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ALLAMA IQBAL OPEN UNIVERSITY, ISLAMABAD

(Department of Agricultural Science)

Course: Environment and Forestry (2516)

Level: BS/MSc

Semester: Autumn 2026

Assignment No. 1 (Units 1-4)

Total Marks: 100 • Pass Marks: 50

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.

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Question 1: Ecosystem — Definition and Types (20 Marks)

Q. 1 Define ecosystem and explain its types. (20)

Introduction

An ecosystem is the basic functional unit of ecology. Wherever living organisms exist — in a forest, a pond, a desert, a wheat field or even a drop of pond water — they do not live in isolation. They constantly interact with one another and with the non-living surroundings of soil, water, air, light and temperature, exchanging energy and materials in a continuous cycle. The term ecosystem, introduced by the British ecologist A. G. Tansley in 1935, was created precisely to describe this integrated whole: a community of organisms together with its physical

environment, functioning as one system. Understanding ecosystems is the foundation of the whole course on environment and forestry, because forests themselves are ecosystems, deforestation is the destruction of an ecosystem, and conservation is the protection of ecosystems. This answer first defines the ecosystem and explains its components and functioning, and then describes in detail the main types of ecosystems — natural and artificial, terrestrial and aquatic — with examples, including examples from Pakistan.

Definition of Ecosystem

An ecosystem may be defined as a self-sustaining, functional unit of nature in which living organisms (the biotic community) and their non-living (abiotic) environment interact with each other, through the flow of energy and the cycling of nutrients, so that the system maintains itself over time. In simpler words, an ecosystem = biotic components + abiotic components + their interactions in a given area. Several features of this definition deserve emphasis. First, an ecosystem has no fixed size: it may be as small as a pond, a rotting log or an aquarium, or as large as an ocean or the whole biosphere, which is the largest ecosystem of all. Second, it is an open system — energy enters it as sunlight and leaves as heat, while materials are largely recycled within it. Third, it is dynamic rather than static: populations rise and fall, seasons change its appearance, and over long periods one ecosystem may develop into another through ecological succession, yet at any given time it shows a recognisable structure and a working balance, sometimes called homeostasis, which human disturbance can easily upset.

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Components of an Ecosystem

The abiotic components are the non-living factors: sunlight, temperature, rainfall, humidity and wind; water and soil with their physical and chemical properties; and inorganic substances such as carbon dioxide, oxygen, nitrogen, phosphorus and minerals, which plants absorb and from which all food is ultimately built. The biotic components are usually grouped by their nutritional role. Producers are the green plants (and some bacteria) that manufacture their own food by photosynthesis, converting solar energy into chemical energy stored in plant tissue; all other life depends directly or indirectly on them. Consumers feed on other organisms: primary consumers or herbivores (deer, rabbits, insects, cattle) eat plants; secondary consumers or small carnivores (frogs, small birds, foxes) eat herbivores; and tertiary consumers or top carnivores (tigers, eagles, large fish) eat other carnivores. Decomposers — mainly bacteria and fungi — break down dead plants, animals and waste into simple inorganic substances, returning nutrients to the soil and water for producers to use again. Without decomposers, nutrients would remain locked in dead matter and life would grind to a halt, which is why this inconspicuous group is ecologically indispensable.

How an Ecosystem Functions: Energy Flow and Nutrient Cycling

Two great processes bind the components together. The first is the one-way flow of energy. Sunlight captured by producers passes along food chains — grass to grasshopper to frog to snake to hawk, for example — and at every transfer a large part, roughly ninety per cent, is lost as heat in respiration and movement, so only about ten per cent passes to the next trophic (feeding) level. This is why food chains are short, why top carnivores are few, and why the

numbers and biomass of organisms form pyramids. Real feeding relations are not single chains but food webs, in which each species eats and is eaten by several others, giving the system stability. The second process is the cycling of nutrients — carbon, nitrogen, phosphorus, water and other elements circulate repeatedly between the living and non-living parts: plants absorb them, animals eat the plants, decomposers release them again. Energy flows through and is lost; nutrients go round and round. A healthy ecosystem performs both processes efficiently, and most environmental problems, from eutrophication of lakes to the build-up of carbon dioxide in the atmosphere, can be understood as disturbances of one or the other.

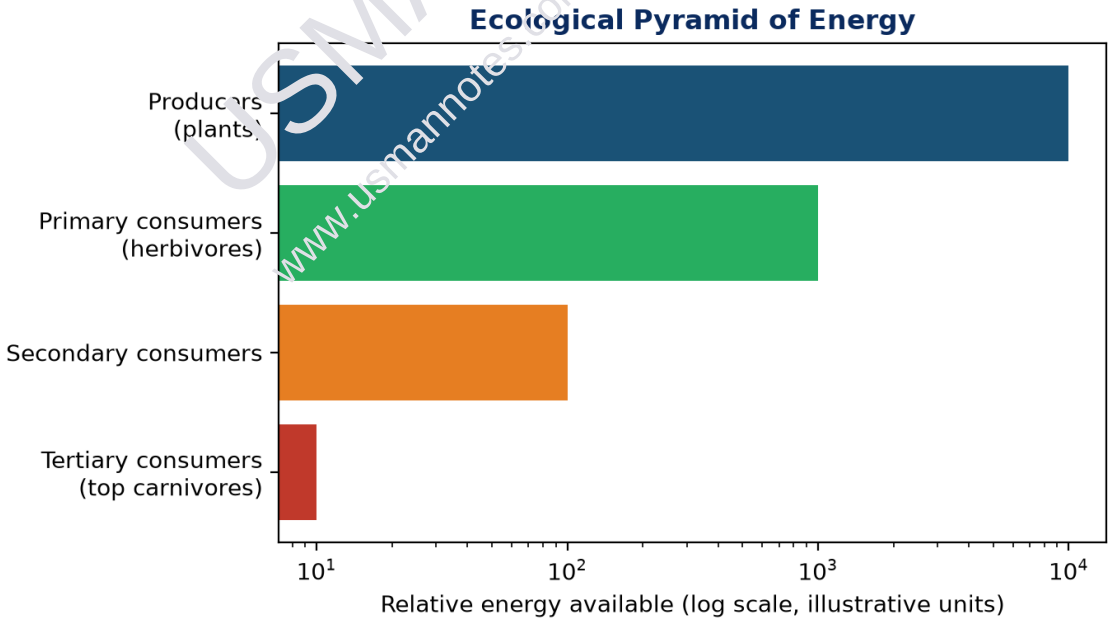


Figure 1: Ecological pyramid of energy — energy decreases sharply at each trophic level, which is why top carnivores are always few. Values are illustrative.

Basis of Classification of Ecosystems

Ecosystems are classified on several bases: by origin, into natural ecosystems, which develop without deliberate human management, and artificial or man-made ecosystems, which humans create and maintain; by habitat, into terrestrial (land) and aquatic (water) ecosystems; by size, into micro-ecosystems (a pond, a tree trunk), meso-ecosystems (a forest, a lake) and macro-ecosystems (a biome or the biosphere); and by climate and vegetation, into the great biomes such as tropical forest, temperate forest, grassland, desert and tundra. The most useful classification for this course combines origin and habitat, and it is followed below. The student should note that the boundaries between types are not walls: a river flowing through a forest links the two systems, migratory birds link continents, and every local ecosystem is nested inside larger ones.

Type 1: Natural Terrestrial Ecosystems — Forests, Grasslands, Deserts and Tundra

Forest ecosystems are dominated by trees and are the richest land ecosystems in species and in stored carbon. They include tropical rainforests near the equator, with very high rainfall, several canopy layers and the greatest biodiversity on Earth; temperate deciduous forests of cool regions, whose trees shed leaves in winter; boreal or taiga coniferous forests of cold northern latitudes, dominated by pine, spruce and fir; and the varied forests of Pakistan — Himalayan moist temperate forests of deodar, fir and spruce in the north, dry temperate and sub-tropical pine (chir) forests, sub-tropical scrub and thorn forests of the plains, riverine (bela) forests along the Indus, and mangrove forests of the Indus delta. Forest ecosystems regulate water, protect soil, shelter wildlife and store carbon, as later questions in this assignment

discuss in detail. Grassland ecosystems are dominated by grasses with few trees, maintained by moderate rainfall, grazing and fire; they include the savannas of Africa, the prairies and steppes of temperate regions and grazing lands everywhere, supporting large herbivores and their predators and storing much carbon in their deep root systems and soils.

Desert ecosystems receive very little rainfall (generally under 250 mm a year) and show extreme temperatures; plants such as cacti, thorn bushes and ephemeral herbs are adapted with deep or wide-spreading roots, small or waxy leaves and water-storing tissues, and animals are often nocturnal. Pakistan's Thar, Cholistan, Thal and Kharan deserts are examples, fragile systems in which overgrazing or removal of shrubs can quickly trigger sand movement and desertification. Tundra ecosystems, found in the far north and on high mountains (alpine tundra), have very short, cold growing seasons, permanently frozen subsoil (permafrost) in the Arctic type, and low vegetation of mosses, lichens and dwarf shrubs; they are highly sensitive to warming. Mountain ecosystems, important in northern Pakistan, combine several of these types in vertical zones, so that a single valley may pass from scrub through pine and fir forest to alpine pasture and bare rock within a short distance, each zone with its own community.

Type 2: Natural Aquatic Ecosystems — Freshwater and Marine

Freshwater ecosystems cover only a small fraction of the Earth's surface but support a disproportionate share of species and provide drinking water, irrigation, fish and waste assimilation. They are divided into standing-water (lentic) systems — lakes and ponds, with zones from the sunlit littoral margin through open water to the deep, dark bottom, each with characteristic life — and running-water (lotic) systems — springs, streams and rivers, where

current, oxygen and temperature change continuously from source to mouth, and organisms are adapted to flow. Rivers such as the Indus also create floodplains and wetlands. Wetlands — marshes, swamps and floodplain lakes such as Haleji, Keenjhar and the lakes of Sindh and Punjab — deserve special mention: lying between land and water, they are among the most productive ecosystems of all, recharging groundwater, buffering floods, filtering pollutants and supporting fisheries and migratory birds. Marine ecosystems cover about seventy-one per cent of the Earth's surface. They include the shallow, productive continental shelves and estuaries where rivers meet the sea — rich nurseries for fish and shrimp; coral reefs, the rainforests of the sea; and the vast open ocean, whose sunlit surface waters, through phytoplankton photosynthesis, produce a large share of the Earth's oxygen, while its dark depths support communities independent of sunlight. Pakistan's Arabian Sea coast, its estuaries and its mangrove-fringed creeks belong to this type.

Type 3: Artificial (Man-Made) Ecosystems

Artificial ecosystems are created and maintained by human effort and would change or collapse without continued inputs. Cropland ecosystems — fields of wheat, cotton, rice, orchards and plantations — are the most important: the farmer selects one or a few crop species, supplies water, fertilisers and pesticides, removes weeds and competitors, and harvests a large part of the production, so diversity is low, nutrient cycles are open and the system depends on constant energy and material subsidies. Urban ecosystems — towns and cities — are extreme artificial systems that import almost all food, water, fuel and materials and export wastes and pollution, supporting dense human populations but very little self-sustaining production. Other examples include village ponds, reservoirs and dams, aquaculture ponds, gardens, parks and

plantation forests raised by forest departments. Artificial ecosystems are not inferior or useless — civilisation depends on them — but compared with natural ecosystems they are simpler, less stable and less self-regulating, and they impose loads on the natural systems around them. Sound environmental management aims to make artificial systems work more like natural ones: recycling nutrients, maintaining diversity where possible, protecting soil with trees, and reducing wasteful inputs — the principle behind agroforestry and sustainable agriculture.

Table 1: Main types of ecosystem with characteristics and examples

Type	Key Characteristics	Examples
Forest ecosystem (natural, terrestrial)	Tree-dominated; layered canopy; high biodiversity and carbon storage	Tropical rainforest; Himalayan moist temperate forest; mangrove forest
Grassland ecosystem (natural, terrestrial)	Grass-dominated; grazing animals; fire and grazing maintain openness	Savanna; steppe; prairie; alpine pasture
Desert ecosystem (natural, terrestrial)	Very low rainfall; water-conserving adaptations; fragile soils	Thar; Cholistan; Sahara
Tundra / mountain ecosystem (natural, terrestrial)	Cold, short growing season; low vegetation; sensitive to warming	Arctic tundra; alpine zone of the Himalayas

Freshwater ecosystem (natural, aquatic)	Lakes/ponds (lentic) or streams/rivers (lotic); wetlands highly productive	Lake Keenjhar; River Indus; marshes and floodplains
Marine ecosystem (natural, aquatic)	Salt water; shelves, estuaries, reefs and open ocean	Arabian Sea; Indus delta creeks; coral reefs
Cropland / urban ecosystem (artificial)	Human-created and maintained; low diversity; depends on external inputs	Wheat and rice fields; orchards; cities; reservoirs

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Conclusion

To conclude, an ecosystem is a functional unit in which a community of producers, consumers and decomposers interacts with its abiotic environment through a one-way flow of energy and repeated cycling of nutrients. Ecosystems may be natural or artificial, terrestrial or aquatic, and as small as a pond or as large as the biosphere. Forest, grassland, desert and tundra systems dominate the land; lakes, rivers, wetlands and oceans dominate the waters; and croplands and cities are the artificial systems on which human life directly depends. Every topic that follows in this course — natural resources, deforestation, climate regulation, conservation and pollution control — is best understood as the study of how these ecosystems work and how human action strengthens or degrades them.

Question 2: Natural Resources and Environmental Sustainability (20 Marks)

Q. 2 Discuss the importance of natural resources in environmental sustainability. (20)

Introduction

Natural resources are the materials and services that nature provides and on which all life and all economic activity ultimately rest: land and soil, water, forests, minerals, fossil fuels, air, sunlight, and the living diversity of plants, animals and micro-organisms. Environmental sustainability means meeting the needs of the present generation without destroying the ability of future generations to meet their own needs — using nature's capital in a way that lives off its income rather than consuming the capital itself. The two ideas are inseparable: there can be no sustainability without natural resources in a healthy state, and natural resources remain healthy only when they are used sustainably. This answer explains what natural resources are and how they are classified, and then discusses in detail why each major group of resources is indispensable to environmental sustainability — for life-support, for the economy, for climate and ecological balance, and for social well-being — with particular reference to the situation of Pakistan.

What Are Natural Resources? Classification

A natural resource is any part of the natural environment that human beings find useful — useful directly, as food, water and timber, or indirectly, through services such as pollination, flood control and climate regulation, which were long taken for granted and are now

recognised as among the most valuable of all. Resources are classified in several ways. By renewability, renewable resources — forests, fisheries, soil fertility, water in rivers and rain, solar and wind energy — can regenerate within human timescales if the rate of use does not exceed the rate of renewal; non-renewable resources — coal, oil, gas and metal ores — were formed over millions of years and, once used, are gone for practical purposes, so sustainability for them means economy, recycling and substitution. By origin, resources are biotic (forests, crops, livestock, fish) or abiotic (minerals, water, air, sunlight). By ownership and scale they may be individual, community, national or international — a distinction that matters, because resources owned by no one in particular, such as the atmosphere, open fisheries and village grazing lands, are the most easily over-used unless communities and states govern them deliberately, a problem known as the tragedy of the commons.

Life-Support: Resources as the Basis of All Life

The most fundamental importance of natural resources is that they are the life-support system of the planet. Green plants, using sunlight, water, air and soil minerals, produce through photosynthesis all the food and much of the oxygen on which animals and humans depend. Soil — itself a resource built over centuries from rock, organic matter and living organisms — grows about ninety-five per cent of human food. Fresh water sustains drinking, sanitation, agriculture and industry; Pakistan's agriculture, which employs a very large share of its people, rests almost entirely on the Indus river system and its groundwater. The atmosphere supplies oxygen, filters harmful ultraviolet radiation through the ozone layer, and maintains, through its composition, a temperature range in which life can flourish. Biodiversity — the variety of species and genes — is a resource in the same deep sense: it provides the raw material for crops and medicines, the

pollinators without which many crops set no fruit, the predators that control pests, and the resilience that allows ecosystems to recover from drought, flood and disease. To degrade any of these resources is therefore not merely an economic loss; it is damage to the machinery that keeps life going, including our own.

Economic Importance: Resources as the Foundation of Livelihoods

Every economy is built on natural resources, however advanced its technology. Agriculture converts soil, water, sunlight and seeds into food and raw materials; forestry supplies timber, fuelwood, fodder, fruits, resins and medicinal plants; fisheries, mining and energy supply food, materials and power; and nature-based tourism, from the northern mountains to the Indus delta, earns income precisely because landscapes and wildlife survive. For the poor, natural resources are especially important: a rural family in Pakistan may depend on common grazing land for its animals, on fuelwood for cooking, on a local forest or rangeland for fodder in drought, and on wild foods and medicinal plants in hard times. When such resources degrade, it is the poor who suffer first and most, because they have the least money to buy substitutes. Sustainable management therefore protects livelihoods and reduces poverty at the same time: a well-stocked community forest, a recharged aquifer or a conserved fishery is a continuing income, whereas a mined-out, eroded or salinised resource is a one-time gain followed by lasting loss. Environmental economists express this in the language of natural capital: sustainability means keeping the total stock of capital — natural plus man-made — intact for the future, and since many natural services cannot be replaced by machines at any price, their conservation is not optional.

Table 1: Major natural resources, their services and the sustainability risk if degraded

Resource	Main Services / Uses	Risk When Degraded or Over-Used
Soil and land	Food production; habitat; water filtration; carbon store	Erosion, salinity and desertification; food insecurity
Water	Drinking, irrigation, industry, hydropower, fisheries	Scarcity, conflict, falling water tables, waterlogging
Forests	Timber, fuelwood, fodder, climate regulation, wildlife habitat	Floods, erosion, carbon emissions, biodiversity loss
Biodiversity	Pollination, pest control, medicines, genetic material	Crop vulnerability, ecosystem fragility, lost future options
Minerals and fossil fuels	Energy, construction, industry, fertilisers	Exhaustion, pollution, greenhouse-gas emissions
Air / atmosphere	Oxygen, climate stability, ozone shield	Air pollution, climate change, health damage
Sunlight, wind (renewable energy)	Clean, inexhaustible energy; photosynthesis	Under-use perpetuates dependence on polluting fuels

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Ecological and Climate Importance

Natural resources, woven together as ecosystems, perform regulatory services that keep environmental conditions stable. Forests and soils store enormous quantities of carbon and release oxygen; wetlands and floodplains absorb floodwater and release it slowly; vegetation cover prevents erosion and keeps rivers and reservoirs free of silt; the water cycle, driven by solar energy through evaporation, forests and oceans, distributes fresh water across the continents; and natural nutrient cycles keep soil fertile without artificial inputs. These services operate free of charge and at scales no technology can match — the cost of replacing pollination by hand, or of building flood protection equal to a lost wetland, is prohibitive. This is why environmental sustainability is defined in terms of resources: a society is sustainable when its soils are not thinning, its aquifers are not falling, its forests are not shrinking, its climate is not destabilised and its species are not disappearing. Each of these indicators is a statement about the condition of natural resources. Conversely, nearly every major environmental problem — climate change, biodiversity loss, land degradation, water scarcity — is at root the over-use or abuse of a natural resource: burning fossil carbon too fast, clearing forest faster than it regrows, pumping groundwater faster than rain refills it, or ploughing soil faster than it forms.

Social, Cultural and Intergenerational Importance

Natural resources also carry social and cultural value that markets do not price. Landscapes, rivers, sacred groves, historic trees and wildlife form part of the identity and heritage of

communities; outdoor recreation, clean air and green surroundings support physical and mental health; and resources held in common underpin cooperation and social organisation in villages. Above all, natural resources raise the question of justice between generations. The present generation inherited forests, soils, aquifers and a stable climate built up over thousands of years; it has no right to hand on a depleted planet and call it development. The Brundtland definition of sustainable development — development that meets the needs of the present without compromising the ability of future generations to meet their own needs — is essentially an instruction about natural resources: consume the renewable yield, not the stock; use non-renewables sparingly and invest part of their proceeds in renewable substitutes; and keep pollution within the capacity of air, water and soil to absorb it harmlessly. Pakistan's low forest cover, stressed water resources and vulnerability to climate change make these principles urgent rather than theoretical for its students and policy-makers.

How Sustainable Use Is Achieved

The importance of natural resources for sustainability leads directly to principles of management, which later units of this course develop. They include: harvesting renewables at or below their regeneration rate, as in sustained-yield forestry; protecting the resource base itself — soil conservation, watershed protection and protected areas for biodiversity; using resources efficiently and reducing waste, since the least damaging unit of energy or water is the one never consumed; recycling and reusing non-renewables, especially metals; substituting renewables for exhaustible resources, as solar and wind replace fossil fuels; applying the precautionary principle where damage may be irreversible, as with species extinction; and ensuring that local communities, who live closest to the resource, share in its benefits and in

decisions about it, because resources guarded by those who depend on them are guarded best. Education, law and economic incentives — pricing that reflects true environmental cost, for instance — support these principles, but the principles themselves follow from the simple fact established throughout this answer.

Conclusion

In conclusion, natural resources are important to environmental sustainability in every dimension: they are the life-support system that produces food, water, oxygen and a stable climate; the foundation of livelihoods and economies, above all for the poor; the regulators that control floods, erosion, pests and carbon; and a heritage held in trust for future generations. Sustainability is therefore measurable as the condition of these resources. A development path that enriches people while impoverishing soil, water, forest and climate is borrowing from the future and will fail; a path that conserves and wisely uses natural resources can continue indefinitely. That is why the conservation and sustainable management of natural resources stands at the centre of environmental science and of this course.

Question 3: Deforestation — Causes and Environmental Impacts (20 Marks)

Q. 3 Explain the causes of deforestation and its impacts on the environment. (20)

Introduction

Deforestation is the permanent removal of forest cover and the conversion of forest land to other uses — farms, settlements, pastures, roads or bare degraded land. It must be

distinguished from temporary felling followed by regeneration: a forest harvested and regrown remains a forest, whereas deforestation means the trees are gone and are not replaced, so the ecosystem itself disappears. The world has lost vast areas of forest over the past century, and although rates vary by region, tropical forests continue to shrink while many countries, including Pakistan, hold far less forest than their ecology needs. Pakistan's forest cover is commonly reported at only about five per cent of its land area, well below the roughly twenty-five per cent often recommended for a balanced environment, and its natural forests face heavy pressure. This answer explains the causes of deforestation — direct (proximate) causes such as agricultural expansion and fuelwood cutting, and the underlying causes such as poverty, population pressure and weak governance — and then examines its impacts on climate, soil, water, biodiversity and human communities.

Direct Cause 1: Expansion of Agriculture and Settlement

Historically and today, the largest direct cause of deforestation is clearing land for cultivation and settlement. As populations grow and food demand rises, forests on fertile or accessible land are felled and ploughed; shifting cultivation, in which farmers clear and burn a patch, crop it for a few years and move on, becomes destructive when fallow periods shorten under land pressure, so the forest cannot recover. Commercial agriculture adds a powerful modern driver: plantations and large-scale production of commodities for distant markets clear forest at a scale subsistence farming never could. Expanding towns, villages, roads, dams and industries likewise consume forest land, and infrastructure built into a forest — a road above all — opens the interior to loggers, settlers and hunters, so its indirect effect far exceeds the strip it clears. In Pakistan, pressure for agricultural land, housing and development projects has steadily eaten

into riverine, scrub and hill forests, while encroachment on state forest land remains a continuing problem for forest departments.

Direct Cause 2: Fuelwood, Timber Demand and Overgrazing

In poor rural communities the forest is the energy source: the great majority of households in forest-adjacent areas depend on fuelwood for cooking and heating, and where demand exceeds what dead wood and sustainable cutting can supply, live trees are felled and whole slopes are stripped. Charcoal-making intensifies this pressure because it consumes several times its own weight in wood. Demand for timber — for construction, furniture, mining props, railway sleepers in earlier times, and pulp and paper — drives both legal over-harvesting and illegal logging, which flourishes where enforcement is weak, prices are high and corruption protects the 'timber mafia', a problem repeatedly reported in Pakistan's northern forests. Selective removal of the best trees also degrades the forest that remains, a process called forest degradation, which often precedes outright deforestation. Overgrazing is a quieter but equally serious cause: large herds of goats, sheep and cattle browse seedlings and compact the soil in and around forests, so that even where mature trees survive, no young generation replaces them, and the forest ages and thins towards disappearance. Fire, set deliberately to clear land or improve grazing, or spreading accidentally in dry forests such as chir pine, completes the destruction where protection fails.

Underlying Causes: Poverty, Population, Tenure and Governance

Behind the axe and the match lie underlying causes that any serious answer must name. Poverty and lack of alternatives are fundamental: a family without land, work, gas or electricity

does not choose to destroy a forest; it survives by it, and deforestation will continue until fuel, fodder and income are available from other sources. Population growth multiplies every demand — for land, food, wood and water. Insecure or unclear land and tree tenure discourages planting and protection: no one plants a tree on land from which they may be evicted, and state forests treated as nobody's property invite encroachment. Weak governance — under-staffed forest departments, poor enforcement, corruption and policies that price forest land and timber below their true value — allows illegal use to outcompete legal management. Market and policy failures complete the picture: because the climate, flood-control and biodiversity services of a standing forest are unpaid and unpriced, clearing it appears profitable to the individual while its true costs fall on society and the future. Natural factors — drought, pests, disease and climate-driven fires — can also kill forests, but in the present era they usually act on forests already stressed by human pressure.

Table 1: Causes of deforestation — direct and underlying

Category	Cause	How It Destroys Forest
Direct	Agricultural expansion and settlement	Forest felled and converted permanently to farms, housing and infrastructure
Direct	Fuelwood and charcoal demand	Daily cutting beyond regeneration; whole slopes stripped near villages

Direct	Commercial and illegal logging	Over-harvesting; degradation opens forest to clearance
Direct	Overgrazing and fire	Seedlings browsed, regeneration fails; fires kill trees and soil life
Underlying	Poverty and lack of alternatives	Survival dependence on forest for fuel, fodder and land
Underlying	Population growth; insecure tenure	Rising demand; no incentive to plant or protect
Underlying	Weak governance and unpriced services	Illegal use unchecked; standing forest appears valueless

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Impact 1: Climate Change and Loss of Carbon Storage

The gravest global impact of deforestation is on climate. Forests store immense quantities of carbon in trunks, roots and soils; when they are felled and burned or left to decay, that carbon returns to the atmosphere as carbon dioxide, the principal greenhouse gas — deforestation is a significant contributor to global emissions. At the same time the world loses the forest's continuing service of absorbing carbon dioxide through photosynthesis, so emissions rise while

absorption falls. Regionally, forests recycle rainfall: moisture transpired by a large forest helps generate the rain that sustains it and the farmland downwind, so extensive clearing can reduce rainfall and lengthen dry seasons. Loss of canopy also changes local climate directly — cleared land is hotter by day, colder by night, windier and drier at the surface — worsening the conditions for crops, livestock and people nearby. For a climate-vulnerable country such as Pakistan, already suffering heatwaves, floods and glacial melt, the loss of its remaining hill and riverine forests removes one of the few natural buffers it possesses.

Impact 2: Soil Erosion, Flooding and Water Regime Damage

On slopes and along rivers the most immediate impact is physical. Tree canopies intercept rain, litter protects the surface, and roots bind the soil; remove them and raindrops strike bare earth, runoff races downhill, and sheet, rill and gully erosion strip the topsoil that took centuries to form. In Pakistan's northern catchments, deforested slopes deliver heavy silt loads to the Indus and its tributaries, shortening the life of Tarbela and Mangla reservoirs, raising riverbeds and reducing irrigation and hydropower capacity — a national cost of local tree-cutting. Without forest infiltration, rain that once soaked in and fed springs and steady streamflow now runs off at once, so floods become flashier and more destructive while dry-season flows shrink and springs dry up — the familiar paradox that deforestation brings both more floods and more drought. The devastating floods Pakistan has experienced cannot be blamed on deforestation alone, since extreme rainfall is the trigger, but stripped and degraded catchments unquestionably worsen flood peaks, landslides and the sediment that chokes channels and settlements.

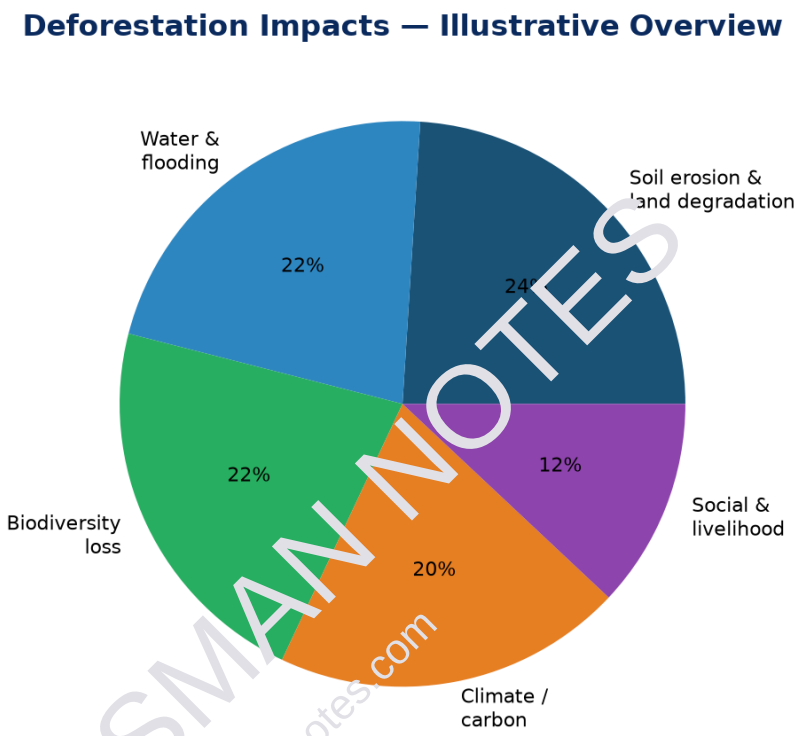


Figure 2: How the impacts of deforestation are distributed — an illustrative overview for study purposes, showing that soil, water, biodiversity and climate impacts are all major.

Impact 3: Biodiversity Loss and Ecosystem Breakdown

Forests, especially natural and old-growth forests, shelter the majority of terrestrial species. Clearing a forest destroys habitat outright, fragments what remains into isolated patches too small for many species, opens edges to hunters, fire and invasive species, and so drives local extinction long before the last tree falls — a process that continues for years in the fragments. Pakistan's forests support snow leopards, markhor, black bears, monal pheasants and countless plants, insects and fungi, many with medicinal or genetic value not yet studied; each lost species is an irreversible loss of genetic resource, of pollinators and pest controllers, and of the resilience of the ecosystem itself. Deforestation also breaks ecological services that farms and

villages depend on: wild pollinators decline, natural enemies of crop pests lose shelter, medicinal plants disappear, and fisheries suffer as eroded soil silts spawning streams. Because extinction cannot be undone, biodiversity loss is considered the most permanent of all the impacts discussed in this answer.

Impact 4: Social and Economic Impacts on Communities

Forest-dependent communities — often among the poorest — lose fuelwood, fodder, grazing, wild foods, honey, medicinal plants and building materials at once, and must spend more time and money obtaining substitutes; women and children, who usually collect fuel and fodder, walk further and work longer as forests retreat. Downstream, farmers suffer eroded fields, silted canals and less reliable water; cities face worse floods and hotter microclimates; and the state loses timber revenue, tourism potential and reservoir life. Deforestation also feeds social conflict over shrinking land and resources and contributes to rural migration. These impacts close the circle of causes: degraded land deepens poverty, and deepened poverty drives further clearing — the vicious cycle that integrated programmes of protection, planting and alternative livelihoods, discussed in the next questions, are designed to break.

Conclusion

To conclude, deforestation is caused directly by agricultural and settlement expansion, fuelwood and timber demand, overgrazing and fire, and underlyingly by poverty, population pressure, insecure tenure, weak governance and markets that value a felled tree but not a standing forest. Its impacts strike every system this course studies: carbon is released and rainfall disturbed, worsening climate change; soils erode, reservoirs silt and floods and droughts

intensify; species and whole ecosystems are lost irreversibly; and the poorest communities lose their safety net. Understanding these causes and impacts is the necessary first step towards the remedies — protection, afforestation, reforestation and community forestry — that the remainder of this assignment examines.

Question 4: Role of Forests in Climate Regulation (20 Marks)

Q. 4 Describe the role of forests in climate regulation. (20)

Introduction

Climate is the long-term pattern of temperature, rainfall, humidity and wind in a region, and its stability is one of the preconditions of agriculture, water supply and settled life. Forests are among the most powerful natural regulators of that climate, at every scale from the shade beneath a single tree to the composition of the global atmosphere. They do this through several distinct mechanisms: absorbing and storing carbon dioxide, releasing oxygen and water vapour, moderating temperature, influencing rainfall, slowing wind, and protecting the soils and waters that buffer climate extremes. At a time when human-caused climate change — driven mainly by burning fossil fuels and by deforestation itself — threatens Pakistan with heatwaves, shifting monsoons, glacial melt and floods, understanding the climatic role of forests is not academic: it identifies one of the cheapest and most beneficial tools available for both slowing climate change (mitigation) and coping with its effects (adaptation). This answer describes each mechanism in turn and then discusses the limits of what forests can do.

Carbon Sequestration and Storage: The Global Thermostat

The most important climatic role of forests is the regulation of atmospheric carbon dioxide, the principal long-lived greenhouse gas. Through photosynthesis, trees absorb carbon dioxide and convert it into wood, leaves and roots, releasing oxygen in the process: a growing forest is thus a carbon sink, continuously withdrawing the gas that warms the planet. The carbon is stored — sequestered — in five pools: above-ground biomass (trunks and branches), below-ground biomass (roots), dead wood, litter and, largest and most durable of all in many forests, soil organic carbon accumulated over centuries. Global forests store hundreds of billions of tonnes of carbon, more than the atmosphere itself contains, which is why their fate matters so much: conserved and expanded, they steadily cool the climate; cleared and burned, they become a major source of emissions, as the previous question explained. Young, vigorously growing forests absorb carbon fastest per hectare, while old forests store the largest stocks and continue slow absorption; both therefore matter, one for the rate of removal and the other for the safety of the store. Programmes such as REDD+ and Pakistan's large plantation drives rest on this mechanism, paying for or promoting forest carbon as a climate service.

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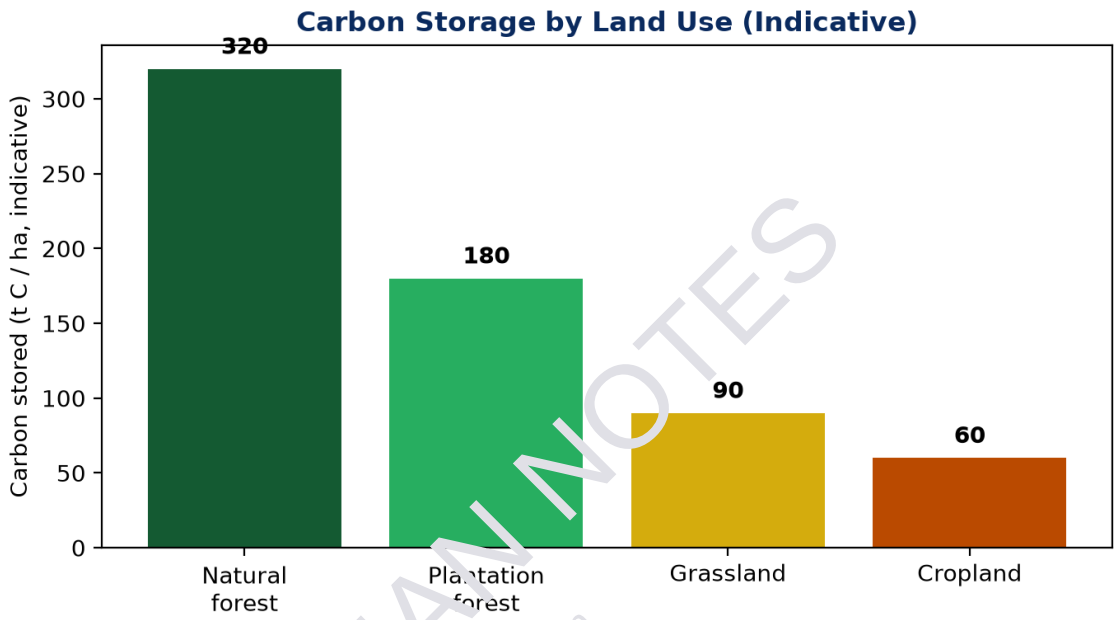


Figure 1: Illustrative comparison of carbon stored per hectare in different land uses — forests store far more carbon than cropland or grassland, mainly in biomass and soil. Values are indicative for study purposes.

Regulation of the Water Cycle and Rainfall

Forests regulate climate through water as powerfully as through carbon. A forest canopy intercepts rainfall, releasing part back to the atmosphere by evaporation, while the rest reaches the ground gently and infiltrates into the soil, recharging groundwater and feeding streams steadily. Through transpiration, a large forest returns enormous volumes of water vapour to the air; this moisture raises humidity, forms clouds and falls again as rain downwind — a recycling process by which continental forests help to generate and distribute the rainfall on which they and surrounding farmland depend. Scientists describe streams of atmospheric moisture from great forests as 'flying rivers'. When extensive forest is removed, this recycling weakens: less moisture is returned to the air, clouds form less readily, and rainfall can decline and become

more erratic, while the land surface, no longer shaded and moistened, heats more strongly and reinforces dryness. For water-stressed Pakistan, whose agriculture hangs on monsoon and western-disturbance rainfall and on river flows from forested northern catchments, the watershed role of forests — steady flows, recharged aquifers, reduced flood peaks — is climate regulation in its most practical form.

Temperature Moderation and Microclimate

Forests moderate temperature directly and measurably. Shade lowers the temperature of the ground and the air beneath the canopy — a forest interior on a hot afternoon can be several degrees cooler than open ground nearby — while evaporation and transpiration from leaves consume heat energy that would otherwise warm the air, a natural evaporative cooling. At night and in winter the canopy acts as a blanket, reducing heat loss and frost severity beneath it, protecting sensitive crops, orchards and livestock. At landscape scale, belts of trees reduce the urban heat-island effect, under which cities run several degrees hotter than their surroundings, and shelterbelts moderate the climate of fields across whole districts. Forests also increase surface roughness and slow the wind: windbreaks cut wind speed for a distance of many times the tree height downwind, reducing evaporation from soil and crops, preventing wind erosion and sand blasting, and sheltering homes and animals from desiccating winds such as the hot summer loo of the plains. These microclimatic services are climate regulation at the scale at which farmers and townspeople actually feel it, and in a warming country they grow more valuable every decade.

Table 1: Mechanisms by which forests regulate climate

Mechanism	How It Works	Climatic Benefit
Carbon sequestration	Photosynthesis stores CO2 in wood, roots and soil	Slows global warming; long-term carbon store
Oxygen release	By-product of photosynthesis	Maintains atmospheric composition
Evapotranspiration and rainfall recycling	Trees return water vapour to the air; clouds and rain form downwind	Sustains rainfall; raises humidity; steadier water supply
Interception and infiltration	Canopy softens rainfall; litter and roots aid soil intake	Fewer floods; recharged groundwater; steady river flows
Shade and evaporative cooling	Canopy blocks radiation; transpiration consumes heat	Cooler microclimate; less heat stress and frost damage
Wind regulation	Tree belts slow and deflect wind	Less evaporation, erosion and wind damage
Soil protection	Cover and roots prevent erosion and carbon loss from soil	Protects the largest land carbon pool; prevents desertification

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Forests, Albedo and Atmospheric Chemistry — A Balanced View

A complete university-level answer should note that forest–climate interactions are not all in one simple direction, and that science treats them with precision. Forests are darker than bare ground, snow or cropland, so they absorb more solar radiation (a lower albedo), which by itself would warm the surface; in the tropics and temperate zones the cooling from evapotranspiration and cloud formation comfortably outweighs this effect, while in snowy boreal regions the balance is finer and large-scale planting there has smaller, sometimes mixed, net benefits — one reason climate policy prioritises protecting tropical and temperate forests and planting in suitable zones rather than planting anywhere indiscriminately. Trees also emit small quantities of volatile organic compounds that take part in atmospheric chemistry, influencing cloud formation and air quality in complex ways, and a forest damaged by drought, fire or pests can temporarily switch from sink to source of carbon. None of this weakens the central conclusion — that the world's forests are indispensable climate regulators, especially through carbon storage and the water cycle — but it shows why forest climate policy must be scientifically designed: the right trees, in the right places, protected for the long term.

Forests as Adaptation: Buffering a Changed Climate

Beyond slowing climate change, forests help societies adapt to the change already under way, a role of direct importance to Pakistan. Hill forests reduce landslide and flood risk in catchments facing more intense rainfall; mangroves of the Indus delta protect the coast against storm surges and sea-level rise while supporting fisheries; riverine and farm forests shade and shelter crops and livestock against heatwaves; urban forests cool cities where heat is most dangerous

to health; and diverse natural forests act as reservoirs of genes and species that allow ecosystems and agriculture to adjust as conditions shift. Adaptation through ecosystems — often called ecosystem-based adaptation — is frequently cheaper and more durable than purely engineered defences, and it yields timber, fodder, food and biodiversity benefits at the same time. Conversely, every hectare of forest lost removes part of this protective infrastructure exactly when it is most needed, which is why climate strategies in Pakistan and internationally now place forest conservation, restoration and plantation at their centre.

Limits: What Forests Cannot Do Alone

Honesty about limits strengthens rather than weakens the case. Forests cannot absorb unlimited carbon: their total potential, though large, is smaller than cumulative fossil-fuel emissions, so planting trees can never be a substitute for reducing emissions from energy, industry and transport — it is a complement to that task, buying time and removing part of the excess. Forest carbon is also reversible: fire, drought, illegal felling or a change of policy can release a stored stock quickly, so permanence and protection are essential to any carbon claim. And forests themselves are victims of climate change — shifting temperature and rainfall zones, new pests and more frequent fires threaten the very systems relied upon for regulation — which creates an urgent feedback: the longer emissions continue, the harder it becomes for forests to keep performing their regulatory role. The policy conclusion is twin-track: cut emissions at source, and simultaneously conserve, restore and expand forests as the Earth's proven, self-maintaining climate regulation system.

Conclusion

In conclusion, forests regulate climate by absorbing and storing carbon dioxide and releasing oxygen; by driving the water cycle through interception, infiltration and transpiration, thereby sustaining rainfall and steady river flows; by cooling and sheltering the land surface, moderating temperature extremes and slowing damaging winds; and by protecting the carbon-rich soils beneath them. They also buffer societies against the floods, heat, storms and droughts that climate change intensifies. Their regulation is not unlimited and not a licence to continue polluting, but no technology exists that performs these combined services at comparable scale and cost. Protecting existing forests and restoring degraded ones is therefore among the wisest climate actions available — for the world, and acutely for Pakistan.

Question 5: Importance of Afforestation and Reforestation (20 Marks)

Q. 5 Explain the importance of afforestation and reforestation. (20)

Introduction

If deforestation is the disease examined in Question 3, afforestation and reforestation are the principal cures. Afforestation means establishing a forest on land that was not forest in recent history — planting trees on bare hills, degraded rangeland, saline or sandy wasteland, canal and road sides, and farmland. Reforestation (also called restocking or regeneration) means re-establishing forest on land from which forest was recently removed — by planting seedlings, by direct seeding, or by protecting natural regeneration from stumps, roots and seed already present on the site. The two are often discussed together because their benefits overlap almost

completely, and both are urgently needed in Pakistan, whose forest area of roughly five per cent of land is far below environmental requirements and whose existing forests continue to shrink under pressure. This answer explains the importance of afforestation and reforestation under ecological, climatic, economic and social heads, describes how successful programmes are carried out, and notes the conditions and cautions that decide whether planting actually delivers its promised benefits.

Ecological Importance: Restoring Ecosystems, Soil and Water

Ecologically, planting trees rebuilds the ecosystem whose loss deforestation caused. New forest cover protects bare soil from raindrop impact and wind, its roots bind slopes and riverbanks, and its litter rebuilds organic matter, so erosion is checked, degraded land begins to recover and, in favourable cases, desertification is halted and even reversed — rows of trees and shrubs are the standard living defence used to stabilise sand dunes in Thar and Cholistan and moving sand along roads and canals. Hydrologically, restored catchments intercept and infiltrate rain again, springs revive, streamflow steadies, silt loads to reservoirs fall, and flood peaks soften, extending the useful life of Pakistan's dams and irrigation system. For biodiversity, plantations and regenerated forests reconnect fragmented habitats, provide corridors along which wildlife can move, shelter pollinators and natural enemies of pests, and — when native and mixed species are used — can approach the richness of natural forest over time. Even single-purpose plantations protect biodiversity indirectly by supplying timber and fuelwood that would otherwise be cut from natural forests, relieving the pressure described throughout this assignment.

Climatic Importance: A Growing Carbon Sink

Climatically, every hectare successfully afforested or reforested is a new or restored carbon sink. Young trees in their vigorous growth phase absorb carbon dioxide rapidly and lock it into wood, roots and improving soil, directly offsetting a portion of human emissions, while the maturing stand later holds a large, long-lived store. At national scale, Pakistan's large planting campaigns — including the Billion Tree Tsunami in Khyber Pakhtunkhwa and the subsequent nationwide Ten Billion Tree Tsunami Programme — were designed substantially around this function, alongside watershed and livelihood goals, and they illustrate both the promise and the scrutiny such programmes attract: survival rates, species choice and protection after planting determine whether the claimed climate benefit is real. Planted forests also deliver the local climate services described in Question 4 — shade, cooling, wind shelter, dust control and humidity — which in cities take the form of urban forestry: avenues, parks and green belts that measurably cool neighbourhoods, filter air pollution and improve public health. As climate pledges under the Paris Agreement include land-based removals, well-documented afforestation and reforestation have become part of how countries meet international commitments and attract climate finance.

Economic Importance: Timber, Products and Employment

Economically, planting creates a renewable productive asset where previously there was degraded land or dependence on shrinking natural forest and expensive imports. Pakistan imports large quantities of timber, pulp and wood products; domestic plantations — of shisham, poplar, eucalyptus where suitable, mulberry for sericulture, and other farm and block

plantings — substitute for imports, save foreign exchange and supply construction, furniture, sports goods (Sialkot's willow and mulberry), paper and match industries. Farm forestry in particular puts trees on field boundaries, watercourses and small woodlots, giving farmers fuelwood, fodder, fruit, poles and a standing 'savings bank' of timber to fell for marriages, house-building or emergencies, without taking land out of crops. Non-timber products — honey from trees kept for bees, gums, resins, medicinal plants, mulberry leaves for silk — add further income streams. Planting, nursery raising, tending and protection are also labour-intensive rural employment, much of it suitable for the seasons when farm work is slack, and restored watersheds protect downstream farms, canals and power generation whose economic value dwarfs the cost of the planting itself.

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Table 1: Afforestation and reforestation compared

Feature	Afforestation	Reforestation
Land history	Land not under forest in recent times (bare, degraded, saline, sandy or farm land)	Land recently under forest, cleared or degraded
Main methods	Planting seedlings; shelterbelts; block and farm planting; dune fixation	Planting; direct seeding; protection of natural regeneration (coppice and seed)
Typical sites	Wastelands, canal/road/rail	Felled coupes, burnt or encroached forest, degraded

	sides, farms, cities, deserts	reserved forest
Primary gains	New forest area; reclamation of wasteland; import substitution	Restoration of forest cover, watershed and habitat where forest belongs
Key condition for success	Correct species for a new site; water and protection arrangements	Early protection from grazing and fire so regeneration establishes

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Social Importance: Fuel, Fodder and Community Well-Being

Socially, afforestation and reforestation answer the survival needs that themselves drive deforestation. Village woodlots and farm trees bring fuelwood and fodder close to home, shortening the daily collection burden borne mainly by women and children and releasing time for schooling and income work. Community plantations on common land, managed under agreed rules, rebuild a shared asset and the cooperation that goes with managing it, an experience that leads naturally into the social forestry examined in Assignment No. 2. Trees around homes, schools, mosques, graveyards and health centres provide shade, cleaner air, beauty and a sense of dignity in the environment; school and student planting builds the environmental awareness on which all long-term conservation depends. In disaster-prone areas, protective planting — mangroves on the coast, catchment forests in the hills, shelterbelts in the desert — is social protection in physical form, reducing the floods, surges and sandstorms that fall hardest on the poor. For all these reasons, planting programmes in Pakistan have

repeatedly been linked with poverty alleviation and rural development rather than treated as a purely departmental forestry activity.

How Successful Planting Is Done: Methods and Conditions

The promised benefits flow only when planting is done properly, and the course rightly stresses method. The sequence is: survey and choose the site, considering soil, water, climate and the purpose of the plantation; select species matched to the site and the objective — native and mixed species for ecological restoration, fast-growing species where early fuel or pulp is the aim, and always species whose water demand the site can bear; raise healthy seedlings in nurseries; prepare the site and plant at the correct season and spacing, in Pakistan typically with the monsoon or spring rains; and then — the step most often neglected — tend and protect the young plantation: watering where needed, weeding, replacing failures, and above all excluding grazing and preventing fire until trees are established. Reforestation should first consider natural regeneration, which is cheaper and genetically suited to the site, assisting it by protection and enrichment planting where stocking is thin. Success is counted not in seedlings distributed or pits dug but in area surviving and growing after three to five years, and honest monitoring on that basis separates genuine programmes from publicity exercises.

Cautions and Limitations

A balanced answer records the cautions. Planting the wrong species in the wrong place can do harm: thirsty monocultures in dry areas can lower water tables; exotic species may become invasive or support little wildlife; and single-species blocks are vulnerable to pests and disease that mixed planting resists. Afforestation must not become an excuse to neglect existing natural

forests, whose biodiversity and carbon a plantation takes decades to approach and never fully equals — protection of old forest always outranks new planting. Land chosen for planting may be grazing or common land on which the poor depend, so programmes that ignore local rights create conflict and fail; participation and benefit-sharing are practical necessities, not courtesies. Finally, planting without assured aftercare wastes public money: a smaller area planted and protected well achieves more, ecologically and economically, than a vast area planted and abandoned. These cautions define good practice rather than diminishing the importance of the activity itself.

Conclusion

In conclusion, afforestation and reforestation are important because they restore what deforestation destroys and supply what a growing country needs: they rebuild ecosystems, protect soil and water, revive springs and reduce floods; they create a growing carbon sink and cool and shelter the land; they produce timber, fuel, fodder and non-timber products, save imports and create rural employment; and they meet the daily needs of communities while protecting them from disaster. For Pakistan, with its small and shrinking forest estate and high climate vulnerability, large-scale, well-designed and honestly monitored planting — combined with strict protection of the natural forests that remain — is not an ornament of environmental policy but one of its foundations.