Review Article

Green Solutions: The Impact of Agroforestry on Climate Change Resilience- A Review

Abstract:

By utilising trees and other vegetation as carbon sinks to store carbon, agroforestry plays a vital role in mitigating climate change by lowering greenhouse gas emissions and boosting ecosystem resilience. These systems enable sustainable soil management, water conservation, and biodiversity preservation-three essential ecosystem services for climate resilience. Additionally, by maximising the use of natural resources, agroforestry practices lessen the burden on forests and aid in the restoration of damaged regions. Climate change poses tremendous difficulties to global agriculture, affecting livelihoods, food security, and ecosystem stability. Agroforestry is a promising integrated land management technique that combines agricultural and forestry practices to lessen the effects of climate change. This summary provides an overview of the vital roles that agroforestry plays in mitigating and adapting to climate change. In order to adapt to climate change, agroforestry offers several benefits, including increased agricultural productivity, improved soil fertility, and improved water retention. Agroforestry systems provide shade, protection, and windbreaks to shield crops and cattle from inclement weather. Moreover, the diverse range of species present in agroforestry systems creates robust and stable ecosystems that ensure food and income security in the face of climate change.

Keywords:carbon sinks, Agro-forestry, climate resilience, food security, climate change, soil fertility, ecosystems, water conservation and biodiversity

Introduction:

Agroforestry is a sustainable method of land management that combines forestry and agriculture on the same plot of land. Agroforestry is a system that mixes agricultural crops, tree crops, and forest plants and/or animals either simultaneously or sequentially. It was first defined by Bene *et al.* (1977). This method tries to improve overall land production while harmonising with the customs of the local community. A revised definition was proposed by King and Chandler (1978), who emphasised sustainable land management as combining forest flora and/or animals with crop production, including tree crops, on the same land unit.Nair

(1983) expanded on the idea, characterising agroforestry as the integration of trees, crops, and animals in farming systems that is supported by science, desirable from an ecological standpoint, practically achievable, and acceptable in society. The deliberate planting of trees and shrubs in agricultural landscapes to maximise land utilisation and provide a variety of benefits like windbreaks, shade, better soil fertility, erosion control, biodiversity enhancement, and additional revenue streams is known as agroforestry (Nair, 2018). This technique can be used to create a variety of agroforestry systems in various ecological and socioeconomic circumstances. Examples include silvo-pasture, which combines trees with cattle grazing, alley cropping, which involves planting trees in between crop rows, and forest gardening, which involves a diversity of edible plants, trees, and shrubs organised in a setting resembling a forest (Jose, 2009). Agroforestry is a sustainable and profitable farming method because these systems provide ecosystem services, improve soil health, and foster ecological resilience.

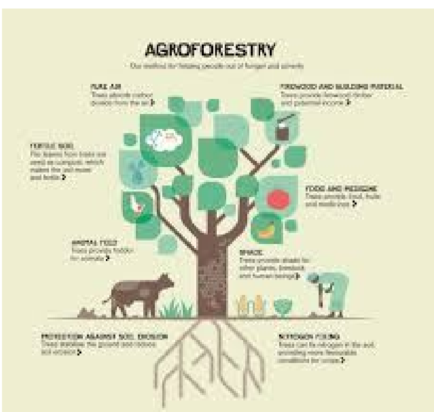

Fig 1-Agroforestry

Agroforestry's significance in combating climate change

Agro-forestry: By offering several benefits to the environment, society, and economy, it makes a substantial contribution to the fight against climate change. Research studies and expert perspectives emphasise its significance in climate change adaptation and mitigation methods.

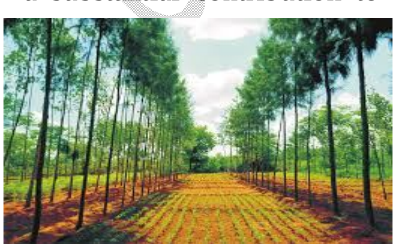

Fig 2-Agroforestry's significance in combating climate change

Carbon Sequestration: By absorbing CO_2 from the atmosphere, agroforestry systems act as carbon sinks. Trees and other vegetation store carbon, lowering greenhouse gas emissions (Nair, 2018). This process lowers atmospheric carbon levels, which aids in the mitigation of climate change.

Biodiversity: By establishing a variety of ecosystems, agroforestry promotes biodiversity. According to Montagnini (2011), biodiverse systems are resistant to climate change, maintaining genetic diversity and the stability of ecosystems. The preservation of biodiversity makes ecosystems more resilient and adaptable to shifting environmental circumstances.

Improved soil fertility and structure are the results of agroforestry practices. Healthy soils absorb carbon and withstand harsh weather conditions better (Jose, 2018). Improved soil health guarantees long-term agricultural productivity even in the face of climate-related problems.

Water Management: Agroforestry helps to preserve available water supplies. In order to maintain a steady supply of water during dry spells, trees and other vegetation control water flow, reduce erosion, and enhance water infiltration (Nair, 2018). The agricultural sector depends on effective water management in light of shifting precipitation patterns.

Economic Resilience: Water resources are preserved by agroforestry. In order to maintain a steady supply of water during dry spells, trees and other vegetation control water flow, reduce erosion, and enhance water infiltration (Nair, 2018). Agriculture needs to effectively manage its water resources in light of shifting precipitation patterns.

Erosion Control: The use of agroforestry systems aids in preventing soil erosion. According to Montagnini (2007), the root systems of trees and shrubs stabilise the soil, halting erosion and the loss of valuable topsoil. It's vital to control erosion, particularly in places where landslides and soil erosion are common.

Climate Modification: Agroforestry provides natural defences against climate-related calamities. Shade trees lessen heat stress on plants and animals during heat waves, and windbreaks and shelterbelts protect crops and cattle from strong winds and storms (Jose, 2009). The resilience of agriculture to climate extremes is enhanced by these adaptive traits.

Social Involvement: Agroforestry promotes information exchange and community involvement. Indigenous and traditional knowledge of agroforestry techniques is crucial for adjusting to the climate in the area (Garrity et al., 2010). Participation in the community increases resilience and adaptive capacity locally

Agri and Global Climate Change:

Climate change has major effects on agriculture, including crop yields, water availability, soil health, and the incidence of pests and diseases (IPCC, 2022). The complex interactions between agriculture and climate change present serious obstacles to livelihoods, food security, and international economies. Here are some significant facets of the connection between agriculture and climate change:

Water shortage: In many places, the lack of water is made worse by altered rainfall patterns and greater evaporation as temperatures rise. Lack of water has an impact on livestock, irrigation, and overall agricultural productivity. Adapting water availability requires the use of effective water management techniques.

Agriculture Production: Crop yields may be positively or negatively impacted by climate change. Certain crops may benefit from increased temperatures and carbon dioxide levels, but others may suffer from heat stress and shifting insect dynamics. Overall, especially in sensitive areas, negative effects on agricultural productivity are anticipated to outweigh positive ones.

Soil Quality: Temperature and moisture variations brought about by climate change have an impact on soil health. Variations in soil moisture content can affect soil structure and nutrient availability. Severe weather conditions worsen soil erosion and deterioration, which further reduces agricultural output.

Dynamics of Pests and Diseases: The distribution and prevalence of pests and diseases are impacted by climate change. Crops, livestock, and aquaculture are all at risk from pests and illnesses that proliferate due to warmer temperatures and changing precipitation patterns.

Resilience Approaches: In order to adapt to shifting weather patterns, farmers and agricultural systems must alter. Crop types that are robust to climate change are planted; effective water management strategies are put into place; sustainable soil conservation methods are encouraged; and agroforestry and diversified cropping systems are combined. Climate-smart agricultural practises are designed to minimise environmental impact and increase resilience. World Food Security: The ability of agriculture to supply the world's growing food needs is threatened by climate change. Vulnerable populations, especially those in developing nations, are more likely to experience food insecurity as a result of climate-related disruptions to agricultural productivity and food supply systems.

Current agroforestry effects of climate change:

The implications of climate change on agriculture require cooperative actions at the policy, research, and community levels as of my January 2022 update of NASA's Earth science. Governments and international institutions must assist climate-resilient agriculture and forestry.

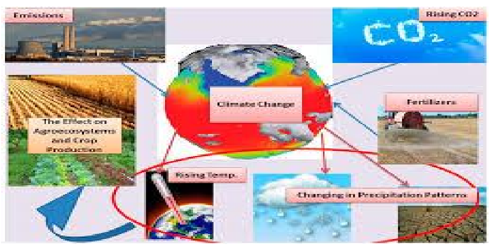

Fig 3.Current agroforestry effects of climate change

Shifting planting periods: The growing season is shifting as a result of changing precipitation patterns and rising temperatures. Crop life cycles can be upset by warmer winters and earlier springs, which lower yields and quality.

Water Shortage and Deserts: As droughts become more regular and severe, many places are experiencing a shortage of water. A scarcity of irrigation water hinders crop development and yield.

Flooding and Waterlogged: Variations in precipitation patterns can result in flooding and heavy precipitation. Overabundance of water can result in waterlogging in fields, which can harm or destroy crops by depriving plant roots of oxygen.

Thermal Stress: Variations in precipitation patterns can lead to flooding and a lot of rain. Overabundance of water can lead to waterlogging in fields, which damages or destroys crops by depriving plant roots of oxygen.

Outbreaks of Disease and Pests: The spread of illnesses and pests is facilitated by changing weather patterns and rising temperatures. Pest infestations are a growing threat to agricultural crops and, if left unchecked, can cause substantial losses.

Soil Eroding: Severe weather conditions, such torrential downpours and thunderstorms, can erode soil, causing rich topsoil to disappear. Both agricultural productivity and soil quality are negatively impacted by soil erosion.

Crop output declines are caused by a number of climate change-related variables, including heat stress, drought, and pest infestations. Soybeans, maize, wheat, and rice are some of the most susceptible crops.

Changes in Appropriate Agricultural Areas: Factors associated to climate change, such as heat stress, drought, and pest infestations, are the main causes of crop output losses. Soybeans, maize, wheat, and rice are some of the most susceptible crops.

Impact on cattle: Modifications in grazing patterns, water availability, and disease prevalence are some of the ways that climate change affects cattle. It has been demonstrated that heat stress lowers animal productivity, which has an impact on the production of dairy and meat.

Concerns about Food Security: The combination of these variables presents serious obstacles to global food security. Vulnerable groups, especially those in developing nations, are more likely to experience hunger and malnutrition as a result of agricultural disturbances brought on by climate change (FAO 2019).

Traditional farming systems are susceptible to a number of problems, most notably modernisation and climate change, despite the fact that they are frequently rich and diversified culturally. The following are some reasons that traditional farming systems are vulnerable:

Environmental Sensitivity: Climate change often has an impact on traditional farming methods. By changing temperature, precipitation patterns, and the frequency of extreme weather events, climate change has the potential to disrupt these long-standing customs and have an impact on animal production and agricultural yields.

Water Limited Supplies: Many traditional farming methods use rainfed agriculture. Water scarcity problems can arise from modifications in precipitation patterns that lead to droughts or lower the amount of water available for irrigation and crop production.

Diversity Changes: A large variety of unique, locally adapted animal breeds and crop kinds are routinely cultivated as part of traditional farming practices. Modern farming methods that reduce biodiversity and genetic resources include monoculture and the use of high-yielding varieties, which can lead to the extinction of native and traditional plant and animal species.

Soil Deterioration: Sustainable soil management practices are often included into traditional farming methods. On the other hand, deforestation, inappropriate land use, and agricultural intensification can result in soil deterioration, erosion, and loss of fertility, which lowers agricultural output.

Limited Access to Sources: In underdeveloped nations especially, traditional farmers may have restricted access to resources like irrigation systems, enhanced seeds, contemporary agricultural technologies, and financial support. This deficiency hinders their capacity to adjust to shifting environmental conditions.

Market Difficulties: It could be difficult for traditional farmers to get into markets and get reasonable pricing for their goods. Modern supply networks and globalisation have the potential to marginalise traditional farmers, making it harder for them to compete and make a living.

Cultural and Social Shifts: As a result of shifting social mores and financial strains, younger generations may decide to give up on traditional farming methods and relocate to urban areas. It's possible that this cultural change will cause important agricultural knowledge and skills to disappear.

Lack of Weather Resilience: It's possible that traditional farming methods lack the adaptability needed to cope with climate change. Although traditional wisdom holds significance, it might require reinforcement with contemporary climate-smart farming methods to enhance adaptability (IFAD 2022).

An Overview of Agroforestry

An approach to land management known as agroforestry involves growing trees or bushes next to or in between pastureland or crops. It combines forestry and agriculture methods to produce more varied and long-lasting land-use patterns. Agroforestry systems purposefully coexist alongside crops and trees, benefiting both, as well as the surrounding environment and community. In Nair (2012) An outline of the main facets of agroforestry is as follows:

Agroforestry Systems Categorisation:

Different agroforestry systems with varying structure, content, age, intensity, technology, and inputs have arisen in different places. These attributes allow for the grouping of related systems. Agroforestry systems are categorised to logically classify them based on the elements impacting their production, identify their management techniques, permit flexibility in information organisation, and be clearly comprehensible. It is difficult to create a single classification system that satisfies each of these requirements. Agroforestry systems can be divided into groups according to certain characteristics or roles in the agricultural system. Nair (1985) presented a classification scheme that took ecological status, socioeconomic considerations, structure, and function into account.

- Function Structure
- Physiognomy Features
- Environmental factors
- Aspects of society and economy

The benefits of agroforestry

Agroforestry systems have a number of benefits, including these. as follows:

EXTEND PRODUCTION:

Given that trees are able to continuously capture solar radiation, the total productivity of forestry land use systems may be higher than that of agriculture. By recycling nutrients, halting soil erosion, and reducing nutrient loss through leaching and runoff, forestry systems are essential for preserving soil fertility. Studies show that soils impacted by trees yield more crops than normal soils (Chaturvedi, 1981; Sanghal, 1983; Verinumbe, 1987). Higher agricultural yields than in conventional fields have been observed using neem, prosopis, and eucalyptus. Leucaena leucocephala, Gliricidia sepium, and Cassia siamea intercropped as hedgerow, with prunings utilised as mulch and green manure, increased maize yields by 30–40% in semi-arid African locations (ICRAF, 1988). In comparison to conventional fields, Verinumbe (1987) showed higher dry matter yields in Sahel soils impacted by forests, particularly for maize and sorghum. In the second season, alley cropping produced maize yields of more than three to five tonnes per hectare (Anon., 1984). In comparison to pure agriculture, agroforestry sites in western Uttar Pradesh and Haryana have recorded yields of grain and wood that are around 20% greater (Dwivedi and Sharma, 1989). Research conducted at IGFRI, Jhansi, indicates that growing fodder grasses alongside fodder trees has a higher overall fodder yield than cultivating only fodder grass (Deb Roy, 1990). The total output of foodgrain, fodder, and fuel is increased when Leucaena leucocephala is interplanted with agricultural crops and fodder grasses (Tiwari, 1970; Anon., 1984b; Pathak, 1989).

SUPPLEMENT FOOD AND FODDER

A wide variety of trees, shrubs, herbs, and climbers are beneficial to rural communities, especially tribal tribes, as they greatly increase the production of food materials. 213 species of big and small trees, 17 palm species, 128 shrub species, 116 species of herbs, 4 fern species, and 15 species of fungi with edible qualities are all included in the extensive list (Solanki, 1981). Remarkable shrubs and trees that provide food (Solanki, 1981; Biswas and Bhuyan, 1983; Singh, 1988). Mahua flowers are prized for their calming, restorative, and soothing qualities. Tribals and rural communities have long relied on these blossoms as a staple food because of their high sugar content and lack of toxicity. The flowers can be powdered and added to chapatis alone or combined with other ingredients, or they can be dried, cooked, and consumed. An individual mahua tree can produce between fifty and three hundred and twenty kilogrammes of dried mahua blooms (Anon., 1962). Based on a conservative estimate of 50 kg of mahua flower production per tree, the total production might reach around 50 million tonnes of mahua flowers annually with an area with about 100 trees per hectare (Dwivedi, 1989). This might significantly and economically increase the amount of food we produce. Making tree fodder could be a solution to the problem of fodder shortages during drought years. Green leaf fodder that is both palatable and nutritious can be produced by a number of tree species, including Acacia nilotica, Aegle marmelos, Ailanthus excelsa, Bauhinia variegata, Celtis australis, Dalbergia sissoo, Dendrocalamusstrictus, Grewia optiva, Hardwickiabinata, Leucaena leucocephala, Moringa oleifera, Morus alba, and Ziziphus spp. (Gulati et al., 1982).

FULFIL MANY OF THE PEOPLE'S NEEDS

Because of the limited amount of land available, we must constantly create highly productive systems in order to supply our needs for basic goods. It has been demonstrated that planting trees alongside annual crops increases total productivity. Worldwide, agricultural productivity is positively impacted by windbreaks and shelterbelts (Caborn, 1957; Frank, 1976). Indian reports show higher agricultural yields credited to windbreaks and shelterbelts (Kaul, 1959, Rao, 1980). By protecting crops from snow and frost, these buildings increase agricultural productivity in colder climates. Comparing agroforestry to traditional agriculture, higher total production is regularly shown in different agroclimatic areas. In a similar vein, silvipasture systems always produce more feed.Many instances under a range of edapho-climatic circumstances demonstrate that the adoption of appropriate crop combinations in mixed cropping systems regularly results in higher production (Budelman, 1988). The goal of agroforestry is to maximise the biomass output of crops and trees. Evidence from Punjab, Haryana, Uttar Pradesh, Gujarat, and several southern states suggests that growing trees along with agricultural crops is a more productive way to supply the demand for firewood and lumber. Irrigated agricultural land can support up to 2.5 cubic meters per hectare per year, but unirrigated land can support around half of that, mostly as border plantations, according to measurements made by Dwivedi and Sharma (2014). An estimated 350 million cubic meters of wood are expected to be produced only by agroforestry, more than satisfying the projected need.

Improve soil health:

Agroforestry systems are essential for protecting soil from a range of harmful effects and providing sustainable land use techniques that enhance soil quality. Several studies carried out globally, as reported by scholars such as Nair (1987) and Young (1989), have demonstrated the beneficial impacts of agroforestry on soil health. A notable nutrient loss has been linked to a few quickly spreading plants with brief rotation times, namely casuarina and eucalyptus (Negi and Sharma, 1984; Singh, 1984). Certain fast-growing tree species create severe competition for moisture, which puts annual crops under stress, particularly in the competition zone (Dwivedi, 1986). Because of their shadowing effect, trees' effects on soil temperature and moisture can occasionally have a negative impact on agricultural crops' ability to develop (Muller, 1970; Rao and Reddy). The beneficial effects of trees on soil are primarily attributed to their roots, crowns, litter fall, and nitrogen-fixing ability, with the magnitude of these effects depending on tree density. Tree crowns shield the soil from raindrop impact, creating a specific microclimate (Pradhan, 1973; George, 1978). The leaf litter from trees absorbs a substantial amount of water, reducing surface runoff, and vegetated watersheds experience less soil erosion compared to cultivated lands (Sinha, 1975).

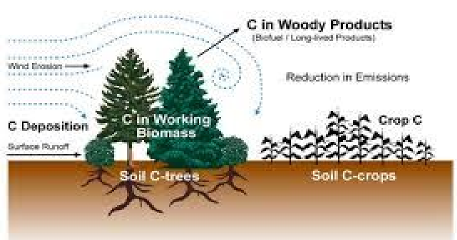

Fig 4.Improvement of soil health

USE DEGRADED LANDS AND WASTELANDS

Examining different species and sources is crucial for particular circumstances. To improve cost-effectiveness, innovations in planting methods, soil working, and maintenance technologies are also required (NWDB, 1989). Reforesting wastelands and degraded areas necessitates the supply of comparatively more inputs. While community and government-owned lands need the right micro-level organisations for effective administration, privately owned areas are probably administered by individual owners (Verma, 1988). According to Gupta and Mohan (1982), there are several examples showing that afforesting wastelands with appropriate tree species and grasses has improved soil conditions, generated significant financial returns, and boosted output and sustainability through tree-based land use systems.

PROVIDE OPPORTUNITIES FOR EMPLOYMENT

Agroforestry systems are essential for increasing employment prospects, especially for agricultural labourers who are underemployed and have the ability to move into forestry-related jobs. Because most forestry activities need a lot of labour, agroforestry projects provide a lot of jobs. Between 200 and 500 man-days are produced per hectare by plantations, including activities such as nursery operations (NCA, 1976; Pant, 1984; Dwivedi, 1986). Agroforestry creates roughly 10–20 times as many jobs at the secondary and tertiary levels as it does at the primary level. Work in wood-based industries such as sawmilling, furniture making, sports goods manufacturing, pulp and paper, plywood and panel products, match-splint manufacturing, bamboo and cane furniture making, agricultural implement manufacturing, doors and windows manufacturing, construction material manufacturing, photoframe manufacturing, handle manufacturing, packing case manufacturing, and musical instrument manufacturing are included in this.To further improve job opportunities, a variety of projects can be started, including the development and manufacture of forestry tools as well as the production of nursery stock. Instead than replacing agriculture entirely, the emphasis should be on using forestry practices to augment it, as this could have a negative effect on employment chances. For these initiatives, careful preparation is necessary to guarantee the creation of additional job possibilities.

IMPROVE FARM PROFITS

When it comes to farming per unit of land, agroforestry is more profitable than exclusive agriculture or forestry techniques. The idea that agroforestry increases farmer profitability is supported by a number of international research (Chaturvedi, 1981; Lahiri, 1983; Pillai, 1983). Tree cultivation has become a very successful and competitive land use in certain places due to the fifteen to twenty-fold increase in the market pricing of items like lumber, firewood, and charcoal (Dwivedi, 1985). Farmers have gained significant benefits from planting trees along farm bunds, canals, pathways, and around dwellings and wells over the past 15 years. Prime agricultural land has occasionally been diverted to tree cultivation. Under some conditions, silvipastural use—which involves growing trees like Prosopis, Albizia, Ziziphus, Acacia, etc.—can produce noticeably higher returns per unit of land than traditional agriculture. In Haryana, agroforestry using eucalyptus has proven to be more profitable than exclusive agriculture (Hooda, 1983). Populus deltoides has been demonstrated to increase farm returns by 50% in terai regions of Uttar Pradesh (Chaturvedi, 1981; Mathur et al., 1984). Reduce the adverse impact of climate-related factors Putting in place an agroforestry system helps increase the amount of trees in an area while supplying necessary commodities that are often found in forests, like firewood, lumber, and fodder. This strategy lessens the burden on natural forests. Many different types of pollution, including as air, water, and noise pollution, are prevalent in different places. Trees are essential for providing protection from a variety of contaminants, such as dust and particulate air pollutants. About 50 tonnes of dust and debris can be filtered by a single hectare of dense woodland.Furthermore, trees mitigate the harmful effects of certain chemical air pollutants on human health by absorbing them. Additionally, trees significantly reduce the amount of noise pollution. Trees and forests help to lower temperatures, raise humidity, and boost precipitation. The 10% increase in precipitation that results from reforestation also lowers the air temperature in forested areas. Research shows that there is a noticeable 3° to 8°C drop in temperature in tree-covered additionally; afforestation reduces soil evaporation, which lowers the requirement for irrigation. Additionally, there is a 5–8% rise in humidity in forested areas, and trees act as a shield against cyclones and high winds.

Complexity of Management: Agroforestry systems need to be carefully planned and maintained.

Learning and Education: In order to successfully implement and sustain agroforestry methods, farmers require both knowledge and training.

Industry Access to: Farmers may have difficulties in finding markets for their agroforestry products. Field Domain: According to Montagnini and Nair (2004), land tenure concerns may make it more difficult to construct long-term agroforestry systems.

Worldwide Importance of Agroforestry:

Agroforestry techniques are widespread worldwide, especially in developing nations where small-scale farmers depend on a variety of long-term systems to meet their demands for a living. Enhancing food security, protecting natural resources, and fostering rural development all depend on these systems. In conclusion, by fusing the advantages of agriculture and trees, agroforestry offers a comprehensive approach to land usage. It is a crucial approach for long-term development in many regions of the world due to its versatility in addressing a broad variety of environmental and socioeconomic problems. Benefits of agroforestry include soil health, carbon sequestration, and biodiversity conservation.

Mitigation of Climate Change through Agroforestry

The contribution of agroforestry to greenhouse gas emission reductionIn order to mitigate climate change and reduce greenhouse gas emissions, agroforestry is crucial. This agricultural method mixes the cultivation of trees and shrubs with crops and/or cattle on the same piece of land. There are several environmental advantages to adding trees to agricultural systems, and these advantages contribute to a decrease in greenhouse gas emissions. Here are a few instances of how agroforestry might be beneficial in this context:

Carboncapture: During photosynthesis, trees take in CO2 from the atmosphere and store it in their biomass and soils. By adding more trees to agricultural areas, agroforestry systems function as carbon sinks, eventually storing large volumes of CO2 (Albrecht and others, 2006).

Decreased Deforestation: By offering substitute supplies of fruit, timber, and other items, agroforestry lessens the strain on natural forests. This helps to stop deforestation, which is a major cause of greenhouse gas emissions, especially when forests are burned and cleared.

Increased Soil Carbon: The roots of plants in agroforestry systems contribute to improved soil organic matter content and soil structure. As a result, the soil can hold more carbon. Leaves and other organic debris produced by trees break down and add organic carbon to the

Methane Emissions from Ruminant Enteric Fermentation Can Be Reduced by Using Silvopastoral Agroforestry Systems: These systems, which include trees into grazing areas for cattle, can help lower methane emissions. The microbial population in animals' stomachs can be changed by the presence of trees in pastures, which lowers the production of methane.

Improved Water Management and Erosion Control: Agroforestry methods lessen soil erosion, which can cause soil-stored carbon to be released into the atmosphere. These systems also lessen runoff and increase water retention, which keeps carbon-rich topsoil from being swept away.

Conservation of Biodiversity: By offering habitat to a variety of plant and animal species, agroforestry promotes biodiversity. Diverse ecosystems have a greater capacity to store carbon and are less susceptible to climate change.

Alternative Energy Sources: Agroforestry generates biomass energy that is sustainable and can take the place of fossil fuels. When biomass is used as a fuel, less fossil fuels must be burned, which lowers greenhouse gas emissions.

Community Involvement and Awareness: Agroforestry practises are often associated with local communities. Agroforestry engages communities in tree planting and forest conservation initiatives, increasing public knowledge of the value of trees in reducing climate change. This helps to mitigate greenhouse gas emissions at the local level.By storing carbon, stopping deforestation, enhancing soil health, lowering livestock methane emissions, preserving biodiversity, encouraging sustainable energy sources, and involving communities in climate change mitigation initiatives, agroforestry contributes significantly to the reduction of greenhouse gas emissions. Because of these benefits, agroforestry is an effective and sustainable strategy for mitigating the effects of climate change (Smith et al. 2014).

Increasing resilience with agroforestry techniques:

By diversifying agricultural systems, offering protection from adverse weather, and enhancing soil fertility, agroforestry increases resilience. Because they operate as windbreaks, shade trees, and mitres soil erosion, agroforestry trees increase the farming system's resistance to the effects of climate change. Water management and agroforestry in a changing climate: By decreasing runoff and raising groundwater recharge, agroforestry techniques increase the effectiveness of water management. Soil erosion can be avoided in part by trees because they absorb water and decrease surface water flow. Water-efficient tree species can be given priority in agroforestry systems, allowing for sustainable agricultural water use during dry spells.(IPCC 2022).

Ecosystem stability through agroforestry and biodiversity conservation:

Agroforestry creates a variety of habitats, which supports biodiversity. Agroforestry systems are able to sustain a diverse array of organisms because of the abundance of different tree species, crops, and understory vegetation. Because of its ability to naturally suppress pests, encourage pollination, and boost the ecosystem's overall resistance to shocks, biodiversity enhances ecosystem stability.

Practitioners of agroforestry deal with socioeconomic issues:

Practitioners of agroforestry usually deal with limited resources, a lack of technical expertise, and market restraints. Securing land tenure, striking a balance between forestry and agricultural needs, and adjusting to shifting market demands are other socioeconomic issues. To solve these difficulties, capacity-building initiatives and supportive policies are needed.

Institutional and policy barriers:

One of the institutional and policy impediments to agroforestry is the absence of cooperation amongst government entities and the unpredictability of land tenure regulations. Moreover, attempts to integrate agroforestry practices into conventional agricultural policies may be impeded by policymakers' ignorance of and lack of comprehension of the potential of agroforestry. Public awareness and policy reforms are necessary to address these issues.

Possibilities and Prospective Courses:

Agroforestry offers various promising opportunities and future approaches in the fields of environmentally conscious agriculture and sustainable conservation. Among the key prospects are:

Climate-smart Agroforestry: By integrating climate-smart practices into agroforestry systems, long-term food supply may be ensured in the face of shifting environmental conditions and increased resilience to climate change.

Technological Integration: Planning and management of agroforestry can be optimised to yield higher output and efficiency by utilising cutting-edge technology like precision agriculture, GIS (Geographical Information Systems), and remote sensing.

Market diversification: By looking into specialised markets for agroforestry products such speciality timber, medicinal plants, and non-timber forest products, farmers can receive financial incentives that will promote the broad use of agroforestry techniques.

Policy Support: By looking into specialised markets for agroforestry products such speciality timber, medicinal plants, and non-timber forest products, farmers can get financial incentives that will promote the general adoption of agroforestry practices.

Conclusion:

Finally, agroforestry is shown to be an essential green strategy for boosting climate change resilience. Incorporating trees into agricultural methods reduces greenhouse gas emissions and encourages carbon sequestration while also enhancing biodiversity and soil health. The several advantages of agroforestry are highlighted in this review, including higher productivity, better water management, and improved ecosystem services. Adopting agroforestry techniques can be extremely important for sustainable land management as climate difficulties increase. This will help communities adapt while also advancing global climate goals. In order to promote environmental sustainability and resilience in the face of continued climate change, a shift to such integrated systems is needed. In summary, agroforestry presents a comprehensive and sustainable strategy for agriculture that tackles issues related to food security, biodiversity preservation, adapting to climate change, and enhancing rural livelihoods. Agroforestry is the practice of incorporating trees into agricultural landscapes to improve resilience, provide ecosystem services, and maintain environmental sustainability. Governments, researchers, farmers, and communities must work closely together going forward. The full potential of agroforestry can be realised by embracing cutting-edge technologies, investing in research and teaching, and developing supporting policies. By working together, we can build an agricultural future that is more resilient and sustainable, protecting both people and the environment.

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