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11. Agro- Forestry Practices for Sustainable Agriculture

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Abstract:

Agroforestry refers to any of a broad range of land use practices where pasture or crops are integrated with trees and shrubs. Agroforestry works because it's farming in 3D – the roots reach deep into the ground to cycle nutrients and store carbon, while above ground, the trees protect crops and animals against the elements. Agroforestry can therefore solve many problems of intensive farming in one fell swoop. Unsustainable agricultural practices pose a serious threat to the integrity of landscapes and availability of soil mineral nutrients to plants. The phenomenon is compounded by changing global climatic conditions. This paper examines the potential role of agroforestry in mitigating changes due to undesirable human behaviour in the once forest dominated western highlands of Cameroon. Data were elicited from existing literature on agroforestry, landscape management, forestry, and subsistence agriculture. Findings lend credence to the fact that agroforestry systems constitute a promising option for maintaining the stability of landscapes and soils that are subjected to human activity. Aside from the major systems namely agro-silviculture, silvo-pastoral, and agro-silvopastoral, there exist other agroforestry categories like aquaforestry, apiculture, and sericulture. Living fences, alley cropping, improved fallow, shelter belts, home gardens, and scattered trees on croplands were highlighted to be suitable agroforestry practices for the western highland region of Cameroon. Agroforestry providing a way to support farmers' living conditions, develop a form of agriculture that is adapted to climate change, preserve biodiversity, and restore soils.

Keywords:

Agroforestry, practices, degradation, mitigation concepts, sustainable and land use systems

11.1 Introduction:

By combining trees with crops or livestock on a single agricultural plot, agroforestry is increasingly viewed as a significant element in the agroecological transition to sustainable farming and food systems. Agroforestry can be defined as a dynamic management system for natural resources based on ecological principles which introduces trees into farms and the agricultural landscape, thereby facilitating a form of diversified and sustained production that improves social, economic and environmental conditions for all land users.

Agroforestry refers to any of a broad range of land use practices where pasture or crops are integrated with trees and shrubs. This intentional combination of agriculture and forestry has multiple benefits, such as greatly enhanced yields from staple food crops, enhanced farmer livelihoods from income generation, increased biodiversity, improved soil structure and health, reduced erosion, and carbon sequestration. Trees in agroforestry systems can also produce wood, fruits, nuts, and other useful products with economic and practical value. Agroforestry practices are especially prevalent in the tropics,[2][3] especially in subsistence smallholdings areas [4] with particular importance in sub-Saharan Africa.[5] However, due to its multiple benefits, for instance in nutrient cycle benefits and potential for mitigating droughts, it has been adopted in the USA and Europe .[6][7][8]

Agroforestry shares principles with intercropping but can also involve much more complex multi-strata agroforests containing hundreds of species. Agroforestry can also utilise nitrogen-fixing plants such as legumes to restore soil nitrogen fertility. The nitrogen-fixing plants can be planted either sequentially or simultaneously.

Agroforestry, the integration of woody perennials with farming systems, has been practiced in India since time immemorial as a tradition land use system because it offers both economically and ecologically viable option to farmers and rural people community for large-scale diversification in agriculture to get supplement fuel, fodder, fruits and fibers on one hand and environment amelioration on the other hand.

Despite Agroforestry’s huge potential in India, the adoption rates are still low because there are several challenges that reap the benefits of agroforestry like shortage of superior planting material, insufficient research, lack of market infrastructure, cumbersome and frustrating legislation in respect of tree felling, wood transportation, processing. The adoption of National Agroforestry policy by the government of India in 2014 expected to remove these challenges as well as increases the farm productivity and the livelihood of the small and marginal farmers substantially in the future.

Alley cropping is defined as the planting of rows of trees and/or shrubs to create alleys within which agricultural or horticultural crops are produced. The trees may include valuable hardwood veneer or lumber species; fruit, nut or other specialty crop trees/shrubs; or desirable softwood species for wood fiber production.

11.2 Alley Cropping System:

Alley cropping can vary from simple systems such as an annual grain rotation between timber tree species to complex, multilayered systems that can produce a diverse range of agricultural products. Alley cropping systems are sometimes called intercropping, especially in tropical areas. It is especially attractive to producers interested in growing multiple crops on the same acreage to improve whole-farm yield. Growing a variety of crops in close proximity to each other can create significant benefits to producers, such as improved crop production and microclimate benefits and help them manage risk.

Alley cropping systems change over time. As trees and shrubs grow, they influence the light, water, and nutrient regimes in the field. These interactions are what sets alley cropping apart from more common monocropping systems. Common terminology used when discussing alley cropping systems are alley, alley crop, tree row, and within row spacing.

Some producers plan alley cropping systems to provide additional functions that support and enhance other aspects of their operation. For example, a livestock producer might grow crops that supply fodder, bedding, or mast crops for their livestock. Some producers may be interested in how alley cropping can support soil health. Other producers may want to produce biomass for on-farm use. Organic producers may choose tree species that fix nitrogen.

Farmers may also use alley cropping systems to transition from one farming system to another. The annual crops grown in alleys can provide short-term annual income until the trees are mature. The versatile nature of this practice allows a producer to react to markets, labor limitations and changing goals. Like all agroforestry systems, alley cropping systems should be considered as part of the whole farm operation.

Forest farming is the cultivation of high-value crops under the protection of a managed tree canopy. In some parts of the world, this is called multi-story cropping and when used on a small scale in the tropics it is sometimes called home gardening. It is not just recreational harvesting or wild harvesting wild harvesting of native understory wood land plants without management; management is an essential part of forest farming. This approach to crop production intentionally uses both vertical space and the interactions of the plants and microclimate.

The intensity of forest farming production can vary depending on the producer's goals, available markets, processing equipment and the site. Some examples of management activities include harvesting and scattering local seed; thinning out competing plants; additional site preparation for planting seeds, bulbs or plant starts; soil amendments for pH or fertility; constructed raised planting beds; pest control; and even fencing to keep out animals and poachers. Non-timber specialty products like goldenseal can be cultivated beneath a tree canopy. Often these woodland crops grown under a canopy are called Non-Timber Forest Products or NTFPs. Crops like ginseng, goldenseal, shiitake or other mushrooms, and decorative ferns are used or sold for medicinal, culinary, and ornamental uses. Forest farming can provide shorter-term income while high-quality trees are being grown for wood or other tree products.

Forest farming is most often used on private lands to supplement family income. Because of the demand and high value of some of these plants they can no longer be found in many places within their historic native range. Wild harvesting of these plants is not allowed on public land in many areas, making forest farming an important option for meeting demand for these plants. Even if the plants of interest are not present in woodland, the careful inspection of the understory woodland plants may identify other non-economic plants that are often found with these more desirable NTFPs.

If so, this may indicate a good location to reintroduce and grow the desired NTFP. Additional benefits of this intensified production is the regular attention in the woods may help to spot and control invasive plants and pests as well as the reduced harvest pressure on wild plant populations that allows them to be re-established in other woodlands in the region.

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A riparian forest buffer is an area adjacent to a stream, lake, or wetland that contains a combination of trees, shrubs, and/or other perennial plants and is managed differently from the surrounding landscape, primarily to provide conservation benefits. Riparian buffers can also be managed to include trees and shrubs that produce a harvestable crop along with the conservation benefits, although this is less common. Buffers are used in agricultural, row crop, range, suburban, and urban settings. A wide variety of state and federal programs support the installation of riparian forest buffers on public and private lands.

Riparian forest buffers can deliver a number benefits including filtering nutrients, pesticides, and animal waste from agricultural land runoff; stabilizing eroding banks; filtering sediment from runoff; providing shade, shelter, and food for fish and other aquatic organisms; providing wildlife habitat and corridors for terrestrial organisms; protecting cropland and downstream communities from flood damage; producing income from farmland that is frequently flooded or has poor yields; providing space for recreation; and diversifying landowner income.

Riparian forest buffers can be included in landscape-scale green infrastructure plans to serve a variety of functions, particularly along the rural-urban interface. Green infrastructure is an approach to conservation that involves creating a network of green areas to benefit people and wildlife. Although riparian forest buffers are often designed primarily for water quality benefits, these practices can also include woody species that provide products such as nuts, fruit, and decorative woody florals. (USDA National Agroforestry Center illustration). A number of factors can impact the effectiveness of riparian forest buffers in meeting these objectives. These include site conditions such as adjacent agricultural practices and crop types, stream size, topography, and soils; landscape conditions such as position in the watershed, adjacent land use, and buffer continuity; and other conditions such as markets and public interest. Riparian forest buffer planning and design is important for enhancing the effectiveness of riparian buffers.

Silvopasture is the deliberate integration of trees and grazing livestock operations on the same land. These systems are intensively managed for both forest products and forage, providing both short- and long-term income sources. Well-managed silvopastures employ agronomic principals, typically including introduced or native pasture grasses, fertilization and nitrogen-fixing legumes, and rotational grazing systems that employ short grazing periods that maximize vegetative plant growth and harvest. The annual grazing income helps cash flow the tree operation while the tree crop matures and creates easy access if and when the trees or tree products are harvested. While these systems can require a number of management activities, the benefits can make it worthwhile.

Potential livestock choices include: cattle, sheep, goats, horses, turkeys, chickens, ostriches, emu, rhea, or game animals such as bison, deer, elk, caribou, etc. Trees can supply valuable fodder or mast such as acorns and honey locust pods for livestock.

One of the main advantages of silvopasture systems is reducing heat stress in livestock, which improves animal performance and well-being. It is important to note that not every pasture in a livestock enterprise needs to be a silvopasture to take advantage of the benefits of this integrated system.

Silvopastures can increase wildlife diversity (e.g., quail, turkey) and improve water quality. The forage protects the soil from water and wind erosion, while adding organic matter to improve soil properties. Silvopastures provide an attractive landscape with an aesthetically pleasing "park-like" setting.

Windbreaks are linear plantings of trees and shrubs designed to provide economic, environmental and community benefits. The primary purpose of most windbreaks is to slow the wind which creates a more beneficial condition for soils, crops, livestock, wildlife and people. Windbreaks, sometimes called shelterbelts, can also function in ways not related to wind reduction. Non-wind related purposes include shade for livestock, visual screening, aesthetics, recreational opportunities, and wood and nontimber forest products. Windbreaks have also been recognized for their value in providing ecosystem services, which often extend beyond the farm. Benefits include enhancement of biodiversity, wildlife habitat, carbon storage, pollinator habitat, and soil and water quality protection. Increasingly windbreaks are being designed to provide additional sources of income and products that can be used in the farm operation.

Windbreaks can be and often are designed to serve more than one purpose. However, windbreaks are not a one size fits all practice. The location, orientation to the wind, height, width, density and species selection all play a role in determining the benefits that the windbreak will provide.

There are several types of windbreaks. Field windbreaks protect a variety of wind-sensitive crops, control soil wind erosion, increase crop yields, and increase bee pollination and irrigation and pesticide effectiveness. Field windbreaks can also be designed to spread snow evenly across a field, increasing spring soil moisture. Livestock windbreaks help reduce mortality from cold weather, animal stress, and feed consumption, all of which lead to increased weight gain and milk production. Windbreaks also help reduce visual impacts, noise, and odors from livestock operations. Living snow fences keep roads clear of drifting snow and increase driving safety. Farmstead windbreaks reduce heating costs and improve outdoor working conditions.

Adding specialty products like red-stemmed dogwood to a windbreak can provide an additional source of income for landowners. (USDA National Agroforestry Center photo)

Increasingly windbreaks are being designed to provide additional sources of income. Some trees and shrubs can produce fruits, nuts, fuel, fodder or materials for crafts that can be sold or processed in order to diversify farm income. In these cases the crop that is harvested from the trees and shrubs in a manner that does not impair the shelterbelt function. Careful design is required to reduce potential conflicts between management of the crop field and the windbreak. Some other specialized windbreaks include pollinator habitat and field buffers for organic production. Pollinators can be supported by including a variety of plants that bloom at different times to provide food over a longer period of time. Native pollinators can also be supported by choosing plants that are used for bee nesting and merely by providing undisturbed soil for ground nesting bees. Shelterbelts can also be designed to intercept pesticides and chemical laden dust to protect organic production fields and active pollinators, both wild and domesticated.

Currently, significant work is being carried out by NAC and its partners to support windbreak inventory, establishment, and renovation. Windbreaks of the Great Plains is a Story Map that visually depicts the history, status, and opportunities of windbreaks in this region. Another web app, Trees Outside Forests Interactive Web Viewer, highlights agroforestry in the Northern Plains states including high-resolution tree cover maps.

A comprehensive synthesis of windbreak adoption in the U.S. by staff of the National Agroforestry Center found that producers use windbreaks primarily for indirect economic benefits (soil erosion control, livestock protection, wind protection and snow control). This was followed by direct agricultural benefits (increased crop and livestock production) and intrinsic values (aesthetics and wildlife habitat). Across the 32 windbreak studies in this review, which covered U.S. producer opinions from 1949-2020, windbreak satisfaction was incredibly high, ranging from 72-99%.

McAdam et al. 2009)

Classification method	Example categories
i) Components	**Agrisilviculture:** crops and trees including shrub/trees and trees **Silvopastoral:** pasture/animals and trees **Agrosilvopastoral:** crops, pasture/animals and trees **Other:** multipurpose tree lots, apiculture with trees, aquaculture with trees
ii) Predominant land use	**Primarily agriculture** **Primarily forestry**
iii) Spatial (in space) arrangements	**Mixed dense** (e.g. home garden), **Mixed sparse** (e.g. most systems of trees in pasture) **Strip** (width of strip to be more than one tree) **Boundary** (trees on edges of plots/fields)
iv) Temporal (in time) arrangements	Overlapping, separate, (coincident, interpolated)
v) Agroecological (environmental adaptability)	Humid, arid, mountainous or high land/low land
vi) Socio-economic and Management level	Based on level of technology input: Low, medium and high input Based on cost/benefit relations: commercial, intermediate, subsistence
vii) Function (*)	**Productive function (provisioning):** food, fodder, fuel wood, other products **Habitat function (supporting):** Biodiversity **Regulating:** Climate, flood and drought prevention, water purification, shelterbelt, soil and water conservation, shade **Cultural functions**: recreation and landscape

(* vii) Function: It is possible to classify agroforestry systems according to the function of the system. **Productive functions** of the tree components of European agroforestry systems include fruit, oil and nuts, timber, firewood, cork, fodder, grain seeds, vegetables, soft fruits and grapes, biomass feedstock.

Agroforestry is a collective name for land-use systems involving trees combined with crops and/or animals on the same unit of land. It combines

- Production of multiple outputs with protection of the resource base;

- Places emphasis on the use of multiple indigenous trees and shrubs;
- Particularly suitable for low-input conditions and fragile environments;
- It involves the interplay of socio-cultural values more than in most other land-use systems; and
- It is structurally and functionally more complex than monoculture.

A. Agroforestry is any sustainable land-use system that maintains or increases total yields by combining food crops (annuals) with tree crops (perennials) and/or livestock on the same unit of land, either alternately or at the same time, using management practices that suit the social and cultural characteristics of the local people and the economic and ecological conditions of the area.

B. Agroforestry is a collective name for a land-use system and technology whereby woody perennials are deliberately used on the same land management unit as agricultural crops and/or animals in some form of spatial arrangement or temporal sequence. In an agroforestry system there are both ecological and economical interactions between the various components. Social forestry is defined as "Forestry outside the conventional forests which primarily aim at providing continuous flow of goods and services for the benefit of people. This definition implies that the production of forest goods for the needs of the local people is social forestry. Thus, social forestry aims at growing forests of the choice of the local population. Shah (1985) stated that Conceptually Social forestry deals with poor people to produce goods such as fuel, fodder etc. to meet the needs of the local community particularly underprivileged section.

A. Farm Forestry: Farm forestry is the name given to programmes which promote commercial tree growing by farmers on their own land. Farm forestry was defined by NCA (1976) as the practice of forestry in all its aspects in and the around the farms or village lands integrated with other farm operations.

B. Extension Forestry: It is the practice of forestry in areas devoid of tree growth and other vegetation situated in places away from the conventional forest areas with the object of increasing the area under tree growth.

It includes the following.

- Mixed forestry: It is the practice of forestry for raising fodder grass with scattered fodder trees, fruit trees and fuel wood trees on suitable wastelands, panchayat lands and village commons
- Shelterbelts: Shelterbelt is defined as a belt of trees and or shrubs maintained for the purpose of shelter from wind, sun, snow drift, etc.
- Linear Strip plantations: These are the plantations of fast-growing species on linear strips of land.

C. Rehabilitation of Degraded forests: The degraded area under forests needs immediate attention for ecological restoration and for meeting the socio-economic needs of the communities living in and around such areas.

D. Recreation Forestry: It is the practice of forestry with the object of raising flowering trees and shrubs mainly to serve as recreation forests for the urban and rural population. This type of forestry is also known as **Aesthetic forestry** which is defined as the practice of forestry with the object of developing or maintaining a forest of high scenic value.

11.3 Types of Agroforestry Systems:

11.3.1 Structural Basis:

A. Nature of Components:

a. Agri silvicultural Systems

In this system, agricultural crops are intercropped with tree crops in the interspace between the trees. Under this system agricultural crops can be grown upto two years under protective irrigated condition and under rainfed farming upto four years. The crops can be grown profitably upto the above said period beyond which it is uneconomical to grow grain crops. However, fodder crops, shade loving crops and shallow rooted crops can be grown economically. Wider spacing is adopted without sacrificing tree population for easy cultural operation and to get more sunlight to the intercrop. Performance of the tree crops is better in this system when compared to monoculture.

b. Silvopastoral Systems:

The production of woody plants combined with pasture is referred to Silvipasture system. The trees and shrubs may be used primarily to produce fodder for livestock or they may be grown for timber, fuelwood, fruit or to improve the soil.

This system is classified in to three categories

- Protein bank
- Livefence of fodder trees and hedges
- Trees and shrubs on pasture

Protein bank: In this Silvipastoral system, various multipurpose trees (protein rich trees) are planted in or around farmlands and range lands for cut and carry fodder production to meet the feed requirement of livestock during the fodder deficit period in winter.

Example: *Acacia nilotica, Albizia lebbeck, Azadirachta indica, Leucaena leucocephala, Gliricidia sepium, Sesbania grandiflora*

Livefence of fodder trees and hedges: In this system, various fodder trees and hedges are planted as live fence to protect the property from stray animals or other biotic influences.

Example: *Gliricidia sepium, Sesbania grandiflora, Erythrina sp, Acacia sp.*

Trees and shrubs on pasture: In this system, various tree and shrub species are scattered irregularly or arranged according to some systemic pattern to supplement forage production.

Example: *Acacia nilotica, Acacia leucophloea, Tamarindus indica, Azadirachta indica.*

c. Agrosilvopastoral Systems:

The production of woody perennials combined with annuals and pastures is referred Agrisilvopastural system.

This system is grouped into two categories.

I. home gardens

II. Woody hedgerows for browse, mulch, green manure and soil conservation

I. Home Gardens:

This system is found extensively in high rainfall areas in tropical South and South east Asia. This practice finds expression in the states of Kerala and Tamil Nadu with humid tropical climates where coconut is the main crop. Many species of trees, bushes, vegetables and other herbaceous plants are grown in dense and in random or spatial and temporal arrangements. Most home gardens also support a variety of animals. Fodder grass and legumes are also grown to meet the fodder requirement of cattle. In India, every homestead has around 0.20 to 0.50 ha land for personal production.

Home gardens represent land use systems involving deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops and livestock within the compounds of individual houses. The whole tree- crop- animal units are being intensively managed by family labour. Home gardens can also be called as **Multitier system or Multitier cropping.** Home gardens are highly productive, sustainable and very practicable. Food production is primary function of most home gardens.

Structure of Home Gardens: Home gardens are characterized by high species diversity and usually 3-4 vertical canopy strata. The layered configuration and compatible species admixture are the most conspicuous characteristics of all home gardens. Generally, all home gardens consist of an herbaceous layer near the ground, a tree layer at the upper levels and an intermediate layer. The lower layer can be partitioned into two, the lowermost being at less than 1.0m in height, dominated by different vegetables and the second layer of 1.0 - 3.0/m height comprising food crops such as banana, papaya and so on.

The upper tree layer can also be divided into two, consisting of emergent, full grown timber and fruit trees occupying the upper most layer of 25m height and medium size trees of 10-20m occupying the next lower layer. The intermediate layer of 5-10m height is dominated by various fruit trees.

Choice of Species:

- Woody species: Anacardium occidentale,Artocarpus heterophyllus, Citrus spp, Psiduim guajava, Mangifera indica, Azadirachta indica, Cocus nucifera,
- Herbaceous species: Bhendi, Onion, cabbage, Pumpkin, Sweet potato, Banana, Beans, etc.

II. Woody Hedgerows:

In this system various woody hedges, especially fast growing and coppicing fodder shrubs and trees are planted for the purpose of browse, mulch, green manure, soil conservation etc. The following species viz., *Erythrina sp, Leucaena luecocephala, Sesbania grandiflora* are generally used.

- **Apiculture with trees:** In this system various honey (nector) producing trees frequently visited by honeybees are planted on the boundary of the agricultural fields
- **Aquaforestry:** In this system various trees and shrubs preferred by fish are planted on the boundary and around fish ponds. Tree leaves are used as feed for fish. The main role of this system is fish production and bund stabilization around fish ponds
- **Mixed wood lots:** In this system, special location specific MultiPurpose Trees (MPTs) are grown mixed or separately planted for various purposes such as wood, fodder, soil conservation, soil reclamation etc.

B. Arrangement of Components:

I. Spatial arrangement

II. Temporal arrangement

I. Spatial Arrangement: Spatial arrangement of plants in an agroforestry mixture may result in dense mixed stands (as in home gardens) or in sparse mixed stands (as in most systems of trees in pastures).

II. Temporal Arrangement: Temporal arrangements of plants in Agroforestry may also take various forms. An extreme example is the conventional shifting cultivation cycles involving 2-4 years of cropping and more than 15 years of fallow cycle, when a selected woody species or mixtures of species may be planted. Similarly, some silvipastoral systems may involve grass leys in rotation with some species of grass remaining on the land for several years. These temporal arrangement of components in agroforestry are termed coincident, concomitant, overlapping, separate and interpolated.

11.3.2 Functional Basis:

All agroforestry systems have two functions.

A. Productive functions,

B. Protective functions

A. Productive Functions

The Productive functions are:

- Food
- Fodder
- Fuel wood
- Cloths
- Shelter
- NTFPs

B. Protective Functions:

The Protective functions are:

- Wind breaks
- Shelterbelts
- Soil conservation
- Soil improvement

11.3.3 Socio-Economic Classification:

Based on socioeconomic criteria as scale of production and level of technology input and management, agroforestry systems have been grouped in to three categories.

A. Commercial Agroforestry systems
B. Intermediate Agroforestry systems
C. Subsistence Agroforestry systems

A. Commercial AF systems:

The term commercial is used whenever the scale of the production of the output is the major aim of the system.

Examples:

- Commercial production of plantation crops such as rubber, oil palm, and coconut with permanent underplanting of food crops, pastures
- Commercial production shade tolerating plantation crops such as coffee, tea and cocoa under overstorey of shade trees

B. Intermediate AF systems: Intermediate systems are those between commercial and subsistence scale of production and management.

Examples: Production of perennial cash crops and subsistence food crops undertaken on farms wherein the cash crops fulfill the cash needs and the food crops meet the family 's food needs.

C. Subsistence AF systems:

Subsistence AF systems are those wherein the use of land is directed towards satisfying basic needs and is managed mostly by the owner and his family.

11.3.4 Ecological Classification:

A. Humid / sub humid
B. Semiarid / arid
C. Highlands

A. Agroforestry systems in Humid / Subhumid low lands Examples:

Home gardens, Trees on rangelands and pastures, improved fallow in shifting cultivation and Multipurpose woodlots.

C. Agroforestry systems in Semiarid and arid lands Examples:

Various forms of silvopastoral systems, wind breaks and shelterbelts.

D. **Agroforestry systems in Tropical High lands Examples:**

Production systems involving plantation crops such as coffee, tea, use of woody perennials in soil conservation and improved fallow.

11.4 Benefits of Agroforestry System:

A. Environmental Benefits

- Reduction of pressure on natural forests.
- More efficient recycling of nutrients by deep rooted trees on the site
- Better protection of ecological systems
- Reduction of surface run-off, nutrient leaching and soil erosion through impeding effect of tree roots and stems on these processes
- Improvement of microclimate, such as lowering of soil surface temperature and reduction of evaporation of soil moisture through a combination of mulching and shading
- Increment in soil nutrients through addition and decomposition of litterfall.
- Improvement of soil structure through the constant addition of organic matter from decomposed litter.

B. Economic Benefits:

- Increment in an output of food, fuel wood, fodder, fertilizer and timber;
- Reduction in incidence of total crop failure, which is common to single cropping or monoculture systems
- Increase in levels of farm income due to improved and sustained productivity

C. Social Benefits:

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

11.5 Role in Sustainable Agriculture:

Agroforestry systems can provide a number of ecosystem services which can contribute to sustainable agriculture in the following ways;

- Diversification of agricultural products, such as fuelwood, medicinal plants, and multiple crops, increases income security[28]
- Increased food security and nutrition by restored soil fertility, crop diversity and resilience to weather shocks for food crops.
- Land restoration through reducing soil erosion and regulating water availability.
- Multifunctional site use, e.g., crop production and animal grazing
- Reduced deforestation and pressure on woodlands by providing farm-grown fuel wood
- Possibility of reduced chemicals inputs, e.g. due to improved use of fertilizer, increased resilience against pests, and increased ground cover which reduces weeds.
- Growing space for medicinal plants e.g., in situations where people have limited access to mainstream medicines

According to FAO's The State of the World's Forests 2020, adopting agroforestry and sustainable production practices, restoring the productivity of degraded agricultural lands, embracing healthier diets and reducing food loss and waste are all actions that urgently need to be scaled up. Agribusinesses must meet their commitments to deforestation-free commodity chains and companies that have not made zero-deforestation commitments should do so.

11.6 Conclusion:

We conclude that agroforestry is one of the best land use strategies to contribute to food security while simultaneously limiting environmental degradation. Agroforestry practices have already clearly demonstrated their value: run-off and soil erosion are reduced; soil ecosystems (microorganisms and macrofauna) and structures are improved, encouraging the availability of water and nutrients; habitats or corridors for the movement of many species. By adopting sustainable practices, farmers will reduce their reliance on nonrenewable energy, reduce chemical use and save scarce resources. Keeping the land healthy and replenished can go a long way when considering the rising population and demand for food.

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