Research article

Effect of Land Use Change and Food Availability in Phatthalung Watershed, Southern Thailand

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Received 30 November 2010 Accepted 21 February 2011

Abstract During the past few decades, land use change has been taking place over the Phatthalung watershed and the major change has been the replacement of paddy fields with rubber plantations. Those changes cause the reduction of paddy field and crop land area. Together with the population growth, urbanization and soil degradation, the food availability becomes a concerned issue. The food availability situation of Phatthalung watershed under different possible scenarios has been investigated as the major objective of this study. The scenarios developed in this study included the biophysical factors, socio-economic factors and policy factors. The projected food production of four scenarios except the worst case exceeded the local consumption rate and the high surplus of rice was found in the best case scenario. The projected food production from the baseline and the moderate case scenarios was medium, whereas the projected food production from the worst case scenario was lower than the household requirement, which can be interpreted as insufficient. These results from the four scenarios should be recognized in order to prevent and avoid the local and national food, especially rice, insecurity in the future.

Keywords biophysical factor, food availability, land use change, Phatthalung watershed, socio-economic factor, policy factor

INTRODUCTION

Food security is currently becoming a global concern due to the rapidly increasing population, the degradation of arable land and the conversion of food crop land into biofuel crop production which is resulting in the depletion of the fertile land for food production. The recent agricultural production data shows that the global cereal production is in decline (FAO, 2004). The assessment of the availability of food helps understanding the situation of food supply and food security. However, there are concerns that there are various factors besides land use which influences food production, e.g. water availability, land quality, the adoption of technology, commodity prices, population and its growth rate as well as the country's policy on promoting rubber plantation and the biofuel crops.

In Phatthalung watershed, the conversion of food production areas (e.g. paddy fields) to rubber plantation is the major land use change (Anisara and Shrestha, 2008). The increasing trend of paddy area conversion to rubber plantation has resulted in the decline of rice growing area and production in the watershed. Among several types of food items consumed by the population of Phatthalung watershed, rice is the major source of staple food. Thus, the decreasing rice production area is a serious concern in terms of food availability.

It is useful to realize the future food availability condition as we are able to prepare for uncertainty and ensure that local food production is sufficient for local people. Scenarios analysis, an environmental assessment tool, is useful to examine the future food availability. There are several scenarios related to food system including IPCC-SRES, GEO-3, Millennium Ecosystem Assessment, Global Scenarios Group, IFPRI 2020 and FAO (Monika, 2006). In this study, the

likely change in future food availability was assessed under four different scenarios involving variation in land uses, the quality of land and water, the commodity prices and the local and national land policy.

MATERIALS AND METHODS

Factors influencing food availability

The availability of food can be influenced by various biophysical, economic, social or policy factors. Fig. 1 presents various factors used in the study to simulate future food availability under different scenarios.

The biophysical factors were the factors which have influences on the rice production system e.g. land area, production rate, the technology input etc. The change in those factors can have positive or negative effect on the food availability. Among various factors, the factors considered in this study included rice production area, land quality and the availability of water. Major economic factors included the import and export of rice and those factors can have effects on the quantity of rice within the watershed, whereas commodity price of agricultural productions was another important economic factor which can have influences on farmers' land use decisions on crop selection to grow in their land. For example, the price of rubber was much higher than that of rice during the study period, hence farmers tended to convert their land to rubber plantation. Even though, the commodity prices did not have a direct effect on the availability of food, it can affect the production area. Population and population growth were the social factors considered in this study, higher population growth can reduce the food availability and hence, consequence to food insecurity as insufficient food supply. Furthermore, the increasing population can also reduce the production area due to agricultural land conversion to urbanization. Policy factors can play important roles indirectly via other factors which can have positive or negative effects on food availability. For example, policy can affect food availability via social factors by establishing the population control policy thus reducing the food demand. Similarly, land use policy can influence area dedicated for rice cultivation through commodity prices.

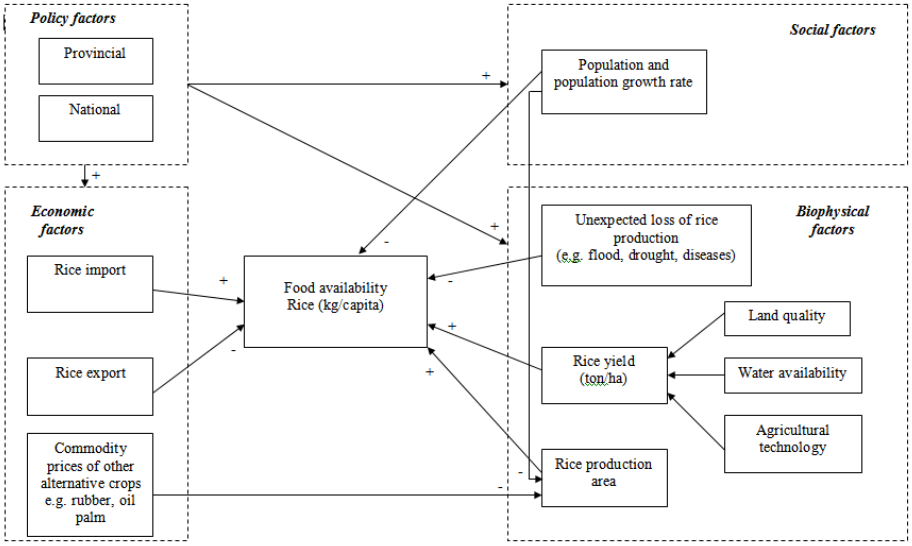

Fig. 1 Factors influencing food availability

Scenarios development

Scenarios are alternative possible outcomes in future, affected by different factors at different levels. Scenario analysis helps make better decisions in the context of uncertainty, particularly associated with future events. In this study, four potential scenarios were developed in order to

predict the availability of food in different situations. The influencing factors considered for developing the scenarios included population and its growth rate, the agricultural commodity prices and rice yield. The rice production area is influenced by agricultural commodity prices and the policy whereas the rice yield is influenced by land quality and water availability.

The availability of food assessed in this study was presented as quantity of rice per capita (kg/capita). There are four scenarios developed in this study, the criteria and assumptions for four scenarios are given in Table 1.

1) Baseline scenario (BL): It assumes a business-as-usual scenario. It is assumed that the current trend will continue in the future too. Hence, the assumptions are simply the extension of the past trend of different factors to continue in the future in the study area.

2) Best case scenario (BC): It assumes the synergy of the factors for the highest level of food availability in the area. The population of this scenario is assumed unchanged and it is under the assumption that the birth rate and the immigration are assumed equal as the death rate and the outmigration.

3) Moderate case scenario (MC): This scenario is less optimistic than best case scenario and assumes that policy intervention and technological development will be at the moderate level.

4) Worst case scenario (WC): This scenario assumes the worst possible condition with high rate of population growth and high decreasing rice production rate.

Table 1 Criteria and thresholds for assessing food availability under four scenarios

Scenario	Baseline (BL)	Best case (BC)	Moderate case (MC)	Worst case (WC)
Social factor				
Population	505,129	505,129	505,129	505,129
Population growth rate (%/year)	+0.26	0	+0.60	+1.09
Biophysical factor				
Rice production area changing rate (%/year)[a]	0	+4.76	+2.10	-16.80
Land quality (%/year)	-0.16	+0.30	+0.15	-0.30
Water availability (%/year)	-5.00	+15.00	+5.00	-6.00
Economic factor				
Commodity prices changing rate (%/year)[b]	0	+4	+15	+30
Policy factor (National/Provincial Plan)				
Land related policy (%/year)	0	+5% of rice production area	+3% of rice production area	-15% of rice production area

Note: [a] *Present paddy field area = 72,826.4 ha*
[b] *The average rubber price in 2006 = 61 Baht/kg*

Food availability projection

The relationships of the influenced parameters mentioned in Table 1 have been constructed in the STELLA environmental dynamic model in order to project the food availability in a 30-year time frame.

RESULTS

Food availability under the baseline scenario

The baseline scenario was projected based on the real situation. The projected population is showing the increasing trend with the moderate rate (Fig. 2). Even though, the area for rice production under this scenario is assumed unchanged (Fig. 3), the projected rice production shows the declining trend (Fig. 4) resulting in the decline of food availability. The present rice production is about 163,000 tons and it decreases to 130,000 tons in 2030. The decrease in rice production under this scenario mainly results from the decreasing of the rice yield; the current rice yield is 2.24

tons/ha/year and it became lower than 2 tons/ha/year in 2025 because the land and water resource is assumed to be left over without improvements.

The decline of rice production area resulting in the declining rice production and the increase in the population can lead to the declining of food availability (Fig. 5). The range of the projected food availability under baseline scenario was between 0.24 and 0.32 tons/capita/year with the average decreasing rate of 1% per year. The projected food availability is found slightly lower than the local rice consumption rate (336 kg/capita/year). Therefore, the Phatthalung watershed will be facing the problem of rice insufficiency in the near future under the current situation. There is the need of having appropriate policy and plan, both local and national, to increase the area under rice production in order to avoid the food insecurity problem in the study area.

Food availability under the best case scenario

Fully aware of the global food insecurity problem and the fact that Thailand is one of the biggest food exporters globally, the Thai government is establishing a policy of paddy area preservation in order to produce more food especially rice for the global market. The growing rice export can also contribute to the growth of national economy through agricultural development. Phatthalung watershed is considered as one of the most suitable area for rice production. The rice production area preservation policy is to turn the area which is suitable for rice but is being used to produce other types of crops (e.g. rubber plantation, oil palm, shrimp farms etc) to rice production area.

As described earlier, this scenario assumes strong policy intervention on rice area preservation, and improvement in land quality and water availability. The rice production of this scenario is increasing not only from the assumed enforcement of rice area preservation policy but also from the assumed very small rate of increase in the rubber prices, which in turn is expected to result in low economic incentives to convert rice production areas into rubber plantations. Fig. 3 shows a rapid increase of rice production area projected under this scenario; the increasing trend becomes stable in 2030 as it reaches the maximum suitable land area for rice production (at 150,000 ha).

Together with the improvement in land quality, the implementation of irrigation system, the projected amount of rice production under this scenario was the highest. The maximum and the minimum of the projected food production are over 640,000 and about 167,000 tons respectively (Fig. 4).

The predicted food availability under the best case scenario was substantially higher than the other three scenarios, because of the increased area under rice production and the increase in rice yield due to land and water improvement accompanied by decreasing of rice consumption due to the population control policy. The predicted annual food availability per capita of the best case scenario ranged between 0.32-1.21 kg (Fig. 5) and it is about double of the household consumption obtained from HH survey from the year 2023, implying sufficiency and surplus of food under this scenario.

Food availability under the moderate case scenario

In this scenario, the population is assumed to increase with moderate rate. Similarly, the rice production area and rice yield are assumed to increase at moderate rate due to the area preservation policy, with the smaller percent compared to the best case scenario, and ongoing land conversion because of the stable increase of rubber prices. The quality of land and the availability of water were assumed to slightly improve through fertilizer and irrigation water supply.

Similar to the best case scenario, the area for rice production was assumed to increase due to the policy even though at lower rate. Also, the economic factor, i.e., rubber prices, has been assumed to have lower influence in encouraging farmers to change the paddy field to rubber plantation.

In terms of social factors, population and its growth rate of this scenario are assumed to increase with the rate of 0.6% per year without population control policy (Fig. 2). The rice

production area of this scenario is projected to increase with the rate at 2.1% per year, the maximum projection area is nearly 136,000 ha (Fig. 3).

The amount of rice production projected under this scenario is increasing at the rate of about 2.8% per year (Fig. 4). The minimum projected amount of rice production under this scenario is about 163,000 tons and the maximum is nearly 379,000 tons (Fig. 4) due to the land and water is assumed to be improved under this scenario.

The projected annual food availability of this scenario ranged between 0.32-0.63 tons/capita. The projected results for first few years (2010-2017) are less than the local consumption rate obtained from the household survey but it rises afterwards (Fig. 5).

In this scenario, the food availability predicted under this scenario is showing sufficiency for local consumption for the next 30 years of the projection period (until 2040) but it is under risk if the population of this scenario keeps increasing without control, resulting in consumption of rice higher than its production.

Food availability under the worst case scenario

The worst case scenario assumed a greater decrease in rice production area, deteriorating land quality, water availability as well as the rice yield, along with the increase in the population and its growth rate. In terms of economic factors, the rubber price was assumed to increase by about 30% from the present one, which encourages farmers to convert rice paddies into rubber plantations.

The increasing population and the development of economic and industrial sectors are the dominant assumption of this scenario. Policy assumed in this scenario mainly focuses on economic development and the growing industrial sector together with the increasing population. Therefore, the paddy areas are encroached and replaced by human habitats and the infrastructures such as roads, buildings, and factories.

The high population growth rate without control and the high increase in rubber price drive to the worsening food availability. The projected population of this scenario shows a rapid increase (Fig. 2). On the other hand, the projected rice production and its area of this scenario are the lowest with the rapidly decreasing rate (Fig. 3-4). The projected area for rice production is found less than 50,000 ha in 2013, the rice production area kept deceasing over the years and it can be completely replaced by other types of land use within few decades. The area was rapidly decreasing to about 30,000 ha in 2015 (Fig. 3) which was the preserved area for rice production due to land properties constraints.

The degradation of land quality and the water insufficiency assigned for this scenario causes negative effects on the rice yield. The projected yield becomes lower with a high rate and it is found lower than 1 ton/ha/year within a decade. The decrease of rice yield causes the decrease of rice production amount and it is found nearly three times lower than the baseline scenario, only for the first decade of the projection.

The results of food availability showed a rapid decline until 2013 with a decreasing rate of about nearly 20% annually; the results ranged between 0.08-0.32 tons/year (Fig. 5) and lower than the local consumption rate (0.33 tons/capita/year) obtained from household surveys. The minimum amount of the projected results under this scenario is inadequate for people in terms of energy requirement from carbohydrate because the general minimum energy requirement from carbohydrate or rice is at about 73 kg/year (Anchanee, 2005).

According to the projected results under this scenario, the situation of food availability of Phatthalung watershed is in crisis as all rice production area can be completely replaced by other types of land use within the two decades.

The food availability of Phatthalung watershed will be insufficient and lead to malnutrition problem if the food production keeps reducing. In this scenario, the declination is resulting from the decreasing production area with the increasing demand for food due to the high population.

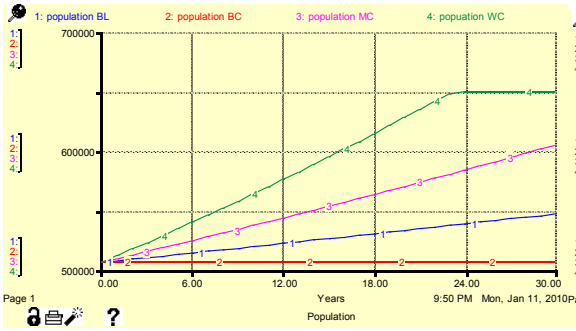

Fig. 2 Projected population for all scenarios

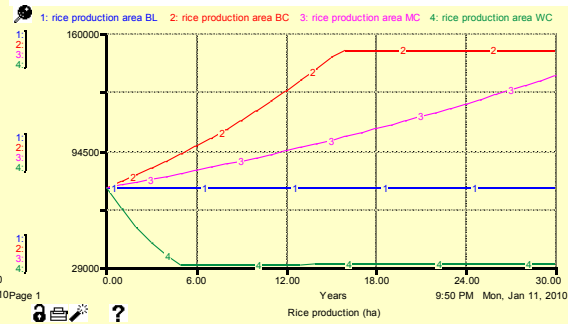

Fig. 3 Projected rice production area for all scenarios

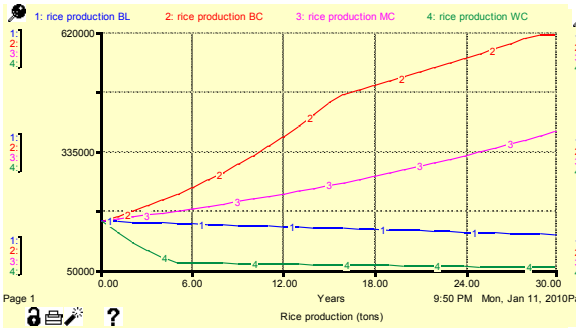

Fig. 4 Projected rice production for all scenarios

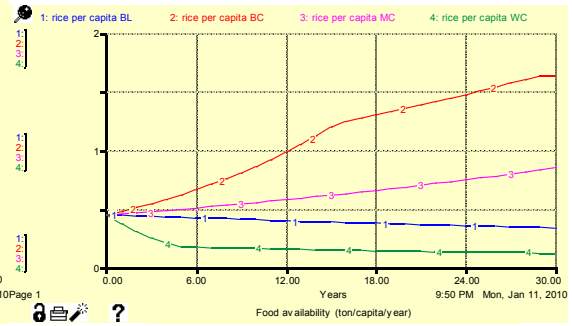

Fig. 5 Projected food availability for all scenarios

CONCLUSION

There are numerous factors which can have influences on the availability of food. In this study, population size, the area for rice production, rice yield, the condition of land and water resources, which are important factors for crop productions, and the policy were considered as the key factors affecting the food availability.

The 30 years projected food production of the four scenarios, except for the one worst case that exceeds local consumption and the minimum human energy requirement. The high surplus of rice was found in the best case scenario, whereas the projected production from the worst case scenario was the lowest and lower than the household requirement.

The promotion of rubber plantation can be good alternative sources of household income, since the economic return from cultivating rubber is higher than producing rice. However, it has to be ensured that the remaining area is capable to produce sufficient food for the local population. Otherwise local people have to purchase imported rice from neighboring countries which will affect the majority of household expenditure in the future.

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