Sustainable integrated farming system: A solution for national food security and sovereignty

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Abstract. This paper provides a comprehensive review of literature related to food security. The world food crisis is a threat to all countries, including Indonesia. The problem of food security in Indonesia is still happening, particularly, aspects of production and increasingly unbalanced food availability. Due to the increasing rate of population growth, land functional shift, degradation of land resources and water, as well as environmental pollution and climate change. Food production has not been able to meet the needs of the population continuously. Therefore, the food policy paradigm applied in Indonesia must change from food security to food independence. Thus, Indonesia is not dependent on other countries. Food diversification is one of the best policies to be implemented in achieving food independence and anticipating the food crisis. Food diversification utilizes land optimally by developing an integrated farming system. The integrated farming system is an efficient and environmentally agricultural system. It is able to utilize sustainable agriculture development, followed by the development of participatory technology (Participatory Technology Development) which refers to the local wisdom of the community.

1. Introduction

Food has become a primary need of human beings to ensure their life. Indonesia is one of the developing countries known for its agriculture. Most of the people do farming for a living. Indonesia has a massive land being potential for farming, although food security still becomes a solemn problem requiring a serious attention. Laws on food issues are made to amend that food is not only a strategic and crucial matter, but it has also become a part of human right. As such, on condition that the state does not fulfill people's need of food, it is said to violate human right.

Food security in Indonesia has recently been worse in as much as vigorous change of agriculture land function for use beyond agricultural sectors, a situation under which the government need to be more sensitive. Managing food security and its sustainable development is one of the biggest challenges in Indonesia. Countries are not able to provide sufficient quantities of nutritious food to these people so that they can live healthily. It is strongly believed that there is enough food to feed everyone adequately but the problem is distribution and management [1]

This has drawn the attention of many international bodies, not to mention Food and Agriculture Organization (FAO), which argue that Indonesia sits at an insecure levelin the Global Hunger Index. This is predicted to be worsen in line with the increase in the number of its population and, in the long run, food scarcity may occur because of several reasons such as environmental damage, land conversion,

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high price of fossil fuel, and climate change. Climate changes have started showing its impact on water resources and agricultural yield worldwide. Water and food security are the key challenges under climate change as both are highly vulnerable to continuously changing climatic patterns. Climate changes have started showing its impact on water resources and agricultural yield worldwide. Agricultural sector and food securities are threatened and if the basic adaptive measures such as changes in crop pattern, crop breeding and types and innovative technologies, which use less water are not used global food production [2]

There is a new urgency to improve the accuracy of predicting climate change impact on crop yields because the balance between food supply and demand is shifting abruptly from surplus to deficit [3]. This reversal is being driven by a rapid rise in petroleum prices and, in response, a massive global expansion of biofuel production from maize, oilseed, and sugar crops. Soon the price of these commodities will be determined by their value as feedstock for biofuel rather than their importance as human food or livestock feed.

Food autonomy is a prerequisite of food security. Such security becomes intricate to achieve if a state and its people do not have an authority on the consumption and production process of the food. Food security means every individual is able physically and economically to fulfill sufficient, secure, and nutritious food for an active and healthy life. National food security is reached when the food need of every individual household is fulfilled, which is portrayed in the safety, equality, accessibility, and availability of sufficient food both in quantity and quality. Of these, production and availability of food are still problematic in ensuring food security. Food production has not been able to continually fulfillthe people's need because of a relatively slower food production growth than the demand.

In recent years, Indonesia faces food security problem. For this, it is important to find out ways to solve it, which includes increase of food availability, stability and accessibility of food to promote competitiveness in the state economy. It is undeniable that to extend the quantity of land for agriculture and to slow down population growth in Indonesia are difficult, but what is important in this matter is to find out the strategy to improve food security by effectively cultivating and making the best ofthe available land. Space management of the land must also be carefully done for further reservation of "permanent farming land", which is regulated through central government regulation or local government regulation.

The other challengesare global warming affecting climate change and food competition for consumption and bioenergy. Consequently, climate is unpredictable, causing production uncertainty or failure in harvest, which severely declines food production. Scarcity and continuous resource usage competition (land and water) results in more difficult food production and ultimately causes food shortage. In fact, Law No.18/2012 on food has entrusted that food provision is intended for fulfilling basic needs of human beings equitably, equally, and continually on the basis of food sovereignty, food autonomy, and food security [4] (Kemenkumham).

This paper provides a comprehensive review of literature related to objective: to explain or to describe the role of integrated agriculture in the handling of national food security.

2. Developing National Food Security

The success of a state development is indicated by the availability of quality human resource those who are physically and mentally strong, healthy, and intelligent. Empirical data indicate that this type of resource is built through good nutrition, and good nutrition is determined by the quantity of intake received. Thus, fulfilling food and nutrition is a necessity to promote health of the society and becomes an investment to boost the quality of human resource.

Establishing food security and nutrition is a part of the national perspective. Indonesia, a nation with a huge number of population and a large coverage of territory, food security and nutrition, has an important agenda in its economic development. The government must continually push development of food security and nutrition through programs that are able to strengthen food security and at the same time improves prosperity of the society. Food shortage is another part of the Indonesia National perspective, which is considered sensitive in the part of the dynamic socio-political life. Hence, it is important for Indonesia to actualize regional food security and nutrition, and food-security-based

household and individual. Programs intended for nutrition and food security development are to be integrated, measurable in its successand sustainable.

The world food crisis threatens all countries, including Indonesia. The national policy on food implemented in Indonesia should be shifted from food security to food autonomy to avoid food dependency on other countries. One of the policies considered appropriate to be implemented in order to achieve food autonomy as well as in anticipation of food crisis is diversification. It is a process of diversifying food, or efforts to increase consumption of varied foods based on the principle of balanced nutrition. One of the obstacles in developing local foods is there has not been any local food easily accepted and afforded by the people. Apart from this, the people consider rice is the main food for them. One of the ways to develop local food product is by providing incentive for enterpreneurs or industries that use local food as raw materials.

3. Food Security Policy and System

Food security is divided into three: *(i) food availability; (ii) access to food; and (iii) food usage*. Food availability is physical availability of the food in the area, gained either from domestic product, import/trade or food aid. Food availability is indicated by domestic product, which comes from market, food stock owned by trader and government, and food aid from either government or food aid agencies. Food access is the ability of household to get sufficient food, either from own production, purchasing, trade, gift, loan and food aid, or combination of the six. Food availability in a certain area may be sufficient, but not all households have equal access to it either in terms of quantitative or food diversity. Food usage refers to food use by households and individual ability to absorb and metabolize nutritious essences (conversion of nutritious essence by the body efficiently). Food usage also includes strategy of storing, processing and serving the food, including use of water and fuel during the process and hygienity. Another important aspect of food usage is the custom for serving the food, particularly for the individual needing special food, distribution of the food in the household which suits each individual need, and health record of every individual member of the household.

One of the government policies in empowering food security is Acceleration of Food Consumption Diversification (*AFCD*). It is an implementation of strategic plan of the Ministry of Agriculture, one of which is increasing food diversification. Acceleration of diversification on consuming local food is a national move supporting food security of the society on the basis of local wisdom and cooperation of central and local governments as well the people. Activities of *AFCD* include: using house yardas affectively as possible following the concept of Sustainable Food Center (*SFC*). Itis done by empowering women to make the best of the available house yard as a family food source. This concept requires cultivation of varied kinds of plantation that suit the family needs, such as various roots, vegetables, fruits, and livestockand fish as supplement for availability of source of carbohydrates, vitamins, minerals,and protein for the family in an area of housing /community living nearby. This leads to an establishment of an area rich with own produced food as a result of making the best of house yard. The approach to this development is through sustainable farming, such as opening seed plantation by prioritizing local resources and making use of local wisdom, to ensure the nature remains protected. Home gardens are an integral part of local food systems and the agricultural landscape of developing countries all over the world and have endured the test of time [5].

4. Sustainable Integrated Farming System

Integrated farming system is an agricultural system which combines the activities of crops and horticulture, animal husbandary, fishery, forestry and other sciences related to agriculture within an area simultaneously at a time or so. Developing an integrated farming system needs an appropriate technology, because such technology is partly important in sustainable farming and food security. As a tool, it is necessary to think about how to help farmers improve the quality of their crops. Technology also needs to be considered as a solution to overcome and to balance decrease in food production due to decrease of agricultural land. Some countries with small land are still able to overcome their food problem because of technology. Crop production can increase if irrigated areas are expanded or irrigation is intensified, but these may increase the rate of environmental degradation. Since climate

change impacts on soil water balance will lead to changes of soil evaporation and plant transpiration, consequently, the crop growth period may shorten in the future impacting on water productivity. Crop yields affected by climate change are projected to be different in various areas, in some areas crop yields will increase, and for other areas it will decrease depending on the latitude of the area and irrigation application [6]. This has encouraged Indonesia to integratedly cultivate its land adopting the so-called Integrated Farming System.

Implementation of integrated farming system promotes higher income, minimizes risk of crops failure of one type of crop, and creation ecological farming system which is able to make the best of local resources as efficiently as possible for the puprpose of sustainable environmentally-friendly farming system. Maximizing use of land, which currently has decreased, encourages integrated farming system of crops, forestry and livestock within the same land space simultaneously. The adoption of integrated poultry-fish-duck farming in different forms such as intensive broiler production, backyard poultry rearing, etc. leads to conservation of natural resources and provision of additional income/employment opportunities, especially to the youths and women workers in the villages. That the integrated poultry-fish system could address issues of sustainability, women empowerment and livelihood security effectively [7].

4.1. Polyculture system

Cultivating land under yearly crop stands sustainably can be done through polyculture system. Polyculture means planting more than one type of plants in an area at a time or almost simultaneously. Some planting patterns of polyculture system include Intercropping and Interplanting, Multiple Cropping, Companion Planting, Mix Cropping, and Alley Cropping. Implementing polyculture, in principle, intends to make land use efficient, minimize land damage, overcome risk of crop failure, increase income of farmers, and guarantee food availability.

Planting intercropping plants of varied kinds of food among coconut trees is profitable. In Lampung is one of the central areas of coconut plantations in Indonesia, covering an area of about 126,129 ha, only about 30% of the total area under coconut trees was used for intercrops. Types of plants for intercrops were maize, bananas, and upland rice. This is because 80 percent of the land under the coconut trees can be used for other plants and livestock [8]. The kinds of intercropping plants that can be planted under this area include plantation crops, food crops, and horticulture depending on the land and the climate of the area. One of the obstacles in using land under coconut stands, besides the percentage of sun light, is fertility of the land. Planting intercrops and livestock in such a land can increase efficiency of land use, and the income of the farmers from intercrops and livestock increases at least 30 percent, and another 30 percent from crops of coconut.

Some research also reported that it is economically profitable when corn plantation is managed well. Planting corn as intercrop plants among coconut stands yealds 80 percent more than planting corn monoculturally [9]. To increase income and efficiency of corn planting needs modification of corn planting system for a more optimal use [10]. Moreover, [11] found that such a modification of corn planting for the purpose of double earnings—that is seeds and stover for animal feed—is economically appropriate to be implemented with a B/C value and an anaverage of more than 2.0.

Such efforts need an integrated and sustainable management with technological innovation suitable with a specific location. One of the breaksthroughs in coconut plantation technology is to move from a traditional farming system of monoculture to a polycultural farming of coconut, including developing food crops among coconut plants, to support community food security.

4.2. Livestock plant system

Farmers have long been employing the concept of integrated farming involving plants and livestock although they still did it traditionally in a small land. Such farming is really potential to develop commercially to support national food security. Integration of livestock in farming system is of importance in: 1) ensuring farming to be sustainable through diversification of activities in order to produce food for the family of the farmers; 2) removing the nutrients and energy between livestock and plants by way of using manure and agricultural wastes as food source to create sustainable farming,

which is environmentally-friendly [12]. The presence of livestock and food plants in the area of coconut plantation within a farming system will open crop diversification opportunity by including *palawija* (crops planted as 2nd crop in dry season), horticulture, and morage in a single unit of farming. Such a link between plant farming and livestock enables the two activities to provide food in support of food security and autonomy of the community.

The food plants planed producing biomass can be used to feed livestock, while the livestock produce manure which can be used to improve soil quality and assure sustainable soil fertility.This will create efficient, productive, profitable and environmentally-friendly farming system. Animal husbandary needs to be developed integratedly to become part of an"organic farming".

4.3. Forest crop system and livestock (agrosilvopasture)

The growing intensification of farming has been accompanied by degradation of wild lands, including tropical forests and wetlands, at an alarming rate. Further pressure on fragile land has come from associated urbanization. Integrating crops and livestock into existing farming systems is being recognized as a means to address these problems and the smallholder farmers have the possibility of realizing immense benefits from the integrated systems [12]. In Indonesia, agroforestry is often regarded as one of the sustainable integrated farming system. It is a collective term of varied kinds of integrated land use (forestry, agriculture, and/or animal husbandary) existing everywhere in the world, not to mention those found in tropical developing countries, i.e. Indonesia. Such traditional land usage has been developed/practiced by the local community or introduced by many parties within the last three decades [13]. Main constituent component of agroforestry is forest, farming, and/or livestock. By looking at the components, agroforestry can be classified into Agrisilviculture, an agroforestry system that combines between forest components (woody plants) and agricultural components (non-woody plants), and Silvopastural, an agroforestry system that covers forest components (woody plants) and livestock components (pasture).

4.4. Intercropping system

Intercropping is one of the traditional plant breeding methods on dry land. In this model, two or more plant species are planted at the same time on the same field. This model can reduce the risk of crop failure, improve soil fertility, decrease soil erosion and increase farmers' income. It can also improve the use of environmental factors, labor and water as well as surpressing weed attacks and plant diseases. In most cases, intercropping system is more lucrative than monoculture system due to high land productivity and varied commodity type. Economical use of production means and lower risk of failure so that the sustainability of food availability can be guaranteed.

Intercropping system can improve the effectiveness of land use. Intercropping soybean and maize is advantageous. This is associated with a greater total intercrop yield, higher land equivalent ratios greater than 1.0, indicating greater productivity per unit area and greater percentage of land saved, which could be used for other agricultural purposes. In addition, land equivalent coefficient values exceeded 0.25, indicating yield advantage of the intercropping system. Competitive pressures were low, signifying that the crops were found to be complementary and suitable in mixture [14].

As one of the alternative ways in agricultural intensification program, intercropping system is suitable for multiplying agricultural products in less productive areas. Not only can the system increase the harvest amount per year, it can also maintain the fertility of soil by restoring many organic matters and ground covered by canopy plants. Intercropping system gives more benefit than monocropping does. It can reduce production cost due to the efficiency of land use.

Intercropped between leguminosae and cereal crops has been a common combination done by the farmers. The use of legumes like levials as intercropping plants can be profit-making for the staple plants because it produces a lot of nitrogen. The root nodule of the legume crops can bind the free nitrogen from air and this is quite profitable for increasing the nitrogen in the soil and meeting nitrogen needs of other plants. The planting soybeans using right intercropping system can avoid plants from pest attacks, resulting in high crop productivity. Intercropped system between corn and soybean from various soybean cultivars at various planting items as a whole is more advantageous than the monoculture system [15].

4.5. Dry farming system

The development of food crops in addition to rice is often done on dry land, even on critical land. With narrow land ownership, annual water availability remains an obstacle to cropping patterns. As a result, the rate of soil fertility and the tillage is low and is relatively susceptible to erosion in rainy season. For that reason, it is important to seek for alternative technology so that corn farming on dry land can give an extra income for farmers increasing their family food security. The crop production should focus on increasing crop productivity through Integrated Nutrient Management (INM). INM systems more efficient using compost, farm wastes, green manures, sewage, sludge etc. Bio-fertilizer technology needs to be to be made more acceptable to farmers. Microbial strains which can compete with indigenous ones and work over a range of soil climatic conditions need to be isolated and multiplied [16].

Indeed, dry farming system has not been understood in depth while its ecosystem diversity is quite complex. The constraints pertaining to environment, socio-economic condition of society and less touch of adaptive technology cause the quality, productivity and stability of existing farming to be limited. Plant that can be cultivated on dry land is *palawija* crops, and one of the crops is corn. The corn demand both for food and non food tends to be high from year to year. Any efforts to increase corn productivity in the country have been done, including the use of improved varieties, fertilization and spacing on farming areas [17]. According to [15], double cropping pattern is one of the agricultural technology managements that can be applied to minimize the risk of dry land use in food crops development. Pest anticipation, on the other hand, is aimed at reducing risk of pest attacks and diseases in intercropping pattern. In order to avoid a plant from becoming the source of pest and disease for other intercropped plants, it is suggested to plant crops with different pest and disease.

5. Conclusion

The problem of food security in Indonesia is still happening, particularly, aspects of production and increasingly unbalanced food availability. Due to the increasing rate of population growth, land functional shift, degradation of land resources and water, as well as environmental pollution and climate change. Integrated Farming System which combines activities of food-crop farming with horticulture, animal husbandry, fisheries, forestry and other science related to farming on the same field at the same or almost the same time needs to be developed as a solution to food security problem resulting from decreasing food productivity area out of land conversion and climate change. It plays a role in suppressing land degradation and water resources and environmental pollution as well. It is an efficient and environmentally-friendly farming system utilizing the potential of local resources in optimal way for a sustainable development of agriculture. However, the development of integrated farming system needs to be followed by participatory technology development, which is based on local wisdom in society.

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