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Description of an agroforestry system

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Abstract

This study aimed to determine the definition of agroforestry and the functions of agroforestry system that could be modified to strengthen agrarian communities. The methodology of this study consisted of literature review and data analysis by content analysis technique. The results indicated that the definition of agroforestry could be shown in easy formula: Agriculture + Forestry = Agroforestry or building forests through agriculture. By cultivating crops in a condition similar to nature, it is possible to bring diversity back to fields and achieve sustainable production of crops that were previously mono-cultural. This study found three functions of Agroforestry System: 1) economic functions, composed of the four sub-functions of various, even and resilient incomes, production efficiency, expenditure reduction and economic immunity; 2) environmental functions, composed of the seven sub-functions of land conservation, sedimentary reduction, flood and droughty relief, storm resistant, micro-climate amelioration, carbon sequestration and biodiversity; 3) social security functions, composed of the five sub-functions of product charity, good health, knowledge sources, traditional descent, and social grouping and networking. The functions of agroforestry system might help strengthen the agrarian communities in many aspects of sufficient economy, capacity building, self-esteem, quality of life, social harmony, and ecological improvement. However, levels of the strength of the communities depended on some accelerators. In the future, agroforestry system extension can be one of the measures to support or be integrated into the routine socio-economic and environmental programs and projects of central and local governments in all types of agrarian communities.

Keywords: agroforestry, economic, environmental, social security, agrarian communities

1. Introduction

Usually, trees play a crucial role in most terrestrial ecosystems and provide a range of products and services to rural and urban people such as foods, fiber, fuel, herb, timber, oxygen, carbon sequestration, land and water conservation for a watershed [1]. Unfortunately, trees and forests around the world, especially in many developing countries have been decreasing as to socioeconomic development. Conversely, agricultural areas in most of these countries have been increasing to respond to rural people earning, commodity export, agroindustry, and Gross Domestic Products growth.

Currently, most of the agricultural practices are mono-cropping which can increase farm productivity and generate satisfactory income when crop price is good but it can also cause some negative impacts and suffer from perturbations, especially economic and climatic uncertainties [2]. Certainly, as natural trees is cleared for agriculture and other types of development, the benefits that trees provide are best sustained by integrating trees into agriculturally productive landscapes — a practice known as agroforestry [1]. So, why don't we change from current mono-cropping to agroforestry in order to at least increase diverse incomes, food and social security and mitigate environmental problems? Thus, this study aims to review the various functions of agroforestry system and then modify it to strengthen agrarian communities.

2. Definition of Agroforestry

Definitions of agroforestry might be diverse by individuals and organizations with different background and interest. A definition of agroforestry, though not perfect in all respects, increasingly used in publications of International Center for Research in Agroforestry (ICRAF) and thus achieved wide acceptability, is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence [3]. In agroforestry systems there are both ecological and economical interactions between the different components [4].

The definition could be shown in easy formula: Agriculture + Forestry = Agroforestry or building forests through agriculture. Many examples of agroforestry can be found worldwide in regions, especially in tropical zone such as Africa, Latin America, South Asia, Southeast Asia.

3. Function of Agroforestry System

There were three functions of Agroforestry System.

3.1. Economic functions, composed of the four sub-functions as follows:

3.1.1. Various, even and resilient incomes

Agroforestry can be source of various, even and resilient incomes. For example, a rubber based agroforestry plot at first 3 years of rubber trees the farmer gains income from intercrop such as rice, chili, longbean, pineapple, corn, banana and papaya. After 3 years old of rubber trees, the increasing rubber shades are suitable for planting most associated crops so that the plot income can be generated by associated crops such as Miang (*Gnetum gnemon* Linn.), Sala (*Zalacca edulis* Reinw.), Yellow palm (*Chrysalidocarpus lutescens* H. Wendl.), bamboo (*Bambusa sp.*), Kor (*Livistona speciosa* Kurz). Also,when the rubber trees are 7 years old, they start yielding for several decades.

Resilient income may be defined as the propensity of a system to retain its income following a perturbation. For instance, a rubber plot (15 rais = 6 acres) is associated with 2 kinds of timber and 4 kinds of fruit trees in Songkhla province, Thailand (Figure 1). The black graph shows income in case of fixed rubber price in 2012. The red graph shows income in case of lower rubber price during 2017-2021 = 40% from the fixed rubber price so that lower income is around 486,000 Baht in total. The green graph shows income in case of the lower rubber price and farmer sells 98 Eagle woods in 2021 so increase of income amounts to 490,000 Baht. Therefore, this plot has high resilience because the farmer uses only one year to compensate the five years lower income. Additionally, this plot has 952 Eagle Woods and 2000 Iron Woods left, fruit trees for consumption and all trees for environmental services [2].

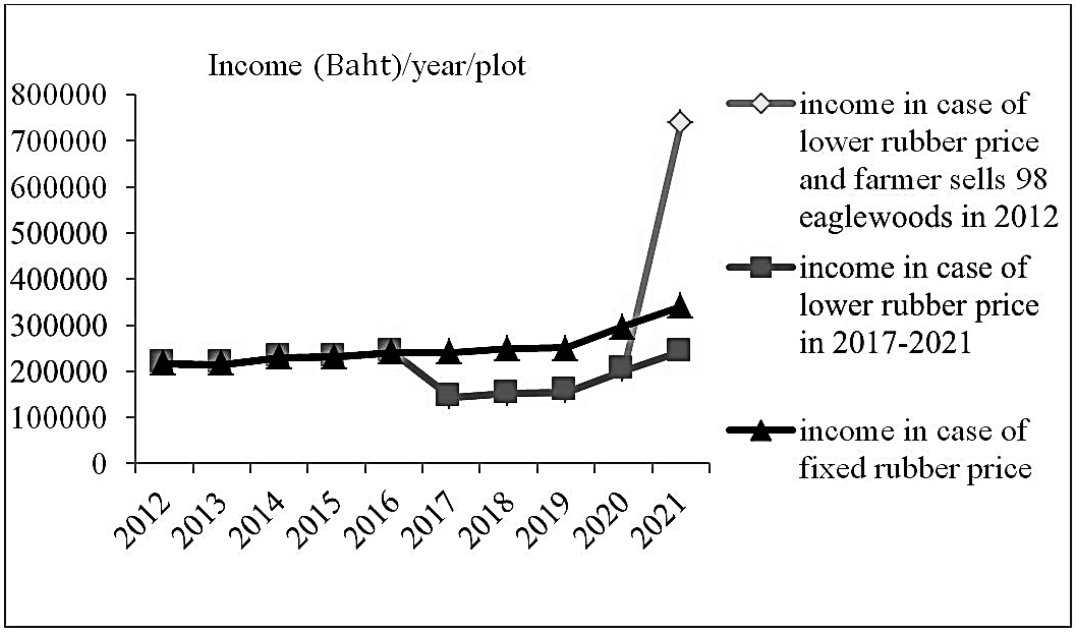

Figure 1 Resilient income of agroforestry system

3.1.2. Production efficiency

When a farm costs are reduced and/or farm yields are increased under condition of other things being equal, it indicates that the farm production efficiency is improved. Agroforestry practices can improve the farm production efficiency as following aspects:

- Increase in land use efficiency: Because in the same agroforestry plot farmer can plant more than one species and these species can co-exist and support each other in growing and/or yielding. So, it reduces land cost per species and is suitable for small farmers who are majority of the farmers around the World and need the efficiency increase of small land use to compensate for the loss of economy of scale.
- Reduction of input expenditure: In agroforestry plot together with ~~and~~ low~~er~~ or no agrichemical application in the plot *the plant nutrient cycling* will recover more or less so that the necessity to buy fertilizer will decrease or be none. For instance, leaves and organic matters in rubber based agroforestry fallen and decomposed with higher rate than mono rubber crop so it could be a better alternative in terms of the plant nutrient cycling (5).
- Increase in crop yield: The well co-existence of different plants in an agroforestry plot, including supplementary practice of farmer could increase some crop yields. For example, a rubber plot associated with salas in Songkhla province the farmer found that irrigating salas in summer helped increase rubber latex yields by about 5-10 % [6].

3.1.3. Expenditure reduction

Agroforestry provides not only various incomes but also farm productions for self-consumption. These kinds of production and increase of internal inputs help save farm and family expenses. The examples are as follows:

- A rubber-pineapple plot in Phatthalung province, Thailand provided crop income from pineapple about 34,000 Baht per rai (1 rai = 0.3954 acre) and the rest for self-consumption and charity [7].
- A rubber-Kor plot in Songkhla province provided income from both latex and Kor leaves sale (2 Baht/leaf), and the rest for self-use such as making roof, bag, mat [6]. Also, these handicrafts are eco-friendly products that help support green society policy.

3.1.4. Economic immunity

Agroforestry allows sharing financial risk between various outputs, for instance, a rubber-Miang plot in Songkhla province when rubber price was going down, the farmer still gained satisfactory income from young Miang leaves. In 2013 the plot incomes were shared between various outputs as follows [7]:

- Annual income from young Miang leaves, 42,800 Baht per rai
- Annual income from rubber latex, 21,400 Baht per rai

3.2. Environmental functions, composed of the seven sub-functions as follows:

3.2.1. Land conservation

Agroforestry practices will improve soil fertility via restoration of plant nutrient cycling. Also, more canopies will prevent rain drops attacking topsoil directly. Meanwhile, various root systems of plants will hold topsoil. So, it helps prevent or mitigate soil erosion. For instance, a rubber-eagle wood plot in Songkhla province, eagle wood roots and rubber roots are intertwined and hold topsoil in the plot [8]. The example is in line with comment of Young about one of the highest capacity of agroforestry system in term of prevention of erosion in slop area, increase in crop yield and expenditures less than crop terrace making [9].

3.2.2. Sedimentary reduction

Therefore, preventing or mitigating soil erosion by agroforestry, particularly in the upper land will reduce the downstream sediment of watershed. Conversely, deforestation will effect on sedimentation of watersheds and marine environments. For instance, in a region of Madagascar, the rate of deforestation per watershed varied between 6 to 15% of the entire watershed, and was increasing non-forest coverage from 1990 to 2010. As seen in the potential soil loss image, the region also was at risk of 36 to 140 tons per hectare per year of soil loss. The largest sedimentation plume in Antongil Bay was found in the estuary of the region, and had a strong correlation of continuously increasing throughout 2000 to 2010 [10].

3.2.3. Flood and Droughty relief

The upper land covering with Agroforestry will slow down overflow of heavy rain. So, flooding in the lower land will relieve. Also, droughty will relieve because agroforestry in the upper land can store the water and moisture both inside various trees and underground and then gradually drain the water into the water sources in dry season [11]. Conversely, introducing monocultures over large areas of biophysically and geo-morphologically diverse landscapes, including riparian areas, will most likely result in vulnerable systems in which water flows, soil stability and crop yield will be highly unpredictable [12].

3.2.4. Storm resistant

Agroforestry could resist climatic uncertainty. For example, a rubber based agroforestry plot in Songkhla province mostly resisted the storm in November 1, 2010 as to high density of various trees and crops in the plot meanwhile a mono-rubber plot nearby, most rubber trees were fallen when hit by the storm [8].

3.2.5. Micro-climate amelioration

Agroforestry could improve micro-climate, the better for crop and human health. For instance, a farmer in Songkhla province, said, "*My Bamboo associated crop provides a lot of oxygen and lower canopy, so my plot is cool and shady. It is good for my health. My neighbor who is tired from doing his daily farm work likes to get a rest and feel refreshed in my plot"* [13]. In Niger *F. albida* shade induced reduction of soil temperatures (at 2-cm depth the reduction was by 5°C to 10°C depending on the movement of shade) particularly at the time of crop establishment, contributed to the better growth of crops under these trees. In coffee and cacao plantations shade trees have been observed to buffer high and low temperature extremes by as much as 5°C. Since the microclimatic modifications within agroforestry systems depend on tree/crop combinations, tree spacing and height, and the prevailing climatic conditions, the benefits or otherwise of agroforestry are strongly dependent on the specific technology adopted [14].

3.2.6. Carbon sequestration

Many trees and trees density in agroforestry could stock large organic carbon. Additionally, examination of 3,471 soil profiles taken across Lao PDR highlighted a correlation between land use and soil organic carbon stocks, with the largest being found under forest, smaller stores under shifting cultivation and the smallest under continuous cultivation [12].

3.2.7. Biodiversity

Where is diverse, that it is sustainable both in ecology and socioeconomic aspect For example, a rubber based agroforestry with various flora and fauna to live. So, the diverse food sources and various trees with different heights and canopy layers can attract more kinds of birds than rubber monoculture [5]. Additionally, planting rubber based agroforestry helps prevent some threats to the farm such as fire, insect pests [15].

3.3. Social security functions, composed of the five sub-functions

3.3.1. Product charity

The various productions from agroforestry can be shared with the farmer's relatives, neighbors, friends, community and so on. If there are more diverse agroforestry plantations in a community, the more diverse agroforestry productions will take place. This condition will encourage good chance for the charity and the increased utility of the receivers. However, the charity ratios of each farmer were influenced by the following factors: (1) prices of agroforestry products. The higher the price, the more the sale; (2) in a community where specific agroforestry was popular, the donation ratio would be small or none or the receiver's utility would be low or none as regards the Law of Diminishing Marginal Utility in case of over consumption of the receiver (Figure 2-3); (3) a farmer's expectation of making friends and helping each other; (4) kindness to the poor; and (5) donation for charity in a rural community is mostly a traditional way [13].

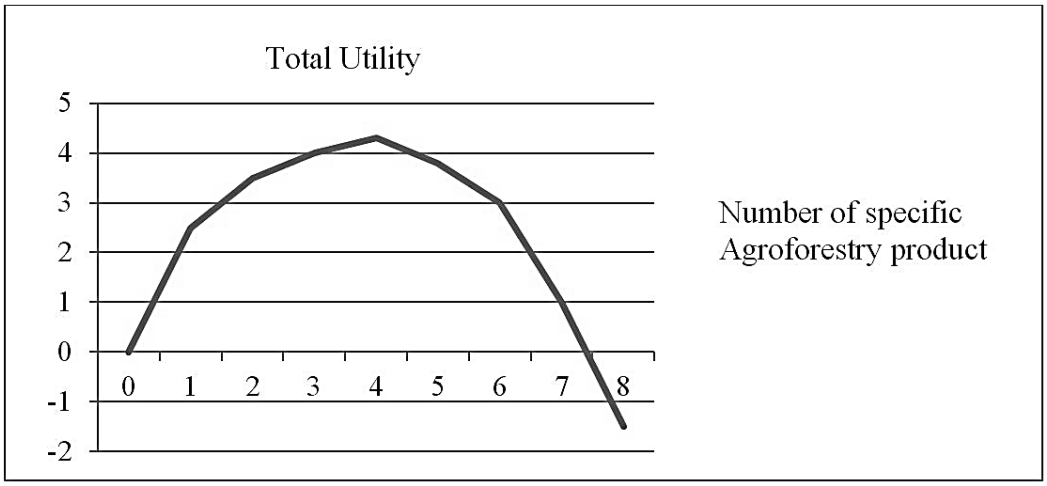

Figure 2 Total utility of a consumer per total specific Agroforestry products

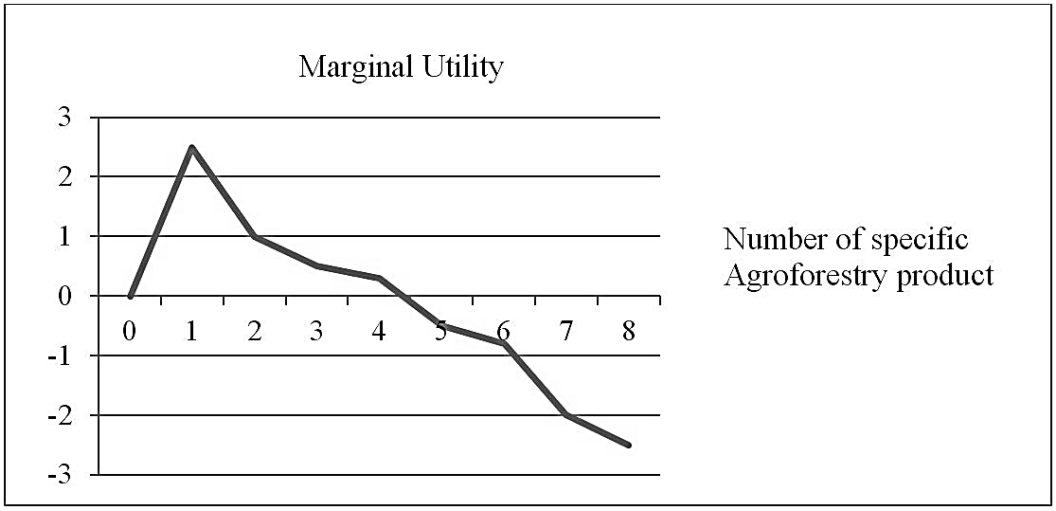

Figure 3 Marginal utility of a consumer per marginal specific Agroforestry product

3.3.2. Good health

Agroforestry practices together with avoiding agrichemical use will improve environment in the farm such as clean air, cool air, decrease in agrichemical contact, eating herbal and healthy food from the farm. Therefore, these will improve farmer and family health. A story from Songkhla province, regarding better health could be cited as follows: Mr. Suchart said, "*I work in a shady farm where there are various kinds of trees and birds. I can see spring, flowering and fruiting in my farm and eat my chemical-free products from associated crops. They make me happy and healthy"*[13]. Additionally, dust exposure is thus far little recognized as a threat to the health of people in the drylands of Eastern Africa. Trees planted in the areas of origin of the dust and around human settlements have the potential to reduce exposure to dust, and therefore health gains are possibly achievable through trees [14].

3.3.3. Knowledge sources

A succeeded agroforestry plantation could be knowledge sources for other farmers, students, academics and so on. For example, a farmer in Phatthalung province set up his outstanding biodiversity agroforestry farm as community learning center giving rubber based agroforestry knowledge and confidence for many rubber farmers to practice some agroforestry. Also, the farm has been an interesting laboratory of academics and studies.

3.3.4. Traditional descent

"Cultural plants" in Agroforestry plot such as pan palm, bamboo, Kor, banana, herb help conserve local cultures from generation to generation. For example, bamboo stems were donated to build flagpoles for a monk's boat at the annual Shuk-Pra tradition in Southern Thailand. Farmers used leaves of pan palm to wrap stick rice

mixed with coconut milk, salt and sugar; and then steamed them as sweet for the festival of Tenth Lunar Month or known in Thai as Sat Duan Sip [13]. In African dryland, tree species are important in religious and spiritual ceremonies and are conserved because of this cultural significance, for instance, the tree, namely the baobab (*Adansonia digitata*) features in many myths and tales [14].

3.3.5. Social grouping and networking

The last one of social security functions is social grouping to promote agroforestry in rural and agrarian landscapes. This local group helps each other, share experiences among the members, and sometimes form networks with other local groups and various partners to scale up agroforestry. In the future, we hope that these networks will have important roles in actively advocating a national policy on agroforestry promotion. For instance, a local agroforestry group in Phatthalung province, up to now planted many associated trees in rubber plots such as iron wood, eagle wood, neem (*Azadirachta indica* A. Juss.), mahogany (*Swietenia macrophylla* King) more than 20,000 trees in 253 rais [8].

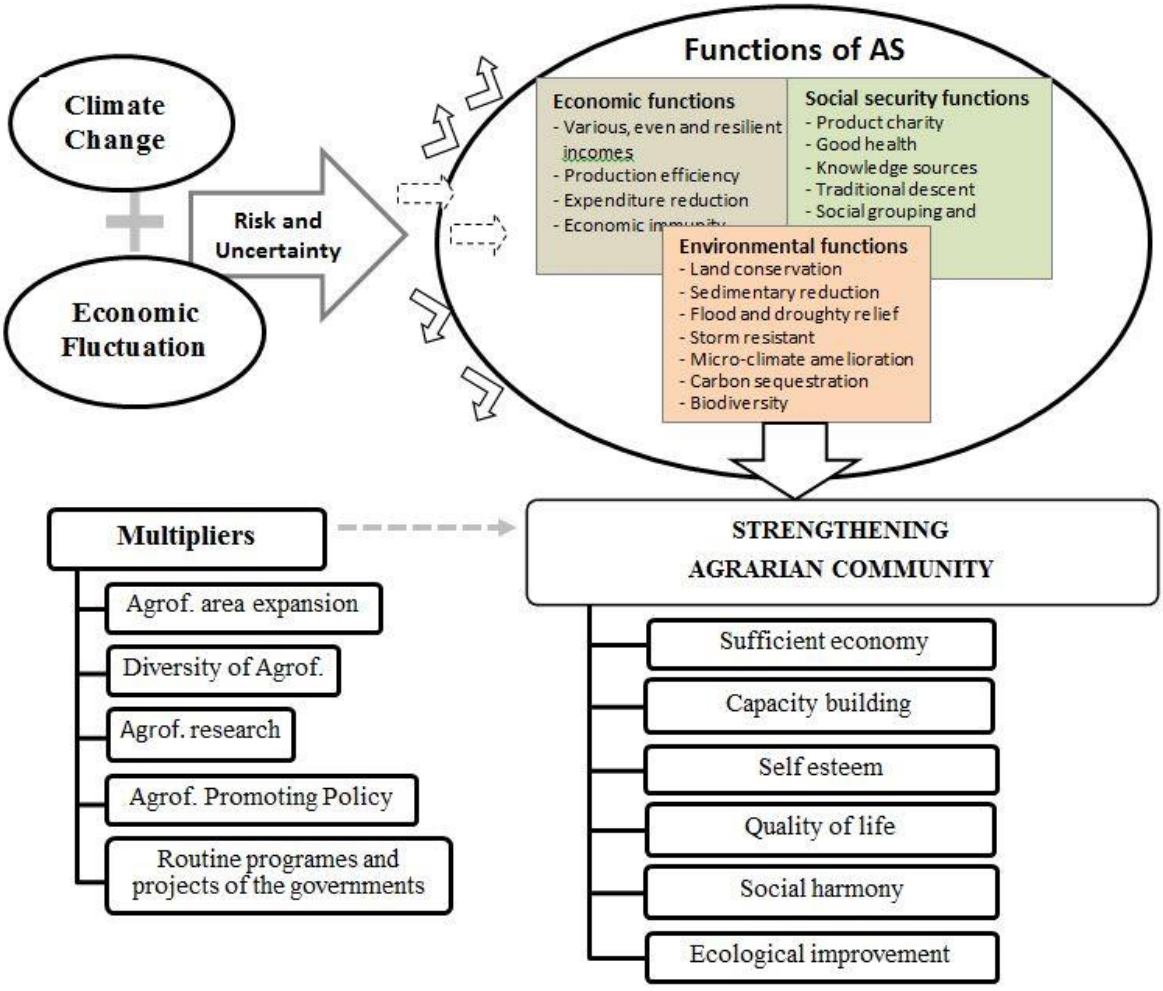

Figure 4 Agroforestry system can resist risk and uncertainty and strengthen agrarian community

4. Strengthening Agrarian Communities through Agroforestry

In the future, the three functions of agroforestry will help strengthen agrarian communities in many aspects as follows:

- Sufficient economy that has three components: moderation, reasonableness, and self-immunity, with two accompanying conditions: appropriate knowledge and ethics & virtues will be promoted via agroforestry practices, regarding reduction of input expenditure, family expenditure reduction, economic immunity, various and resilient incomes, increase in land use efficiency, product charity, and traditional descent.
- Capacity building through activities of the community learning centers, the local groups and networks promoting agroforestry such as training course, fieldtrip, knowledge exchange, learning by doing.
- Self-esteem that derived from the achievement of the farmers' agroforestry practices as well as respect from individuals and related organizations. So, increase in the number of agroforestry farmers and their agroforestry success in their community will expand the self-esteem [13].
- Quality of life improved via better health of farmers, micro-climate amelioration, increasing food security, more knowledge, traditional descent, flood and droughty relief, caused by the agroforestry practices.
- Social harmony derived from the charity of products from agroforestry and activities of the local groups and networks promoting agroforestry such as visiting farm sites, knowledge exchange, help each other among the members & networks, and traditional descent via the productions of agroforestry for traditional activities.
- Ecological improvement in agricultural areas via the actively environmental functions of agroforestry system.

However, levels of the community strength depended on some accelerators of (1) agroforestry area expansion in community (2) diversity of agroforestry in community because at a family level, several kinds of productions from a agroforestry help increase a diverse food security and distribute a farm economic risk caused by price uncertainty. This diverse agroforestry will be more useful if it can be scaled up into a community level (3) agroforestry research (4) agroforestry promoting policy that should base on the results of the research and be in line with area context and (5) active routine socioeconomic and environmental programs and projects of local and central governments.

5. Conclusion

Agroforestry system is mostly resistant to the risks and uncertainties caused mainly by climate change and economic fluctuation. In the future it can strengthen many agrarian communities in many aspects. However, the degree of the strength depends on some multipliers. Therefore, agroforestry system extension can be one of the measures to support or be integrated into the routine programs and projects of central and local governments to strengthen socioeconomically and ecologically many agrarian communities.

Some recommendations to promoting Agroforestry are as followings:

- The best practices and local wisdoms of Agroforestry farmers in regions with different contexts, including the benefits and values of Agroforestry that people will get should be collected systematically and shared as much as possible by using mass media, social media and so on.
- Addressing tenure security, institutions, laws and regulations that support an environment which encourages land users to introduce and manage trees sustainably and benefit from the products and services that they provide.
- Promoting leadership among local people to take the initiative in building Agroforestry, community learning center, local group and network to promote Agroforestry.
- Priority over Agroforestry extension on sloping lands where have been covered by monocultures and risks of land erosion and land slide, especially during wet season.
- Any policy formulation for Agroforestry should be a knowledge-based policy and up to participatory approach of all stakeholders.

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