

Research Article

Climate change impacts on tropical agriculture and the potential of organic agriculture to overcome these impacts

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Abstract

Global warming mostly causes climate change which affects agriculture by increasing the temperature, modifying the rate of rainfall, water-preservation and soil fertility. Climate change impact on agriculture is different depending on the agro-ecosystem condition, but based on a number of studies, the most affected part of the world would seem to be the tropical region. South East Asian countries located within the tropical belt will be most affected. The probable impacts include productivity loss, drought risk, varying monsoon pattern and shifting crop cycle. Since most of the agricultural products in South East Asia are climate-dependent plants, the impact will be widespread. For example, rice is a staple food product in South East Asian countries and its cultivation is very dependent on climate conditions and water resources. Any loss of productivity with rice would cause socioeconomic problems and have implications for food security in the longer term. A number of studies have suggested that organic agricultural practices have the ability for enhanced drought resistance and greater adaptability to climate change. Organic agriculture is also self regulating and has proven to be a sustainable agricultural system. Based on the available evidence, organic agriculture is expected to help farmers overcome the impacts of climate change. This paper will assess the impact of climate change towards agriculture in the tropical region, especially in South East Asian countries, as well as analyzing the potential of widespread application of organic agriculture to alleviate climate change impacts on agriculture.

Keywords: climate change impacts; South East Asia; organic agriculture

Introduction

Today, global warming is a major and controversial issue all over the world. It affects many aspects of life; agriculture, plant and animal biodiversity, environment and socio-economic well being. Global warming occurs because of heat-entrapment in the atmosphere by greenhouse gases (GHG). Those gases cover the atmosphere and hold the heat from the Earth, thus increasing the Earth's temperature. Global warming causes climate change. Since agricultural crops are greatly affected by climate patterns, the agro-ecological sustainability of crops will be affected. A study by the Indian Agricultural Research Institute (IARI) found that a temperature increase by about 2^oC will reduce grain yields in some regions [1]. This study also stated that reduction yields in tropical areas will be greater. As a consequence it will influence livelihood for most people in agrarian countries and impact on social, economic and food security aspects in those regions.

It is difficult to avoid climate change impacts, however, it is possible to mitigate the effects by good agricultural management. Since the agricultural sector contributes GHG and is the main source of economic income in agrarian countries, there must be efforts to mitigate the impacts in agrarian countries [2]. Organic agriculture (OA) seems to be one answer for an agricultural management system to mitigate climate change impacts. One of the characteristics of OA is that it is ecological friendly in that it consumes less energy, thus providing the ability to mitigate GHG emissions. Moreover, organic systems perform better than conventional ones under climate change conditions. Some studies reported that organic agriculture is more profitable in the drier region, likely due to their superior drought performance and it is also self sustainable [3]. This paper will discuss the impacts of climate change towards tropical agriculture, especially in South East Asia, the concept of organic agriculture to mitigate the impacts and the potency of organic implementation in the South East Asian region.

Water is a critical element of tropical crops and higher temperatures generally result in less available water. Some 20% of the world's crops are irrigated and most of this occurs in Asia where 40% of the total agricultural crops are produced [4]. Rice cultivation, in particular, is heavily dependent on water. Irrigation or stored water can help mitigate the effects of climate [5].

Methods

The study method in this paper is by literary study, collecting data, analysis and then drawing conclusions.

Results and Discussion

Climate change and tropical agriculture

Global warming is defined as the increasing temperature of the Earth's surface caused by greenhouse gases [5]. The three major greenhouse gases are carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O). The greenhouse effect occurs when the concentration of greenhouse gases ranges from about 190-280 parts per million (ppm). The problem only arises if there is imbalance between greenhouse gas production and gas sequestration. Unfortunately, this imbalance has been occurring since the industrial revolution up until this day. In the tropics, GHG are mainly due to deforestation and increased agricultural production, which of course are often related [6].

Since the advent of industrial development, mostly in the temperate regions, greenhouse gas emissions have been increasing, thus enhancing the greenhouse effect. CO₂ gas makes the biggest contribution to global warming, being about 56%, while CH₄ contributes 18% and N₂O about 6%. Data from the Intergovernmental Panel on Climate Change [7], revealed that the concentration of CO₂ gas increased from 280 ppm to 379 ppm/year, and is still increasing at the rate of 1.9 ppm/year. If this continues without any prevention efforts, the Earth's surface temperature is expected to rise between 1.8 up to 2.9°C in 2100. The increasing temperature up to 3°C will destroy biodiversity which affects both food production and water conservation. It may also lead to increased pest and disease infestations [8].

One impact of global warming is climate change. The climate change issue is global, long term and complex. Its impacts are expected to be different amongst different countries. Crop simulation models, driven by future climate scenarios from global circulation models, suggest that the reduction in agricultural production would be more severe in tropical regions [9]. South East Asia is acknowledged as a tropical agriculture region and is thus very vulnerable to the impacts. Paddy is the main crop in this region and its cultivation is dependent on irrigated and rain-fed systems, making it highly susceptible to climate patterns. Any deterioration of paddy production through the impact of climate change will result in serious problems in South East Asian countries in the longer term [10]. The impact of climate change in South East Asia for the long term (years 2000/2080) is described in Table 1.

Table 1. Climate Change Impacts in South East Asian Agriculture.

Aspects	Impacts
Agriculture production	Climate change will make precipitation level increase to 3.6% in 2020 which cause raising temperature and humidity in South East Asia. For tropical areas, increased temperature above a critical temperature greater than 30°C by itself could lead to grain yield decreases and will decline up to 10% of paddy production [11].
Economic	Agriculture as critical sector in South East Asian countries contributes industrialization and economic growth [12]. Climate change impacts will decline agriculture productivity, rising food prices and cause negative GDP (Gross Domestic Product) in agrarian countries.
Social	Agriculture sector absorb most of labor (almost 50-75%). Unsustainability in agriculture sector will cause poverty, unemployment and hunger problems.
Food security	About 90% of world's rice production is in Asian countries, productivity losses and high population growth in the world (population growth 1.25-1.50) will risk food security and hunger problems.
Environmental	Climate change affects environment such as increase drought risk, degradation of water resources and soil fertility. It also affects pest developmental rates and numbers of pest generations per year [13, 14].

Based on a study by the Singapore-based Economy and Environment Program for Southeast Asia (EEPSEA), Simamora [15], stated that Thailand, Malaysia and Vietnam are regarded as high adaptive, however, Cambodia and Laos are low adaptive to climate change. As agriculture is a critical sector in almost South East Asian countries, they must prepare themselves to survive under climate change and its impacts.

Organic agriculture concept in mitigating climate change impacts

As previously discussed, climate change has the potential to adversely affect tropical agriculture, so that some efforts must be made to mitigate the impacts of this change. The mitigation process involves reducing GHG production or increasing their sequestration from the atmosphere. Since agricultural activities also contribute 13.5 % of GHG such as N₂O and CH₄ [7], the sector has the potential capacity to help reduce greenhouse effect. Some studies have suggested that organic agriculture systems have the capability for mitigating global warming and aiding adaption to climate change.

The US National Organic Standard Boards (NOSB) defines organic agriculture as “*an ecological production management system that promotes and enhances biodiversity, biological cycles, and soil biological activity. It is based on minimal use of off-farm inputs and on management practices that restore, maintain, or enhance ecological harmony. The primary goal of organic agriculture is to optimize the health and productivity of interdependent communities of soil life, plants, animals, and people*” [16]. Some studies have suggested that organic grain production requires an energy consumption of only 6%, compare to 46% for conventional production.

The concept of organic agriculture globally is respecting the natural capacity of plants to adapt to environmental condition and build their natural resistance. This reduces the need for external inputs such as chemical pesticides, herbicides and fertilizers, so organic products are safer and healthier for consumption. Organic agriculture principles including: biodiversity, integration, sustainability, natural plant nutrition and natural pest management will conduct self regulation, sustainable agriculture and ecological friendly to environment. The principles of organic agriculture and its practices in mitigating climate change are described in Figure 1 below.

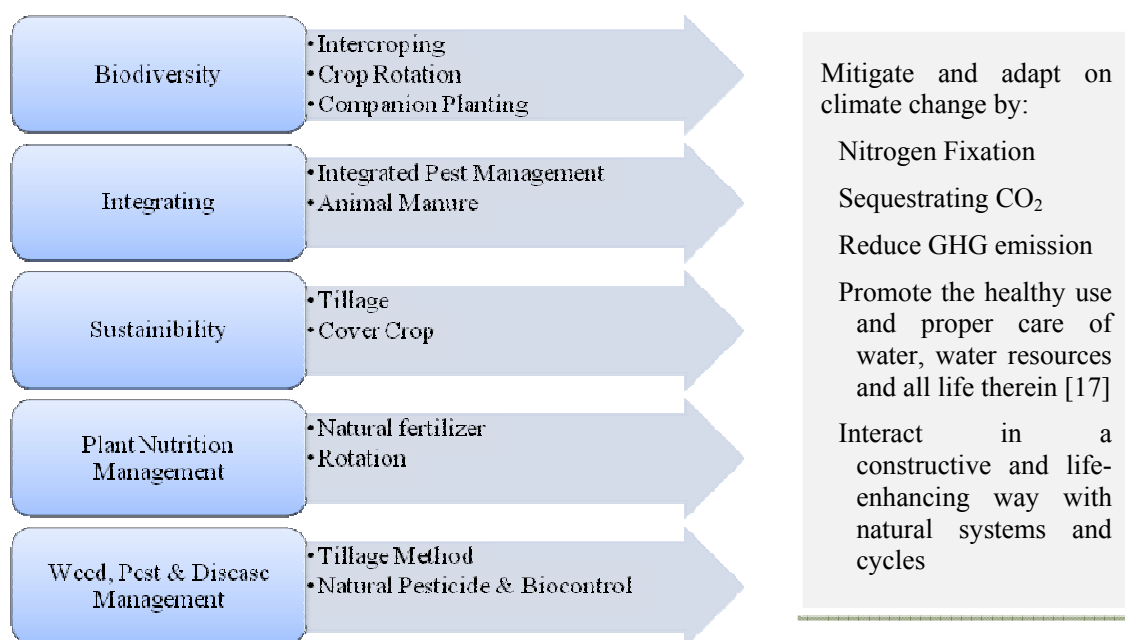


Figure 1. Organic agriculture principles and practices in mitigating climate change impacts.

One definition of biodiversity means that agricultural activity mimics the diversity of nature by practices such as intercropping, crop rotation and companion planting. The diversity of crops is believed to provide nutrient cycling in soil, disease suppression, erosion control and nitrogen fixation. Whereas the main point of integrated agriculture is practices such as using animal manure and Integrated Pest Management. These will enhance the biological activity in the soil, reduce GHG emission and prevent residues of pesticide in soil and products. The third principle is sustainability by tillage methods keeping the natural soil regulation which balances soil microorganism life in maintaining its fertility [18].

Plant nutrition management is a method to maintain and improve physical, chemical and biological condition of soil by natural fertilizer application and rotation method. Natural fertilizers such as manure and compost characterized as slow-releasing of its nitrogen component and recognized to improve soil organic matter and humus levels. Consequently, it maintains high crop yield and keep balances of carbon/nitrogen ratio in soil (C:N ratio of 12:1). The last principle is weed, pest and disease management which is also done by tillage practices, natural pesticides and biocontrol. Intermediate tillage systems allow more flexibility than either a no-tillage or conventional till system might. They are more beneficial to soil organisms than a conventional clean-tillage system of moldboard plowing and disking.

Potential for organic agriculture implementation in South East Asian countries

South East Asian countries have natural resources that offer good potential for organic agriculture implementation. The characteristic of organic agriculture in South East Asia is small-scale farms with diversity in every region, so localised organic agriculture concepts are suitable in this region. This concept will give maximum economic efficiency (for labour, transportation and management costs) and social benefits (by increasing community connections). In order to be sustainable, the implementation of organic agriculture must be productive and profitable.

The major points to support sustainability of organic agriculture are described in Figure 2. They include availability of natural resources, sustainable productivity, good marketing design and stakeholders' support. Sustainability of productivity is conducted by technological inputs, farmer knowledge and an integrated agriculture system. Green and Duncan [19], stated that community-based marketing and value adding are key strategies for connecting farmers and consumers in a local system. So that market design must be planned to meet consumer demand by good distribution, market niche and quality product assurance. At least, teamwork among stakeholders such as government, farmers, industry and organic association should be built well to aid marketing expansion of organic products. Thailand, Indonesia, Vietnam, Cambodia, Laos, Myanmar, Malaysia and the Philippines are countries that the agriculture is still the sector with largest employer. For that reason government plays important role in developing this sector.

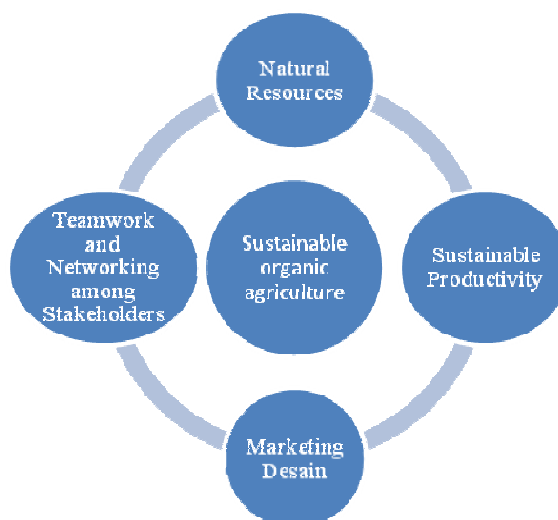


Figure 2. Potential resources and strategy to build sustainable organic agriculture.

Conclusion

Organic Agriculture has the capability to adapt and resist under climate change conditions by its principles. Its principles conduct self-regulation and are ecologically friendly, which makes this system sustainable for long term. Organic agriculture also has capability to mitigate climate change, so this system has high potential to be implemented in South East Asian countries in order to face climate change impact on agriculture sector. The implementation of organic agriculture must be supported by its productivity and profitability by ensuring integration and networking from farming to consumer. Due to South East Asia's natural resources and its agriculture characteristic, it has good potential to implement organic agriculture systems to overcome climate change impacts.

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