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Original Article

Assessing processes of change and innovation in smallholders agriculture around Tonle Sap Lake, Cambodia♣

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Abstract

Sustainability of agricultural systems is often presented in the literature as the capacity of these systems to be maintained over time, even though the circumstances in their environment may be changing when resources available get rare or when markets and value chains can be transformed. Such a vision tends to limit sustainability as a static concept. This paper challenges such a static conceptual framework to propose an opposed one, where sustainability is ensured when the systems are able to change and innovate to adapt to their environment and achieve even better efficiency of the use of their resources (compared to before the modification in the environment). For illustrating this point of view, this paper assesses the dynamics of farming systems around Tonle Sap Lake, Cambodia. This rural province is facing a number of changes in its environment, which may be agroecological, as the regime of floods from the Tonle Sap every one year, or economical as the opportunity costs of the labor that are pulled up by the rapid growth of the neighboring city of Siem Reap. It examines the interaction between resource endowment and production strategies of the major stakeholders, capture the agricultural transformation in the study area. This study borrows agrarian system diagnosis framework, a multistage analysis, to identify the changes in the strategies of the stakeholders. In-depth interviews were first carried out to collect historical data and build pre-typology. The study then collected quantitative data from 143 households to construct the main farm typology. The results reveal that five major distinctive farm types develop various innovative strategies in response to the modification of the environment to ensure their sustainability. However, there may also be some major innovations, like the extension of the broadcasting of the paddy extending in all systems at the same time to replace the transplantation. The conditions for such a "bulk innovation", in response to sustainability needs, are discussed. The conclusion of this research confirms that sustainability should be held as a dynamic concept, adapted to societies in movement, rather than a resistance concept, marked by the maintenance of previous systems in changing environment.

Keywords: sustainability of agricultural systems, innovation in agriculture, farming systems, Cambodia

1. Introduction

Sustainable agriculture has become one of the most critical components of sustainable development for the past thirty years as many contemporary challenges such as climate change, soil degradation, biodiversity loss, water depletion, and falling in the number of farms threatening the food security of the growing world population have strong interactions with agriculture (Velten, Leventon, Jager, & Newig, 2015). Ideally, the goal in agricultural development is to achieve sustainability, but it is tremendously difficult in practice since there are many elements involved in agriculture, and the concept of sustainability is quite broad in its meaning in agriculture. The simplest way is to look at sustainable

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agriculture as a system where environmental, economic, and social aspects are interacting and interdependent (Cacho, 1997; Lampridi, Sørensen, & Bochtis, 2019).

Over the years, the sustainability of agricultural systems has often been presented in the literature as the capacity of these systems to be maintained and reproduced over time. Since the Brundtland Report (Hurlem, 1987), which introduced the concept of sustainable development and described how it could be achieved, the question of the assessment of the sustainability of agricultural systems has often been raised. Different scales have been considered, from the international level down to the local and farm scale, each of them being addressed with different sets of indicators. Although there is certainly no common viewpoint among scholars about the indicators of such sustainability, there is a consensus that it can be appreciated only in a systemic way, integrating social, economic, and environmental parameters, with all their interactions (the final result being more than the sum of the parties) (Norman, Janke, Freyenberger, Schurle, & Kok, 1997). Most of the proposed methodologies also are based on the paradigm that sustainable systems are capable of facing changes in their environment without being modified by this change. In other words, that sustainable systems have the capacity to come back to their initial stage after a shock and to resume the organization of their production on the same modes and organizations that they could do before the shock.

However, the vision of sustainability as a static equilibrium that is due to be maintained throughout the events and the modifications of the environment (markets, climate, and access to resources) does not properly address all the situations of change and innovation in agriculture (Gomiero, Pimentel, & Paoletti, 2011; Marshall & Toffel, 2005). Particularly in developing countries, the process of change and innovation within agricultural systems can be slow when significant innovations can take one generation for being extended within the rural society. Nevertheless, there are also cases where the changes are so fast that the return to the initial stage of the system before a shock would not indicate a capacity of resilience, but rather the inability to make good use of the modification of the environment, a lack of social relevance, low economic competitiveness or partial environmental soundness. On the contrary, in this case, the real capacity of resistance to the environmental change is not to come back to the initial stage after a shock but to get a different production organization.

We illustrate this point of view by the case of the dynamics of change and innovation within farming systems around the Tonle Sap Lake, Cambodia, which used to be the center of the Angkorian Khmer Empire and has always been the central agriculture production zone. Nowadays, it is the most important natural and historical tourist attraction site in the country and has attracted many different types of activities and market opportunities in the area. As a result, it has become one of the fastest developing regions. At the same time, it is recently facing a number of changes in its environment and economic conditions. For example, economically, the labor cost has significantly increased as more demand for labor grew in the city (Hauser-Schäublin, 2011). Environmentally, the province is bordering the Tonle sap lake, which is connected to the Mekong River and thus subject to an annual flood, with a mean of six meters of water elevation difference between the dry season and the monsoon. With the more irregular climate, and also due to the construction of several dams upstream of the Mekong River, the regime of the annual flood has changed in the last several years.

In this paper, we shall analyze the recent changes in local farming systems by clustering the stakeholders according to their different strategies to maintain their livelihoods. By developing these resilience strategies, they confirm the sustainable character of the farming systems in place, whereas at the exact moment, the paddy-based cropping systems are in profound transformation. We shall enlighten how the transformation of the cropping systems, by the shift from transplanted to broadcasted paddy, with all the related changes that go together with it, like the land preparation, fertilization mode, or water management, is a condition now raised for the sustainability of the small-scale family farming in the area. We shall conclude by the lessons learned more generally in terms of adaptation capacity of family farming to maintain and even extend their production capacity in a context of agrarian revolution imposed by the transforming environment, circumstances that have never been met before since the Angkorian times 1,000 years ago.

2. Methods and Materials

2.1 Definition of innovation

Innovation is considered as ideas, tools, or practices that are perceived as new by the individual or group of people. In agriculture, innovation can classify into institutional innovation and technical innovation. Institutional innovations are a new way of managing, organizing, and arranging agricultural production, while technical innovations often refer to new farming practices (Minh, 2009; Rogers, Singhal, & Quinlan, 2014).

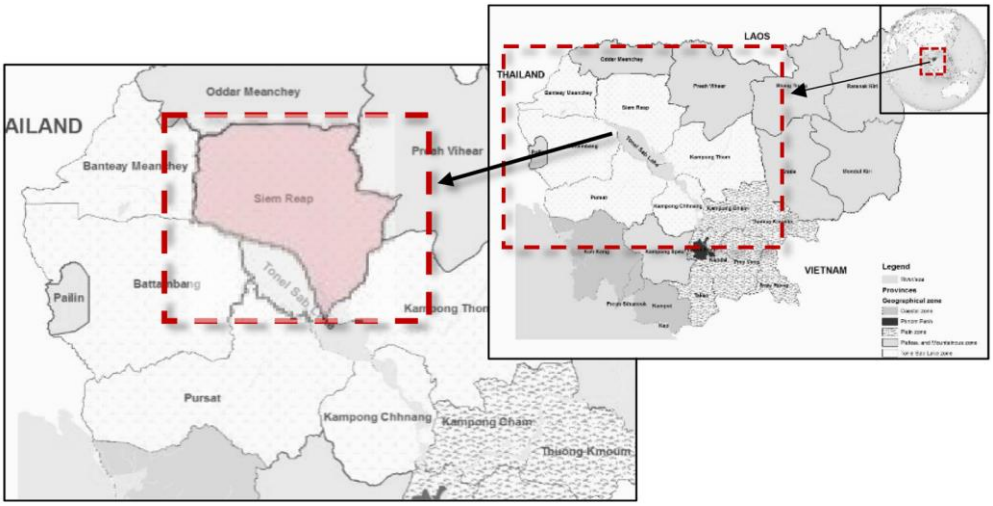
2.2 Study area

The study was conducted around the Tonle Sap Lake zone, the most extensive cultivation zone located in Northwestern Cambodia. Siem Reap Province was purposively selected for the survey based on two main criteria: (1) main agricultural production and (2) rapid development in urbanization, socio-economic, and agriculture (Figure 1).

2.3 Study method: procedure, sample, data

To capture the diversity of farming systems and their transformation, agrarian system diagnosis was employed to identify different strategies of the stakeholders and to cluster them into a farm typology. Agrarian system diagnosis is a multistage study, and it could be summarized in four stages: (1) study the agrarian landscape; (2) identify pre-typology of farming systems and their transformation; (3) Analyze the cropping systems and other income-generating activities; and (4) build farm typology and determine their total income (Diepart & Allaverdian, 2018).

The survey was carried out from July to September 2019. Group discussion with commune leaders and local people was primarily conducted to identify the noticeable changes in the local biophysical and human activities, and that



Source: National Institute of Statistics (2015)

Figure 1. Location of study site

information was used to create a guideline for more in-depth interviews with individual farm households.

First, farm households were purposively selected for in-depth interviews for their different characteristics such as resource endowment (resident, vehicle, agricultural equipment and machinery, farm size and livestock), production strategies of the major stakeholders to capture the agricultural transformation in the study area. With the assistance from the commune head, 50 households were chosen for being interviewed, and the interview was semi-structured with some open-ended questions. We then collected quantitative data from a random sample of 143 households to identify the distribution of different farm types and constructed the main farm typology. Principle component analysis was employed to reduce the dimension of the data and create a new set of variables that could reduce the complexity and distortions of the next step of cluster analysis (Hair, 2009). Finally, hierarchical and K-mean clustering methods were utilized to determine the number of clusters (farm types).

3. Results and Discussion

3.1 Farm typology

The results allow identifying five major farm types currently existing in the district. Farm types 1 (33.6%) and 2 (16.1%) possess low and medium levels of resource endowment, for which subsistence farming was their main strategy, and they represented about half of households. Meanwhile, farms in type 3 (16.8%), 4 (26.6%), and 5 (7.0%) and have chosen commercial farming as their objectives, even though the resource endowment were ranging from low, medium to high, respectively (Table 1).

1) Type 1. Subsistence rice-based farming with low resource endowment, highly dependent on off-farm activity

This type of farming household mainly cultivated rice once time a year for self-consumption, but they sometimes partially sold if they were short in money. This group was the poorest in terms of resource endowment; labor, capital, and farm size (less than 1ha on average) was the primary constraint. Most of their income was coming from off-farm activity, more specifically working as construction or migrant worker. The majority of household heads were less educated.

2) Type 2. Subsistence rice-based farming with medium resource endowment, income generate income from various off and non-farm activities

Similar to the previous group, this farm type was also subsistence farmers, who grow rice for self-consumption, but had more resource endowment available in terms of income and asset. The biggest constraint in this group was labor because their household size (less than four members on average) was the smallest of all farms group. However, household heads generally had better education compare to farms in type 1. The source of income largely depends on different off and non-farm activities, including running a small business at home or market, working as salarymen, or selling labor.

3) Type 3. Commercial farming with low resource endowment heavily relied on on-farm income

Farm in this type has chosen commercial farming as the primary strategy for households but generally had very little resource endowment, specifically financial capital. This farmer group depends on on-farm income for their income source, with less income generated from off/non-farm activities. Unlike the two previous farmer groups, farmers mostly grow other crops besides rice, specifically vegetable type, because they had small farmland, and it is more profitable to produce vegetables than rice or other cash crops. Crop rotation between rice and different type of vegetables is often practiced by most vegetable farmers. Household size was also small, but heads had better education (about six years of education).

Table 1. Characteristics of the current farm types in the study area based on the survey conducted in 2019.

		Farm type				
		1	2	3	4	5
	Number of observations	48	23	24	38	10
	Share of sample %	33.56	16.08	16.78	26.57	6.99
Resourc endowment	Education of head (year)	0.40	5.78	5.96	2.68	3.30
	Household size (person)	4.60	3.52	4.08	5.05	7.90
	Farm labor (person)	0.80	0.39	1.33	1.53	2.80
	Farm size (ha)	0.81	0.93	1.68	2.84	8.38
	Total asset (Riel) *	22.21	47.20	27.92	38.74	100.26
	Income (Riel) *	6.70	8.85	7.60	12.85	38.13
	Credit/loan (Riel) *	2.87	15.72	3.04	8.85	36.30
Production strategies	Off/non-farm ratio %	90	95	12	73	55
	Diversify cropping %	17	13	96	74	80
	Rice main crop %	98	100	12	82	60
	Crop sales %	27	19	65	60	68

Note: (*) variable was calculated in million Riel, 1USD is approximately 4000Riel (*)

4) Type 4. Commercial farming with medium resource endowment

Household of farm type 4 was the commercial farming family with a good amount of resource endowment in hand. The main constraint was labor availability on farms per hectare. Households partially engaged in both on-farm and off/non-farm activities, but on average, off/non-farm income is higher than on-farm income, and their off/non-farm activities were diverse similar to type 2. Rice was the main crop of most of the family, although a small number of families also grow cash crops or vegetables. Heads only had a few years of education. The average farm size was about 2.8 ha which is relatively big compare to the previous three groups.

5) Type 5. Commercial farming with high resource Endowment

Type 5 was the group with the highest level of resource endowment, including labor, capital, and farmland (more than 5 ha). Household size was about eight people on average and managed by old household head. Although the family size was big, they sometimes had to hire extra labors, especially during harvest season due to the large size of their operation. Agriculturally, some farmers grow only rice, but some grow rice and other cash crops (mung bean, cassava, and cashew nut). However, rice and cash crops did not cultivate in the same plot and primarily grew only once a year. The main source of income equally generates from on-farm and off/non-farm activities.

Overall, production strategies of farm type 1 and 2 were to invest more labor for non-farm activities and cultivated rice on a small piece of land for self-consumption. In contrast, commercial farming groups tend to invest more labor and acquire bigger farmland and diversify their crop productions. Among the three types of commercial farms, type 3 mainly depend on non-farm activities, and type 5 relied on half and half, while type 4 earn more income from non-farm.

3.2 Transformation of farming system and innovation over years

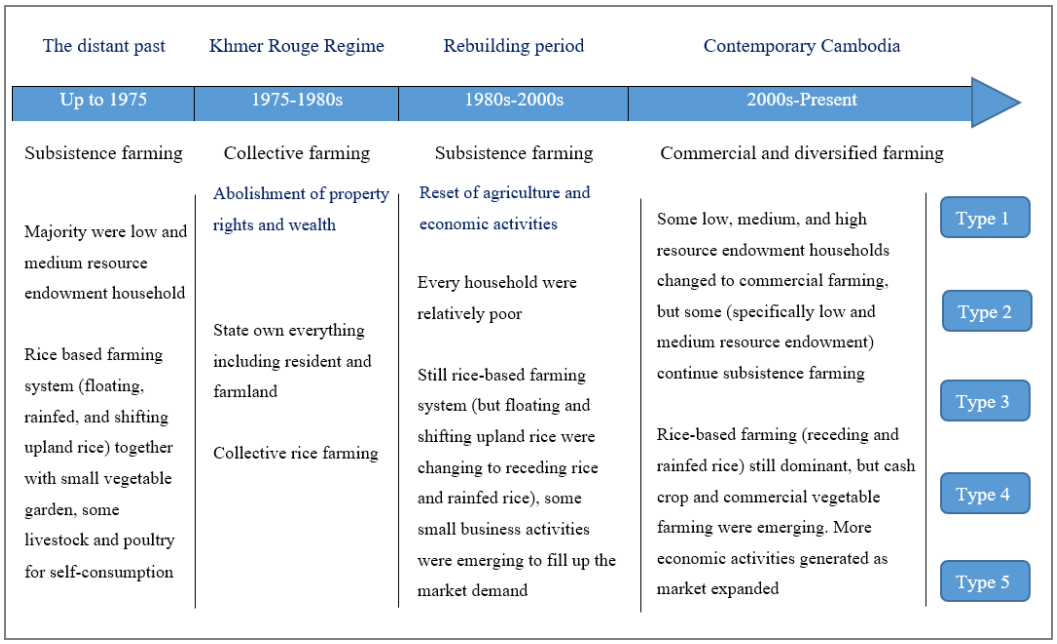
From Angkor Empire to the 1970s, people around Tonle Sap Lake mainly cultivated rice with small vegetable gardens and raising livestock/poultry for self-consumption. There were three major rice-based cropping systems: rainfed rice, floating rice, and shifting upland rice. However, their farming practices (including cropping calendar and water management) and tools (such as plow, rake, and oxen cart) have generally not changed for more than a century. From 1975 to 1979, Khmer Rouge take over the country and force people to collectively cultivate rice using human labor with hand tools like hoe and rake.

Cambodia had immensely suffered during the Khmer Rouge Regime, which ended in 1979, and it was one of the greatest resets in every sector of the country. After the war, every household was relatively poor and had to start from zero because everything had been abolished by the regime, such as individual property, farmland, school, market, and religion. Therefore, from the 1980s to the early 2000s, subsistence farming rice farming was dominated in the agricultural system of this country, and the majority were doing the same thing in agriculture and economic activities (Figure 2).

The current farming systems were the result of farm households evolved in response to constraints and opportunities presented by the change in its environment, social, and economical.

3.3 Transformation of farming system and innovation over recent years

Since the early 2010s, young labors in the study area had started to look for jobs in the cities hoping to improve their livelihood. As a result, there was less labor available which affected wage labor from year to year. The price of labor has increased more than double from 10 thousand to 23-25 thousand Riel per day in just a decade. Since each farm



Source: The Agricultural Households Survey in 2019

Figure 2. Transformation of farming system from distant past until present time

type commonly has less than a person dedicated to the farm per hectare, as shown in Figure 3, they had to hire extra labor, which also increased the cost of production when wage labor is high. Therefore, there was a significant change in farming practice across all farm types.

In the last few years, households in the area had totally abandon transplanting and adopted broadcasting technique which could reduce labor input from 10 to 20 times depending on the availability of labor for their rice farming, even though yield had decreased up to 15 percent. The acceleration of broadcasting adoption was also associated with the availability and affordability of herbicide in the local market, which could help to control weed to some extent. In addition, people were not able to spend more time transplanting rice in the field lately due to the rise of temperature in the hot and humid climate of Cambodia. Broadcasting in rice production had early adopted by commercial farmers, specifically type 4 and 5, who had limited labor input but had more resources and farmland to test out the innovation and then adopted by other groups.

The key finding underlines the importance of innovations as a tool used to address the challenges created by the change in environment and social factors. In this case, broadcasting was adopted in order to reduce the labor input since all types already had limited farm labor per hectare.

4. Conclusions

The objective of this paper was to demonstrate the concept of sustainable agriculture as dynamic rather than static as the guideline for policymaking in agricultural development. The result had shown that there were five existing farm types by the time of this study, which evolved out of fewer types. Furthermore, because more farm households are moving from subsistence farming to

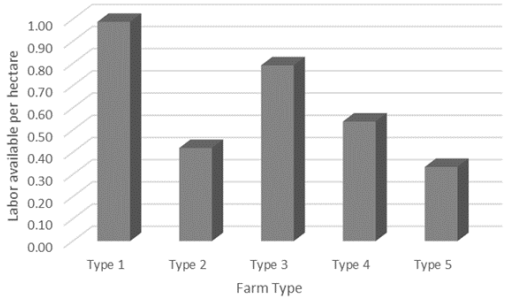


Figure 3. Farm labor available per hectare of each farm type from the survey in 2019

commercial farming, the production system and farm technology have also changed during the process in response to constraints in environmental and socio-economic factors facing by the individual farm. Thus, sustainability in the agricultural system should be viewed as a dynamic where farming systems were able to adapt to the change of their surroundings with appropriate technology and innovation rather than resist it.

In the wake of the ever-changing world, there is a need for government and policymakers to conduct more researches about the transformation of the agricultural system to support smallholder households to reach sustainability goals in different regions since each region developed differently. With that, the government will be able to choose the appropriate innovation and provision for the targeted zone and farm types when there are significant changes in the area.

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