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The Role of Agroforestry for Climate Change Adaptation and Mitigation

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ABSTRACT

The agroforestry system is a plant cultivation technology as a form of adaptation and mitigation to climate change. The role of agroforestry in adapting to climate change through the translocation or transfer of germplasm approach, local genetic adaptation, and plasticization of individual species. The role of agroforestry in mitigating climate change through carbon sequestration, stock protection, and utilization of renewable energy.

Keywords: Agroforestry, adaptation, mitigation, climate change

Introduction

Agroforestry is a forest management model that aims to increase land productivity in the form of forest products, agricultural products, livestock, and fisheries so that farmers can obtain results in the short, medium, and long term. The principle in the agroforestry system is environmental, economic, and social balance.

The agroforestry system is a plant cultivation technology as a form of adaptation and mitigation to climate change. Adaptation is an adjustment activity that needs to be carried out to live and survive as well as increase resilience, and flexibility and lead to migration, due to different climatic conditions. Adaptation is carried out to reduce vulnerability to climate change because the level of carbon saturation is quite high and the residence time of carbon in the atmosphere takes hundreds of years, so the earth also needs a long time to return to normal temperature.

The agroforestry system is a plant cultivation technology and a form of climate change mitigation. Agroforestry reduces light intensity and temperature, increases oxygen, increases humidity, and increases soil fertility and water availability through the role of trees.

Agroforestry plays an important role in mitigating greenhouse gas emissions (GRK) by: 1) Absorbing CO_2 from the atmosphere through photosynthesis and storage as carbohydrates in biomass for a long time; 2) Maintaining soil fertility through leaves falling to the ground.

Material and Methods

The method used in preparing this article is a literature review method sourced from journals, books, scientific articles, and other library sources.

Results and Discussion

The role of agroforestry in climate change adaptation

There are three approaches to looking at the role of agroforestry in climate change adaptation, namely:

Translocation or transfer of germaplasma

The migration speed of species in natural forests in temperate areas, in 2007 due to anthropogenic climate change was more than one kilometer per year or 10 times the speed of natural climate change. Migration is needed by trees to adapt to physiological mismatches and to

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adapt or maintain changes in temperature and rainfall (Dawson et al., 2010). Forest tree types or groups of forest types have adapted to tend to move towards the northern hemisphere and rise to higher elevations (positions). Global warming can increase montana, Grenland and arid (dry) forests.

The agroforestry system in the management context is a facilitator of translocation which does not occur in natural forests. Facilitation includes human influences such as transportation of seeds and seeds, N-fixing bacterial microorganisms and animal or insect pollinators. In germaplasm translocation there are 3 (three) things that must be considered, namely:

a. Suitability of Growing Place and Type Variations
   Dawson et al. (2010), conducted tests on seeds originating from various rainfall patterns on their growth. The recommendation is that this type of germaplasm transfer occurs in one direction from dry areas to wetter areas. Such an exchange would result in better growth in the home region.
b. Germaplasma Exchange Between Countries
   Germaplasm exchange between countries needs to be carried out to increase the diversity of each country so that there is an increase in ecosystem resilience in the event of climate change, at some point the germaplasm species will be able to adapt to other countries or be more suitable in new places, because in old locations they have climate change occurs.
c. Farmers' Access to Suitable Genetic Resources
   Farmers' access to suitable seed needs is better done using a non-centralized system and/or better done by informal commercial seed collectors and then distributed through local officials (Butarbutar, 2012).

Adaptation local genetic

Local genetic adaptation is the development of a certain type in certain numbers ex-situ (outside its habitat). The effective population size (Ne) is the ideal population size with the same genetic characteristics as observed in populations that exist in nature. The Ne value of a particular species is a reflection of 1) the number of individuals of a particular species in a natural or artificial community or plant; 2) have a high level of genetic diversity; 3) have a "natural outcrossing" from the dominant type; 4) produces lots of seeds and 5) pollen and seeds can spread long distances, so long-distance pollination can occur. Local genetic adaptation maintains and increases effective population size (Ne) (Butarbutar, 2012).

Individual type plasticity

Plastic tree species are species that have flexible morphology and physiology and can grow well under minimum conditions without genetic change (Dawson et al., 2011). For example, Pinus patula and P.tecunumanii come from Central America. This species grows better in a wider environmental interval than its natural requirements (Naver et al., 2010). Another type is Eucalyptus from Australia, which can now be cultivated in at least 25 countries with better conditions (Naver et al., 2010). The diversity of local and exotic tree species and agricultural plants can improve the resilience of agricultural systems to environmental change if these species have different responses to disturbances (Dawson et al., 2011).

The role of agroforestry in mitigating climate change

The role of agroforestry in mitigation can be seen from 3 (three) forest management processes that can reduce greenhouse gas concentrations, namely:

Carbon absorption

Carbon absorption is carried out through planting mixtures or types of carpentry wood, animal feed, fruit, food, etc. Dawson et al. (2011) recommend that carbon emissions can be reduced by

implementing agroforestry through a mixture of tree species that produce wood, animal feed and fruit. Kaiser (2000) states that agroforestry activities can increase carbon storage compared to agricultural land, grazing land, forests, and grasslands, respectively, amounting to 390, 125, 240, 170, and 38 x1012 grams of C per year (Tg C / year).

The results of research by Oelbermann and Voroney (2010) show that agroforestry systems in tropical and temperate regions store higher amounts of carbon in the soil compared to single-type plants. Increasing carbon stocks in the soil can also be done with sustainable land management activities such as minimizing land processing and chemical fertilization, using green manure, plant residues, compost, mulch, ground cover crops, and crop rotation (LaI, 2004; Oelbermann and Voroney (2010). Meanwhile, according to Naver et al. (2010) reducing carbon emissions can be done by implementing agroforestry in deforested areas/landscapes with tree species mixed with shade species, and trees with animal feed leaves and fruit.

Stock protection

Stock protection can be done through fire reduction activities and reducing pest and disease attacks by mixing various types of plants.

a. Forest fire reduction

   Forest burning on a large scale will have an impact on the death of flora and fauna in the forest area. Forest fires are one of the threats that disrupt the existence of Indonesia's tropical rainforests. Forest fires and environmental change will have a major impact on atmospheric conditions, carbon cycles, and ecosystem function.

   Carbon reserves (C stocks) are the amount of C stored in biomass and necromass components both above the soil surface and in the soil (soil organic matter, plant roots, and microorganisms) per unit area of land. The unit is Mg/Ha (mega gram/Ha = ton/Ha). Biomass is the mass (Kg/Ha) of the living part of the vegetation consisting of tree crowns, annual plants, and undergrowth or weeds. Necromass is the mass of dead tree parts, whether still upright or fallen or lying on the ground. stakes or twigs and fallen leaves (litter) that have not been decomposed or partially decomposed (Depari et al., 2013).

   The results of research by Depari et al. (2013), in the agroforestry system, showed that carbon stock was 21,447.96 kg/Ha stored in the biomass of onion wood stands; 47,662.14 kg/Ha on onion and coffee plantations. The carbon stock of onion wood in onion wood and coffee and rubber fields is 17,201.60 kg/Ha, while that stored in the biomass of onion wood stands is 38,255.84 kg/Ha. The results of research by Balitbanghut (2010), show that in a resin wood-based agroforestry system, the carbon potential of undergrowth and litter is a forest floor that is not cleaned = 1780.11 kg/Ha, and a forest floor that is cleaned is only 1139.81 kg/ha.

   The results of the research above illustrate that in agroforestry system land there is quite a lot of carbon stock so if it is burned there will be quite a large loss of carbon. Therefore, carbon stock protection needs to be done. According to Akbar (2016), the agroforestry system is effective and efficient in controlling peatland fires, if the development of gardens or plantation forests is carried out using or using: 1) Land preparation with minimal and controlled use of fire; 2) Setting plant distance; 3) Cleaning lower branches and twigs; 4) Minimize weed fuel; 5) Planting short grass for animal feed; 6) Construction of fire breaks; 7) Construction of water wells; 8) Procurement of simple extinguishers and construction of smoke observation towers for large-scale management units and the most important thing in controlling forest fires on peatlands is efforts to empower communities in the pattern of developing gardens or plantation forests with an agroforestry system.

b. Reduction of Pest or Disease Attacks

An atmosphere containing a higher carbon concentration will affect the carbon distribution pattern in plants which has an impact on plant secondary metabolites quantitatively and qualitatively. An increase in plant-bound carbon will reduce nitrogen concentrations. This will trigger insects to increase. Biomass is consumed, which means increased plant damage (Sastrodihardjo, 2003).

Based on field analysis, the effect of increasing CO2 in the atmosphere is specific to pest species and disease type and generally affects the extent of pest and plant disease attacks. An agroforestry system with a mixture of trees, crops, and livestock will have a more stable ecosystem than a food crop ecosystem alone, because of the diversification of plant types and continuity of food availability, so pest or disease outbreaks are rare. In the long term, in the agroforestry system ecosystem, pest or disease populations are at a general balance level. Generally, pest populations are controlled by natural enemies.

Utilization of renewable energy

This strategy uses renewable energy through the production of renewable biomass to replace fossil energy. In Indonesia, there are several types of plants planted in agroforestry systems that can be made from bioethanol and biofuel as renewable energy sources to replace petroleum energy. Corn, cassava, sago, sorghum, and sugar palm plants are sources of bioethanol fuel. Oil palm, coconut, candlenut, and nyamplung (*Calophyllum inophyllum*) plants are sources of biofuel.

Oil palm plants can produce 3.9 kiloliters of biodiesel per year per Ha. Sunan candlenut plants per Ha (100 trees) can produce a minimum of 10 tons/year of biodiesel. Nyamplung plants per Ha (400 trees) can produce 14.8 tonnes/year of biodiesel (Sodiq, 2013). But what must not be forgotten in producing bioethanol and biodiesel is that there is no deforestation of Indonesia's forests. The increasing demand for bioethanol and biofuels should not have an impact on the conversion of forests into agricultural land and plantations. The increasing use of bioethanol and biofuel means reducing petroleum fuels and reducing CO2 gas emissions.

Conclusion

From the description above it can be concluded:

1. The role of agroforestry in adapting to climate change through three approaches, namely translocation or transfer of germaplasm, local genetic adaptation, and individual species plasticity.
2. There are three roles of agroforestry in mitigating climate change, namely carbon sequestration, stock protection, and utilization of renewable energy

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