops, while their permanence, canopy and deep roots cycle nutrients, protect and build soil, moderate microclimate, store carbon, spread risk and relieve pressure on natural forests — provided their competition is managed. Leguminous woody perennials perform all of these roles and add the unique service of biological nitrogen fixation, supplying protein-rich fodder, pioneering degraded land and manufacturing fertility within alley, fallow and fodder systems. It is this double contribution — production plus fertility — that makes leguminous trees and shrubs the most prized component species in agroforestry design.

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