农林业是迈向可持续生态系统的主要步骤：回顾

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Agroforestry is the main step towards Sustainable Ecosystem: A Review

Abstract: Agroforestry, the intentional integration of agricultural and forestry-based land use systems, provides multiple benefits that collectively contribute to agroecosystem sustainability. Agroforestry addresses the nation's land stewardship needs by converting degraded land, protecting sensitive land, and diversifying farm production systems. As part of an ecologically based land management system, agroforestry practices can maintain ecosystem diversity and processes that contribute to long-term sustainability and environmental quality. Many different sustainable management systems have been proposed as viable solutions to take pressure off tropical forests. Different agroforestry practices such as alley cropping, windbreaks, riparian forest buffers, silvopasture, and forestry farming are used, which have their own benefits as well as sustainable ecosystems. In addition, they contribute to the mitigation of climate change. These agroforestry practices provide a land-management system that increases production and ecological stability as well as supports sustainable development. Agroforestry practices encourage the sustainable development of degraded lands by maintaining human activity while conserving natural resources. Complex agroforestry can significantly contribute to sustainable development through its combined economic, environmental, and social functions.

Key words: Agroforestry; Ecosystem Management; Sustainable; Agroecosystem

Introduction:

Agroforestry is the intentional blending of agricultural and forestry-based land-use systems to produce trees and other crop products while preserving, diversifying, and sustaining essential natural, human, and economic resources. In productive agricultural systems, windbreaks are established; however, agroforestry also refers to the intentional cultivation of ginseng, a high-value specialty crop grown in the understory and protected by forest cover. (Schoeneberger, M.M etal., 2017). Agroforestry is "working trees"–the right trees and shrubs planted and/or managed in the right place to do a specific job. Agroforestry practices include windbreaks, alley cropping, tree/pasture systems, living snow fences, riparian forest buffers, tree/specialty crop systems, forest/specialty crop systems (forest farming), wildlife habitat, and fuelwood plantations (. ; Brandle, J.; Bentrup, G. 2017).

In view of the environmental problems confronting modern agriculture and the emphasis placed o-n developing sustainable agricultural and natural resource systems, agroforestry can have lasting economic, environmental, and social impacts. As part of an ecologically based land management system, agroforestry practices can contribute substantially to generating ecosystem diversity and processes that are important to long-term sustainability (Karle, S.T.; Karle, D. 2017). Our agricultural lands can become stable, resilient, diverse, beautiful, and sustainable when agroforestry practices are integrated at the farm, watershed, and landscape scales. Agroforestry techniques can boost

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crop yields, reduce erosion and sedimentation, produce a variety of commodities, including wood products, absorb and biodegrade surplus nutrients and pesticides, control microclimates, and diversify habitats for wildlife and people (Anderson, D.R. 1997). Agroforestry systems sequester carbon and serve as a renewable energy source. By enhancing the production capabilities of rural lands, agroforestry can help revitalize rural communities that have become socially depressed owing to recent "economic downturns.”

Agroforestry offers the opportunity to address some of our nation's, indeed our world's, most complex problems, and thereby constitutes an arena in which a host of stakeholders can come together to develop a common agenda for conservation and land use practices. A "first step" toward that common agenda was accomplished with the February, 1994 publication of the Soil Conservation Service's (SCS), Resource Conservation Act (RCA) appraisal for agroforestry entitled: "Agroforestry: Intergrated Land-Use Management System for Production and Farmland Conservation". The awareness created by the RCA document resulted in a workshop held June 29-30, 1994 to assemble stakeholders to "Develop a framework for a coordinated national agroforestry program"(Mantyka-Pringle, C.S., et al., 2012).

The participants, representing federal and state agencies, universities, and non-government organizations (NGO) from across the U.S., and the Association for Temperate Agroforestry (AFTA), assembled to define and address the unique needs and challenges of agroforestry, and develop the recommendations in this white paper (Minang, P.A. 2014). It is intended that by working together, this community of interest, peers, and other interested parties may "make a difference" for agroforestry and the health of rural America. Agroforestry provides a practical alternative to conventional approaches to the management of our country's farm and forest areas, which is what American people are seeking (Schoeneberger, M.M.; Domke, G. 2017).

However, while the factors that are important to its development are beginning to converge, the benefits of agroforestry will not be fully realized without focused policies, programs, funding, and interdisciplinary teams. Present programs are neither designed nor funded sufficiently to deal with a "cross-cutting" science and practice like agroforestry (Smukler, S.M.; Sánchez-Moreno, etal., 2010). The infrastructure required must be established with the ultimate user, the landowner, at the center, and designed to promote a continuous process of innovation. This will require a concerted team effort o-n the part of many, including established agriculture and natural resource institutions, such as USDA agencies and land-grant universities (Walthall, C.J.; Hatfield, J.; Backlund, P. et al., 2012). At this juncture, it is especially critical that national leadership is provided within the USDA. continuous process of innovation. This will require a concerted team effort o-n the part of many, including established agriculture and natural resource institutions, such as USDA agencies and land-grant universities (Walthall, C.J.; Hatfield, J.; Backlund, P. et al., 2012). At this juncture, it is especially critical that national leadership is provided within the USDA.

Agroforestry and its main types with Ecosystem Benefits

the World Agroforestry Centre (ICRAF) now defines agroforestry as a “dynamic, ecologically based natural resource management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land-users at all levels.”

Public and private property must be included in a comprehensive strategy for climate change adaptation. Agroforestry is the deliberate integration of trees and shrubs into agricultural and zoological production systems to have favorable effects on the environment, economy, and society (Gowda, P.; Steiner, J.L., etal., 2018). With the help of agroforestry, land managers can combine productivity and profitability with environmental stewardship to create landscapes that are healthy and sustainable.

The five widely recognized categories of agroforestry

alley cropping

windbreaks

riparian forest buffers

silvopasture, and

forest farming (also called multistory cropping)

Alley cropping

Alley cropping involves the cultivation of food, forage, or specialty crops between rows of trees. It is a larger version of intercropping or companion planting conducted over a longer timescale. Alley cropping can provide profitable opportunities for row crop farmers, hardwood timber growers, nut growers and Christmas tree growers (Lengnick, L. 2018).

Benefits: Alley cropping benefits both humans and the environment

Income diversification: Crop production during the years before nut trees come into bearing or hardwood timber is harvested creates cash flow and diversifies farm income, thereby improving the return o-n long-term investment in trees.

Marginal land improvement: By planting rows of nut or timber trees o-n land where annual crop production is low due to erosion or other limitations, marginal croplands may be converted to higher-value woodlands.

Shelter: Rows of trees reduce wind speed, thereby controlling wind erosion. They also create sheltered microclimates that improve the yield and quality of crops grown in alleys.

Wildlife: Alley cropping increases the biodiversity of croplands, creating a new habitat for wildlife.

Tab. 1 Alley Cropping and Its Benefits

Practice	Description	Primary benefits and uses
Alley cropping (also called tree-based intercropping)	Trees or shrubs planted in sets of single or multiple rows with agronomic crops, horticultural crops, or forages produced in the alleys between the trees that can also produce additional products	Produce annual and higher-value but longer-term crops. Enhance microclimate conditions to improve crop or forage quality and quantity. Reduce surface water runoff and erosion. Improve soil quality by increasing utilization and cycling of nutrients. Enhance habitat for wildlife and beneficial insects. Decrease offsite movement of nutrients or Chemicals. Increase C storage in plant biomass and soils

Windbreaks

Windbreaks are linear plantings of trees and shrubs designed to enhance crop production, protect people and livestock, and conserve soil and water. Windbreaks can provide valuable opportunities for vine and tree fruit growers, row-crop farmers, livestock producers, and rural homeowners (USDA. 2015).

Benefits: Windbreaks benefits both humans and the environment

Boost crop yield and quality: crop yield and quality. Through microclimate modification, field and orchard windbreaks have been shown to increase the yield of many different crops. Windbreak protection can be especially valuable in orchards and vineyards of high-value horticultural crops.

Produces timber from windbreaks: Multirow windbreaks of fast-growing species such as poplar can be sequentially thinned for timber products while maintaining the continuity of shelters.

Control of wind erosion: soil and water conservation. Windbreaks have been proven to be effective in reducing wind erosion in light-textured soils. By dispersing snow evenly across fields, windbreaks help make more moisture available for crops.

Managing snow dispersal: snow control. Properly placed windbreaks prevent snow build-up around buildings and roadways.

Tab. 2 windbreaks and Its Benefits

Practice	Description	Primary benefits and uses
Windbreaks (also includes shelterbelts)	Single or multiple rows of trees or shrubs that are established for environmental purposes; depending on the primary use, may be referred to as crop or field windbreak, livestock windbreak, living snow fence, farmstead windbreak, or hedgerow	Control wind erosion. Protect wind-sensitive crops. Enhance crop yields. Reduce animal stress and mortality. Serve as a barrier to dust, odor, and pesticide drift. Enhance habitat for wildlife and beneficial insects • Conserve energy. Manage snow dispersal to keep roads open or to harvest moisture. Increase C storage in plant biomass and soils

Riparian forest buffers

Riparian forest buffers are strips of trees, shrubs, and grass planted between croplands or pastures and surface water courses. Buffers protect water quality and reduce erosion and flooding. Riparian forest buffers can provide beneficial opportunities for row-crop farmers, ranchers, horticulturists, and dairy and livestock producers (Hernández-Morcillo, M.; Burgess, P. 2018)

Benefits: Riparian forest buffers provide economic, social and environmental benefits

Water quality: Buffers have been shown to reduce non-point source pollution by absorbing and filtering animal wastes, sediments, nutrients, and pesticides from crops and rangelands.

Erosion and flood control: Riparian buffers combined with bioengineering practices help stabilize streambanks, slow out-of-bank flood flows, and protect croplands from flooding.

Extra Income: Multirow riparian buffers can be managed to allow the periodic harvest of timber or non-timber products while maintaining buffering capacity. This helps offset the loss of productive crops or pasture land to buffers.

Wildlife habitat: Riparian forest buffers provide shade, shelter, and food for fish and aquatic organisms as well as terrestrial wildlife.

Tab. 3 Riparian Forest buffers and Its Benefits

Practice	Description	Primary benefits and uses

Riparian forest buffers	An area of trees, shrubs, and herbaceous vegetation established and managed adjacent to streams, lakes, ponds, and wetlands	Reduce nonpoint source pollution from adjacent land uses. Stabilize streambanks. Enhance aquatic and terrestrial habitats. Increase C storage in plant biomass and soils Diversify income either through added plant production or recreational fees

Silvo-pasture

Silvo-pasture is the intentional combination of trees, forage plants, and livestock as an integrated, intensively managed system. Silvo-pasture can provide profitable opportunities for softwood or hardwood timber growers, forest landowners, and livestock producers (Benipal, G., Austin, H., Srirajayatsayai. 2018)

Benefits: Silvo-pasture has several advantages over timber or pasture alone

Return on investment: By adding a livestock production component, silvo-pasture creates a stable source of cash flow prior to nut or timber harvest (e.g., pine, poplar, or pecan) and diversifies forestry enterprises. For livestock graziers, adding long-term timber while maintaining forage production provides more income than grazing alone does. In some areas, pine straw harvesting can provide supplemental income.

Silvicultural benefits: Nitrogen-fixing forage species, pasture fertilization, and animal manure help improve soil and tree nutrition. Grazing controls competing brushy species and reduces fire hazards. Competition between trees was less in the wider spacings employed with silvopasture. This results in greater timber yield.

Livestock benefits: Trees create a sheltered microclimate to protect animals from heat and cold temperatures. Shelters also improve forage quality and lengthen growing seasons. The pruning of some trees can also be used as fodder, for example poplar. This results in improved livestock growth.

Wildlife: Wildlife habitats are also created by creating a more biologically diverse system.

Tab. 4 Silvo-pasture and Its Benefits

Practice	**Description**	**Primary benefits and uses**
Silvopasture	Trees combined with pasture and livestock production Produce diversification of livestock and plant products in time and space	Produce annual and higher-value but longer-term products. Improve livestock health and productivity. Reduce nutrient loss. Reduce fuel load. Increase C storage in plant biomass and soils

Forest farming

Forest farming is the intentional cultivation of edible, medicinal, or decorative specialty crops beneath native or planted woodlands, which are managed for both wood and understory crop production. It does not include the gathering of naturally occurring plants from native forests, which is also known as wildcrafting. Forest farming can provide profitable opportunities for forest and woodland owners, nut growers, sugar maple growers, and herb growers (Jiao, J., Zou, H., Jia, Y., & Wang, N. 2009).

Benefits: Forests can sustainably produce more than just wood

Extra income and diversification: Cultivation of specialty crops in a forest setting provides new sources of annual or periodic income before or instead of timber harvests.

High-value products: A wide variety of plants can be grown in forests to produce natural or processed (value-added) edible, herbal, medicinal, decorative, and craft products.

Ecologically responsible: The intensively managed cultivation of forest plants that are endangered in the wild owing to over-harvesting is the responsible alternative to wildcrafting.

Tab. 5 Forest farming and Its Benefits

Practice	Description	Primary benefits and uses
Forest farming (also called multistory cropping)	Existing or planted stands of trees and/or shrubs that are managed as an overstory with an understory of plants that are grown for a variety of products	Improve crop diversity by growing mixed but compatible crops having different heights on the same area. Improve soil quality by increasing utilization and cycling of nutrients. Increase C storage in plant biomass and soil

Agroforestry and its main types with Ecosystem Benefits

Agroforestry can contribute to climate change adaptation and mitigation in the following main ways

reducing threats and enhancing agricultural landscape resiliency

facilitating species movement to more favorable conditions,

sequestering carbon, and reducing greenhouse gas emissions

Reducing threats and enhancing Agricultural landscape resiliency

Agroforestry is a distinctive method of agricultural management in the face of climate change because it is based on woody plants and provides functional varieties of a range of sizes. Crops and cattle can benefit from the microclimates created by perennial elements. iThus, itis not a novel concept to employ agroforestry to improve resilience (DeLonge, M.S. 2019). Farmers and livestock producers continue to employ windbreaks to increase agricultural yields, safeguard soil quality, and boost conservation efforts. Similar functions can be delivered by other agroforestry approaches in various agricultural systems, increasing the resilience of the landscape and reducing hazards (Udawatta, R. P.; Garrett, H.E.; Kallenbach, R. 2011)

Facilitating species movement to more favorable conditions

The ability of many species to react, relocate, and/or adapt to climate-related consequences is probably hampered by habitat fragmentation. Agroforestry techniques can serve as stepping-stones or forest corridors in agricultural areas to improve habitat connectivity (Mitlöhner, F.M.; Morrow, J.L, etal., 2001). Foraging and breeding Louisiana blacks, for instance, use riparian forest buffers to move between sections of the forest in the intensively farmed Tensas River Basin.

Sequestering carbon, and reducing greenhouse gas emissions

The ability to offer adaptation and mitigation benefits in an integrated and synergistic manner is one of the special advantages of agroforestry. By storing carbon in soil and biomass, minimizing the number of times farm machinery needs to run over a field, improving energy conservation, and increasing the effectiveness of nitrogen fertilizer use, agroforestry practices can lower net greenhouse gas emissions. Agroforestry may provide significant mitigating advantages in exchange for the space used for the technique. For instance, despite covering only 6% of the overall area, woody riparian and hedgerow habitats on a Central Valley farm in California held 18% of the farmscape's total carbon (C) (Brandle, J.R.; Hodges, L.; 2019).

Agroforestry as the options for management of ecosystem

For farmers and ranchers, agroforestry practices provide perennial living structure that can offer adaptation strategies for different climate change risks depending on the specific practice. While the mitigation services of agroforestry are valuable, they are rarely the driver of design and implementation by producers. Because most farmers and managers do not make management decisions primarily to mitigate climate change, hence these options for management are focused on adaptation.

Tab. 6 Ecosystem Change Risk associated adaptation services provided by agroforestry practices

Risk	Adaptation	Agroforestry Practice
Intense precipitation events	Slow water runoff to reduce flooding, soil erosion, and water pollution	Riparian forest buffers; alley cropping
Increased temperatures	Reduce heat stress on animals by providing shade	Silvopasture
Increased frequency and intensity of drought	Reduce evapotranspiration by reducing windspeed	Windbreaks
Increased storm intensity (wind & precipitation)	Protect crops from wind damage	Windbreaks; alley cropping
Changes in growing season due to temperature and precipitation	Protect crops by creating microclimates	Windbreaks; alley cropping; forest farming
Winter storms and cold temperature extremes	Reduce cold stress on animals by providing shelter	Silvopasture; windbreaks
Increased insect and disease problems	Control pests by providing habitat for beneficial insects	Windbreaks; riparian forest buffers; alley cropping
Increased possibility of crop failure due to other risks	Reduce total crop loss by increasing crop diversity.	All agroforestry practice

Reduce the impact of Intense Precipitation and Flooding

By increasing the amount of forest and tree cover that intercepts rain, increasing the amount of rain that seeps into the ground, and decreasing the quantity, speed, and peak flows of runoff, agroforestry can assist landowners in adapting to increasingly heavy precipitation events and minimizing the negative effects (Rivest, D.; Lorente, M.; Olivier, A.; Messier, C. 2013). The addition of perennials boosted water penetration to a greater extent than did annual crops (an increase of 59%) when measured against no-till, cover crops, crop and livestock integration, and crop rotation.

Reduce Heat and Drought

Systems for raising livestock and growing crops are significantly challenged by rising daytime and nighttime temperatures, and increasing humidity. By lowering animal heat stress and sustaining both the amount and quality of fodder production under rising temperatures, silvopasture and windbreaks can help alleviate these problems. Agroforestry techniques in cropping systems can reduce the need for irrigation during dry spells (Al-Kaisi and M. M.; Elmore, R.W.; 2018). By lowering the wind speed across neighboring agricultural fields, windbreaks lessen crop water stress and preserve the soil moisture. decreases soil evaporation losses and crop transpiration, which may be especially beneficial in water-stressed environments. By supplementing annual vegetation cover techniques such as cover crops, which may experience difficulties in establishing drought conditions, agroforestry activities can sustain soil protection (Heisler, G. M.; Dewalle, D.R. 1988)

Reduce the impact of Winter Storms and Cold Temperatures

Utilizing agroforestry techniques, especially windbreaks, to reduce wind speed in the winter can also reduce cattle stress, increase feeding effectiveness, and increase survival during the lambing and/or calving seasons. By calming the wind and spreading the snow evenly throughout the field, field windbreaks can aid in capturing the moisture present in snow (Tibke, G. 1988.). Windbreaks that trap snow and shield agricultural plants from winter desiccation can enhance wheat yields by 15–20%.

Diversification

Agroforestry systems are multispecies mixtures of annuals and perennials that are naturally more tolerant to environmental challenges than cropping systems that only grow annuals. They are more diverse in terms of species, have greater root systems that protect them from climatic extremes, and can withstand more disturbances (Bentrup, G.; Dosskey, M.G. 2017). Perennial food crops, including fruits, nuts, and berries, can offer resistance to temperature extremes in areas where winter chilling requirements are not restrictive. Mixtures of species disperse biological and monetary hazards between crops and seasons. Perennial crops, which offer continuous living cover, may be more durable and sustainable solutions in marginal areas than annual crops, which frequently require more soil disturbances (Bowler, D.E.; Mant, R.; Orr, H. et al., 2012).

Plant Adaptation

The ability of trees and shrubs to endure and develop well enough to provide advantages is crucial to the success of agroforestry operations. Which woody species are suitable for an agroforestry practice depends heavily on the local climate, and there is a lot of variation across species in this regard (Al-Wadaey, A., & Ziadat, F. 2014) Consider the many climate vulnerabilities when choosing plants for an agroforestry application: winter chilling requirements, springtime freeze risk, heat and water stress, pollination restrictions, and disease and pest damage. Increasing plant diversity within a planting, which diversifies the mix of genetic, phenological, and physicochemical properties, is another efficient adaptation method (Bentrup, G.; Dosskey, M.G. 2017).

Conclusion:

The contribution of a complex agroforestry system to sustainable development is significant because of its economic, environmental, and social functions. Although complex agroforestry provides considerable socioeconomic benefits, it also requires specific techniques and management. The importance of selecting an appropriate tree species for the environment and the importance of initial care for plants should be considered. The ability of farmers to use postharvest technology should be increased. The application of complex agroforestry systems should be followed by developing both basic and advanced industries to handle the leading commodity within the area, regulating reasonable basic price rates for local commodities within the local producer level, building transportation capacity, developing markets, and empowering the local people to use their natural resources wisely.

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