



Mainly farming ... but what's next? The future of irrigated farms in Thailand

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ABSTRACT

For many smallholder farmers in East and Southeast Asia, farming represents a decreasing share of their income-generating activities, leading to increasing limits to investing family labour in farming. This process has been particularly marked in regions where farmers face limited access to land, water and markets. This study asks whether irrigated farms in central Thailand are on a similar pathway. It analyses how these farms have evolved to face existing constraints and their future prospects. The farms have adapted to constraints including lack of fresh water in the dry season, floods, and sometimes insufficient labour. In almost all farming families, farming is still the main income-generating activity for at least one household member. Most of the farmers involved in fish and shrimp farming had already identified a successor in their family or considered it was possible. This was also the case of rice farmers who had made quite high investments in their farms, most of whom cultivated relatively large areas. However, another group of rice farmers had become trapped in a vicious circle of low farm profitability, the increasing age of the farmers and the fact their farms held little attraction for younger generations. Thai agricultural policies did not provide sufficient means to break this cycle. The future of these vulnerable rice farms thus appears to be uncertain. Breaking this cycle may require a comprehensive approach that explicitly addresses the issue of farm structure.

1. Introduction

Rural inhabitants in East and Southeast Asian countries increasingly obtain their income from off-farm sources. This is the case in low, medium and high income countries in the region (Haggblade et al., 2010; Rigg et al., 2016) and is taking place not only thanks to increased opportunities in non-agricultural sectors but also because of the difficulty of maintaining or increasing incomes from farming. Many studies describe such processes in situations where farm characteristics and the environment in which farms evolve limit the prospects for obtaining an income, these being small size, lack of irrigation water, or limited market access (Fishman et al., 2013; Hu and Rahman, 2015; Pritchard et al., 2017).

Fewer studies have investigated the extent to which better endowed farms in East and Southeast Asia, in particular larger farms and farms with access to irrigation, are on the same pathway towards a diminished role of agriculture as a source of income in farming families. What is happening on these farms needs to be analysed to understand

the evolution of the agricultural sector in these countries as a whole, especially as irrigated areas usually play a major role in supplying inputs to agricultural value chains and in supporting food security at national level.

This topic is particularly relevant in Thailand, where the average farm is quite big (3.1 ha, according to the 2013 agricultural census) compared with other countries in East and Southeast Asia (Rigg et al., 2016). Several studies have underlined the intensity and rapidity of the decline in the economic role of agriculture in farming households with limited access to land and irrigation water in Thailand. Gödecke and Waibel (2011), Nilsen (2014), Rigg et al. (2012) and Rigg et al. (2019) investigated agrarian changes in villages in the Northern and Northeast Regions, where farming is mostly rainfed and where the average farm (between 1.9 and 2.3 ha in these studies) is smaller than the national average.

The image that emerges from these studies can be outlined as follows. First, ageing of the farming population is even faster than at national scale. In the villages studied by Rigg et al. (2012), the average

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age of people whose main activity was farming increased from 36 in 1983 to 55 in 2008. Second, young people are moving out of the villages. Gödecke and Waibel (2011) and Nilsen (2014) identified a wide gap in the age pyramid at village level, as most people aged between 20 and 40 had moved to cities to find work. Third, household members increasingly find opportunities to work in factories and still come home every day (Rigg et al., 2008; Shirai and Rambo, 2017; Shirai et al., 2017).

All these changes have reduced the availability of family labour, and farming households consequently increasingly choose farming systems and practices that require less family labour, e.g., planting trees, mechanisation or the use of paid labour (Formoso, 2016; Podhisita, 2017). In areas located not far from the frontiers of Thailand, hired labourers often come from neighbouring countries (Barney, 2012; Rungmanee, 2015). These changes in the organisation of farming households (in terms of spatial structure and labour) have enabled them to adapt to the constraints and opportunities in both urban and rural areas. However, most of these changes reflect a trend towards less intensive farming (Rigg, 2019). More generally, the increasing labour constraints can limit farmers' capacity to or interest in testing and implementing more productive or more environmentally sustainable farming practices (Bhandari and Mishra, 2018; Phastraporn, 2019).

This description of farm dynamics is representative of what is happening to the majority of the farms in these regions. Nevertheless, in rainfed areas of the North and Northeastern Regions of Thailand, some farms are actively engaged in changes involving the intensive use of family labour (Piotrowski et al., 2013; Plews-Ogan et al., 2017). Moreover, macro indicators do not show that the agricultural sector has become "dormant". Thailand remains a major producer and exporter of agricultural products (Thailand Board of Investment, 2017). Many farms successfully access high-value markets (Kersting and Wollni, 2012) and powerful agro-industries have emerged (Briones and Rakotoarisoa, 2013). The contribution of agriculture to the growth of Thailand's domestic product has not changed much over the past two decades (from 9.1% in 1996 to 8.6% in 2016, according to the World Bank, 2018). However, there have been few recent studies of agricultural dynamics in areas better endowed with resources in Thailand. Formoso (2016) studied rice farms with access to irrigation in the Northeast Region and reported that agriculture was still the main income-generating activity of several farms but did not detail the characteristics of these farms. By contrast, Rigg (2019) reported that in a village located in an irrigated area of the Central Region, almost all the villagers surveyed said farming was no longer their main occupation.

The present study focuses on irrigated areas of central Thailand. Its aim was to understand whether the engagement of members of farm households in farming has declined in a similar way to that described in areas of Thailand where farms have limited access to land and water. Taking into account the diversity in the size and types of production of farms in the study area, our analysis addresses three issues: (i) how farming systems have adapted to key constraints and changes in the environment and within the farms, thus enabling – or not – households to earn their livelihood farming; (ii) what are the future prospects of these farms, especially in terms of the engagement of family members in farming; and (iii) to what extent ongoing policies and local initiatives to support agriculture help farming households deal with prevailing constraints and thus help sustain their engagement in farming.

2. Methodology

2.1. Study area

The study was conducted in the Bang Pakong River delta. This area belongs to a broader zone around Bangkok which also includes the deltas of the Mae Klong and Chao Phraya Rivers. These delta areas are not clearly defined in hydrological terms. This zone represents the largest irrigated area in Thailand and is mainly dedicated to growing

rice. Intensive shrimp farming in coastal areas around Bangkok started in the 1980s (Szuster, 2006), but faced a series of crises in the 1990s and in the 2000s, in particular because of diseases. This activity later recovered and expanded thanks to the development of new production techniques and to the introduction of shrimp species capable of adapting to low salinity levels (Lebel et al., 2010). This enabled the extension of shrimp breeding to inland areas. Today, shrimps are the main agricultural product in the downstream part of the Bang Pakong River Basin (Seekao and Pharino, 2016).

The main role of the Ministry of Agriculture and Cooperatives in this zone is to manage water, i.e. to provide irrigation water in the dry season and address flood problems in the rainy season. Four main national agricultural policies have been implemented in the delta region around Bangkok in the past three decades. The first involved a series of schemes to support rice prices on the domestic market but this support stopped almost completely after the military coup in 2015 (Ricks, 2018).

Second, reduction of the extent of land under rice and the promotion of other crops were declared national objectives in the Fourth National Plan (1977–1981) and were strongly reaffirmed in the Seventh National Plan (1992–1996) because of the low profitability of rice farming and because of water shortages (Sirisup and Kammeier, 2003; Srimanee and Routray, 2012). A major diversification programme was implemented in the Chao Phraya River Basin from 1993 to 1999, but had limited results, the main causes being floods, labour shortages and difficulties related to the marketing of non-rice products (Sirisup and Kammeier, 2003).

Third, from 2000 on, the Ministry of Agriculture and Cooperatives promoted an approach aimed at developing a "self-sufficiency economy" for small-scale farms (Egery, 2014). According to this approach, small-scale farmers should avoid intensive monocropping (related to contract farming, for instance). Rather, small-scale farmers should produce both for home consumption and for the market, they should produce multiple crops, and use limited amounts of pesticides and chemical fertilizers.

Fourth, in 2015, the government announced a new policy that was almost completely opposed to previous ones. This policy aimed at helping small-scale farms improve the production and marketing of one crop (or animal). Groups of farmers were invited to work together in "large-scale schemes" and in partnership with public organisations to reduce production costs thanks to economies of scale, to increase yields and negotiate better prices. In the rice sector, the official objective was to reduce production costs by 20% and increase farm sales by 20% (Department of Agricultural Extension, 2016). This was to be achieved thanks to training, enhanced collective action between farmers and improved connection with markets (e.g., certification or contracting with agro-industries).

The main river in Prachinburi Province is the Prachinburi River, which becomes the Bang Pakong River after the confluence with the Nakhon Nayok River. The study areas are four irrigated zones that receive water from the Prachinburi and Bang Pakong Rivers (Fig. 1). These four zones were selected because they include the main farming systems in the downstream part of the Prachinburi River basin. Farmers in Bang Pla Ra Subdistrict concentrate on fish and shrimp farming and farmers in Bang Taen Subdistrict on rice and fish farming. In the two other zones, farmers concentrate on rice production. Many farmers in the Dong Krathong Yam Subdistrict have purchased agricultural machinery, such as a tractor, and farm relatively large areas (more than 13 ha). Farmers in Bang Kung Subdistrict farm much smaller areas. Each study area receives irrigation water through a network of canals connected to the Prachinburi and Bang Pakong Rivers. The pumps that pump water from the rivers into the canals are operated by water user associations in Bang Kung, Bang Pla Ra and Dong Krathong Yam Subdistricts and by the subdistrict local administration in Bang Taen Subdistrict.

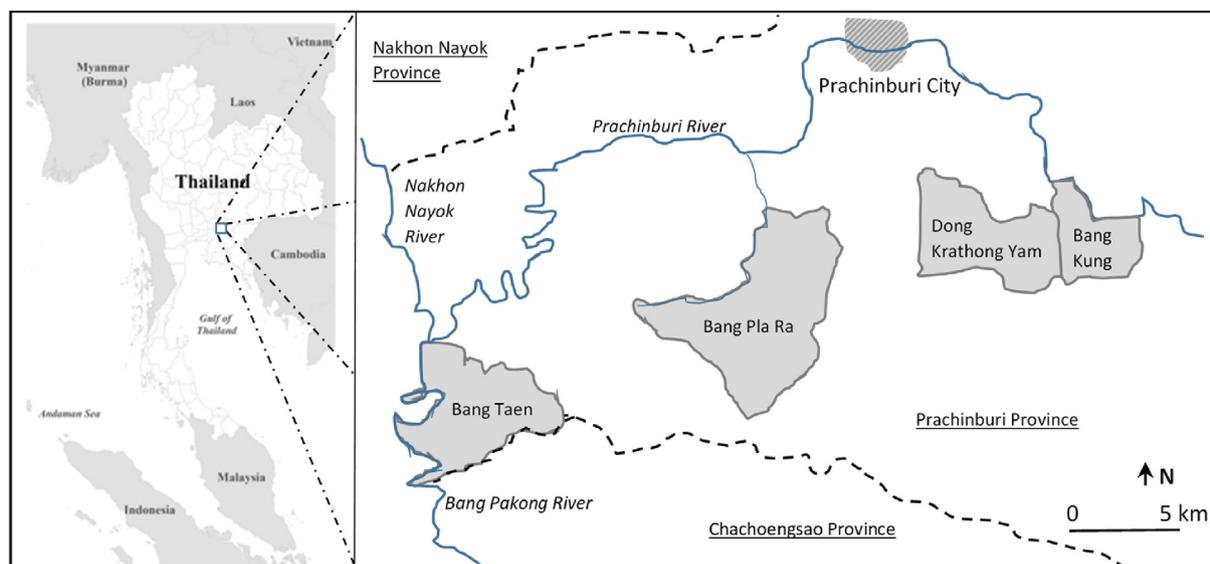


Fig. 1. Location of the four subdistricts studied.

2.2. Analytical framework

We characterised farming systems and investigated how the farms had adapted to the constraints they faced, especially those related to water resources, agricultural equipment and labour. The future prospects of the farms were delineated using two indicators: the farmers' own plans for the future and interest expressed by possible successors in taking over the farm. Preliminary interviews showed that in many farming households, farming was the main activity of at least one member. Thus, we analysed whether farm incomes were sufficient for potential successors to be interested in taking over the farm as their main activity. Possible successors (particularly the farmer's own children) often compare the income they expect from farming with the income they could get from non-farming activities. The economic criterion concerning annual net income is clearly only one among many other criteria they use to decide whether to take over the farm or not. Other criteria include opportunities to increase their income in the future, income uncertainty, quality of life, the possibility to send the children to high-quality schools, the amount of physical effort required, and autonomy in decision making (Ruiz-Salvago et al., 2019).

The minimum wage for a full-time job in Thailand is approximately 8000 baht¹ per month (Thai National Wage Committee, 2016). Working in factories may involve renting a room or daily transport, at a cost of approximately 1500 baht per month. Thus, working in factories may provide a net income of 6500 baht per month. We consequently defined an economic threshold of 78,000 baht (approximately 2450 US\$) net income per year as the minimum amount that possible successors would want before accepting to take over the farm, and to work on the farm as their main income-generating activity. This economic threshold is a very rough approximation, first because of the wide range of opportunities to obtain a non-farming income and of the variability of the cost of living. Second, farms with different characteristics do not require the same amount of labour and a more detailed analysis would involve calculating net income per unit of labour time.

2.3. Data collection and analysis

Twenty-seven farmers were interviewed in each of the four areas, giving a total of 108 farmers (43% of whom were women). We interviewed the farm holder or, if the farm was run by a couple, one of them.

The farms were chosen from lists of farmers provided by farmers' groups (e.g., the water users' association) to ensure diversity in terms of farm size, agricultural activities and the location of the farm within the irrigated areas. Interviews first focused on farm characteristics and family structure and second, on production costs and benefits in 2016. Third, farmers were asked if they had previously faced problems of insufficient irrigation water, brackish water or floods, and if so, what they had done to tackle them. Finally, farmers were asked about their plans in the future (in approximately 5 years) and whether they had already identified a successor within the family to take over their farm. Ten staff members of the offices of the Ministry of Agriculture and Cooperatives in Prachinburi Province were also interviewed to understand the policies and local initiatives implemented in our study areas to support farming activities. The interviews were conducted in 2017.

Farm net incomes were calculated as the difference between gross sales and yearly production costs, but did not account for past investments in agricultural equipment, since our focus was on the net income that a successor would expect if he or she took over the farm as it was. Neither did the assessment of production costs include family labour. We calculated the net annual income for each farm based on what each farm produced in 2016 including the possible cost of renting in land.

We compared net farm incomes with the above-mentioned economic threshold in two ways. First, we assumed the farm could be run by only one family member: the farm was considered economically attractive for possible successors if the net farm income was above this threshold. Second, we considered the number of family members working on the farm as declared in the survey (without accounting for how much time these members actually spent farming). In this case, we compared the net farm income with the economic threshold calculated at 78,000 baht per year multiplied by the number of family members engaged in farming. The farm was considered economically attractive for possible successors if the income generated was high enough to ensure that all members engaged in farming would be better off than working in factories.

3. Results

3.1. Types of farms

Before the 1990s, farmers located in the study areas only produced rice. They grew one rice crop per year, from approximately June to November. In the early 2000s, farmers started producing two rice crops per year: a rainy season rice from May to August and a dry season rice

¹ In May 2018, 1 US dollar = 31.8 baht.

Table 1
Farm types.

Farm type	Type 1 Fish and shrimp farming	Type 2 Rice and shrimp	Type 3 Rice and machines	Type 4 Rice, no machines
Number of farmers interviewed	27	8	19	54
Average age (years)	50.2	49.3	54.0	57.4
Average farm size (ha)	4.4	9.7	13.4	6.0
Proportion of rented land	17%	54%	56%	49%
Average number of family members working on the farm	1.9	2.0	1.9	1.4
Plans for the future				
Intensify or expand current farming system, improve farming practices	24%	22%	0%	3%
Diversification	13%	0%	38%	43%
Reduce agricultural activities	0%	0%	6%	10%
No plan to change farming system or practices	63%	78%	56%	44%
Identified successor within the family				
No	0%	15%	16%	48%
Possibly	50%	58%	42%	28%
Yes	50%	27%	42%	24%

from November to February. Irrigation of rice is complementary in the rainy season but indispensable in the dry season. Shrimp farming also developed in Bang Taen and Bang Pla Ra Subdistricts in the 1990s. One shrimp production cycle lasts four months (one month for preparation of the pond and three months for production per se), so three shrimp production cycles per year are possible. The length of the fish production cycle varies between 8 and 12 months. All the farmers in Bang Pla Ra Subdistrict interviewed had completely stopped rice farming, and at the end of the 2000s, they had shifted from producing shrimp alone to producing shrimp and fish bred together in the same ponds.

Four main types of farms were identified based on their agricultural production and equipment (Table 1). The first type groups farmers in Bang Pla Ra Subdistrict who bred fish and shrimp together in the same ponds. These farmers owned most of the land they used for fish and shrimp production. The second type groups eight farmers in Bang Taen Subdistrict who produced both rice and shrimp. The third type groups farmers in Bang Taen and Dong Krathong Yam Subdistricts who produced rice and had invested in a four-wheel tractor, and in rare cases also in a harvester. These farmers had purchased a tractor to reduce their dependence on service providers, e.g., for deep ploughing. The fourth type groups farmers in Bang Taen, Dong Krathong Yam and Bang Kung Subdistricts who mainly produced rice and had not invested in either a tractor or a harvester. They owned only a small tiller. Their average farm size was less than half the average size of the third type of farms. Some rice farmers grew other crops or had fishponds, but in a very small area and mainly for home consumption.

Farmers who grew rice had increased their farmed area in the past two decades mainly by renting in land. Rented land for rice production represented approximately half their farmed land. Farmers could generally not afford to buy land as the cost (which varied significantly but was approximately 600,000 baht per ha in Dong Krathong Yam) was very high compared to average net profit to be made from rice farming.

Among the interviewees, 74% farmed full time. For 75% of the remaining farmers who had other income-generating activities, such as being head of the village or running a shop, farming represented the main income-generating activity. In other words, in 94% of the households, farming was the main income-generating activity for at least one member of the household. In 41% of the cases, only one family member was involved in farming, in 47%, two were involved, and in 12% of cases, three or more members were involved. In 15% of farms (mostly belonging to Types 1, 2 and 3), the farmers' children aged less than 40, were also involved in farming.

According to the 2013 Thai agricultural census, at national level: 64.2% of farms cultivate less than 3.2 ha and can be considered as small-scale,² 31.1% farm between 3.2 and 9.6 ha and can be considered

as medium-scale, and 4.7% of farms cultivate more than 9.6 ha, and can be considered as large-scale (National Statistical Office of Thailand, 2013). Among the farms we surveyed, 21% farmed less than 3.2 ha (13% only produced rice and 8% fish or shrimp), 55% farmed between 3.2 and 9.6 ha, and 25% farmed more than 9.6 ha. Thus, most of the farms we surveyed can be considered as medium to large scale.

3.2. Adaptation to constraints

Most of the farms we surveyed had adapted their farming practices to brackish water, floods, lack of labour or lack of agricultural equipment. Concerning brackish water, 52% of the farmers we interviewed said that the water in the river near their farm was sometimes brackish in the dry season. These farmers were generally located in downstream areas, Bang Taen and Bang Pla Ra Subdistricts. In their opinion, the occurrence of brackish water in the river had become increasingly frequent in the dry season over the past 15 years, especially in March and April. This was due to increased pumping because farmers had started producing dry season rice. As a result, seawater intruded inland over a much greater distance from the estuary.

At the individual level, rice farmers had adapted by growing short-duration rice varieties, which can be harvested before March. Fish and shrimp farmers had dug ponds to store water. At collective level, in February, the water users' associations pump water into canals to store it for later use when the water in the river becomes brackish. When salinity in the river reaches approximately 1 g/l, the gates connecting the canals to the river are closed and no more water is pumped into canals usually until June. As the gates are closed, if not enough water is stored in the canals, the farmers may face water shortages during this period. Thanks to these adaptive measures, only 11% of the farmers interviewed considered that the occurrence of brackish water affected crop yields or the production of fish and shrimp.

Second, floods occur frequently in the study areas in October and November. In Bang Taen, Dong Krathong Yam and Bang Kung Subdistricts, farmers made sure they harvested rice or completed a shrimp or fish production cycle before the flood period. In Bang Pla Ra Subdistrict, fish and shrimp farmers had installed nets along the edges of the ponds to make sure the fish and shrimp could not escape from the ponds during flooding. Farmers organised in groups (usually three to four members) had also collectively built small dykes around the ponds. Flooding was also managed collectively in Bang Taen Subdistrict, as the pumps operated by the subdistrict local administration, which were used to pump water into the canals in the dry season, were also used to pump flood water back into the river. Thanks to these adaptive measures, the farmers said they were usually not affected by floods.

(footnote continued)

census does not provide figures corresponding to this threshold.

²The Office of Agricultural Economics of Thailand (2013) in fact considers that small-scale farmers farm less than 2.4 ha. However, the 2013 agricultural

Table 2
Proportion of farms above the economic threshold of attractivity for possible successors.

	1. Fish and shrimp farming	2. Rice and shrimp	3. Rice and machinery	4. Rice, no machinery
Considering one family member farming full time	96%	100%	84%	31%
Taking the number of family members farming at the time of the survey into account	74%	100%	53%	28%

Third, almost all the rice farmers outsourced part of or all their agricultural operations. In the study area, rice production involves five main activities: ploughing, sowing, spraying chemicals, applying fertilizers and harvesting. Among the 81 farmers who grew rice, 63 did not do the deep ploughing themselves, and 78 did not harvest themselves, mostly because they did not have the necessary machinery. Approximately two thirds of the rice farmers also paid labourers to sow seeds, spray chemicals and apply fertilizers. The reasons given were: 1) lack of available family labour during periods of high labour needs; 2) health risks associated with the spraying of pesticides; and 3) the farmers' old age. This had consequences for profits since paying for hired labour and renting machines with their operators represented 54% of rice production costs (not including the cost of renting in land). Thus, on farms which only produced rice, only one person was engaged in full-time farming, while the other family members helped occasionally, for instance, with sowing.

By contrast, farmers engaged in fish and shrimp farming or combined rice and shrimp farming generally did the breeding themselves and only hired labourers to harvest the fish and shrimp at the end of each production cycle. They were also significantly younger than the farmers who only produced rice ($p < 0.001$). The average number of family members working on rice farms with no agricultural machinery was lower than in the three other types (Table 1) both because of the outsourcing of agricultural activities and because they farmed less land than rice farms with machinery.

3.3. Future prospects of the farms

Farmers involved in the most profitable activities (shrimp farming or combined fish and shrimp farming) generally either planned to invest in their farming systems or had no major plans to change their systems because they were generally satisfied with them at the times of the interview (Table 1). Almost none of the farmers who only produced rice (Types 3 and 4 in Table 1) planned to intensify or expand their farming system. The advanced age of many of these farmers contributed to their lack of interest in changing their farming systems. Moreover, they considered that rice production had limited prospects for development due to low rice prices (and the government discourse claiming there would be no further subsidies for rice) and lack of identified opportunities for a major improvement in rice farming practices. In particular, rice farmers who had invested in agricultural machinery did not mention a plan to expand their rice cropped area. Another reason for them not to expand rice cultivation was that they considered that they did not have the necessary labour force to do so.

Instead of expanding rice cropped areas, rice farmers who aimed to change their farming systems (41% of farmers who only produced rice) planned to diversify by growing other crops such as vegetables, planting orchards, or fish farming. None of the farmers who only produced rice were interested in shrimp farming because of the high investment costs required, lack of knowledge of the production techniques and markets, and because they considered shrimp farming to be risky, both in terms of diseases and in terms of market prices.

Forty-seven percent of rice farmers had no future plans because they considered their scope for change to be limited. Indeed, two main types of constraints do limit opportunities for change, in particular planting orchards or growing vegetables. The first constraint was the occurrence

of brackish water and floods. Farmers could attempt to avoid flooding by building dykes and they could attempt to deal with brackish water by digging ponds in which fresh water would be stored. However, these investments were costly, and neither was guaranteed to solve the problems of brackish water or floods. Moreover, such costly investments were insecure on land that was rented in by the farmer, and 14 out of the 27 interviewed farmers in Bang Kung Subdistrict owned no land. Among the 73 farmers who only produced rice, only six had started planting an orchard or growing vegetables on very small areas.

Table 1 shows the farmers' own assessment of the chances that someone in their family would take over the farm. The percentage of farmers who already knew there would be no successor in their family was low among farmers engaged in shrimp farming or combined fish and shrimp farming (respectively, 15% and 0%). Rice farmers who had invested in agricultural machinery were also likely to have identified a successor (only four of the 22 farmers who farmed more than 9 ha had no identified successor). By contrast, 48% of rice farmers who had no machinery were sure that no-one in their family would take over their farm, most said their children were not interested.

In 2016, average yields of rice farms were 4.2 t/ha for both rainy season and dry season rice, giving an average net profit of 15,700 baht (i.e., approximately US\$490) per ha per year. If the farmers rented in land, the average net profit dropped to 8350 baht per ha. The average net income for shrimp production was much higher: 108,000 baht/ha in 2016. Combined fish and shrimp production was between the two with an average net profit of 75,000 baht/ha in 2016. The profit had previously been higher, but by 2017, the sales price of fish had been declining for several years.

Table 2 compares net farm incomes with the economic threshold defined in the methods section. The net income of most Type 1, 2 and 3 farms was above the threshold when only one farming family member was considered, or when the number of family members actually involved in farming in 2017 was taken into consideration. Moreover, most Type 1, 2 and 3 farms that were under the threshold when considering the number of family members actually involved in farming may still be considered as being able to provide sufficient incomes for one person farming fulltime. For the six fish and shrimp farms which were under the threshold when considering all farming members but not when considering one member, the ratio of farmed area to the number of farming family members was of 0.6–0.8 ha per person. In practice, 66% of farmers we interviewed who were engaged in combined fish and shrimp breeding farmed more than 1.6 ha per person. This means that these farms could probably be managed by one person alone, and that they can thus be considered as above the economic threshold in terms of economic attractivity for possible successors. The same goes for rice farmers who owned agricultural machinery. The income of six of these farms was above the threshold when only one person was considered, but not when the number of family members actually involved in farming in 2017 was used for the calculations. For these six farms, the ratio of farmed area to the number of farming family member was 3–6 ha per person. However, the ratio of 47% of the rice farmers who had machinery was more than 6 ha per person. In contrast with the situation of fish and shrimp farmers and rice farmers who owned machinery, the income of more than two thirds of rice farmers with no machinery was below the threshold.

Interpreting the differences in economic profitability reveals

similarities with the one based on identifying possible successors. Among the farmers who already had identified a successor, 63% were above the threshold (taking one farmer into account), whereas only 36% of those who had no successor were above this threshold.

Rice farmers who cultivated a relatively larger area were generally more able to buy a tractor. However, the purchase of a tractor did not only reflect farm size: it also reflected farmers' willingness to invest in their farm in order to reduce the cost of outsourcing agricultural work and to have more freedom of choice in deciding when to do the work. Some farmers who farmed a relatively small area had also invested in a tractor. Conversely, the absence of a tractor was only one factor among others (farmer's ageing, lack of an identified successor and small farm) which when combined, weakened rice farms. Hereafter, we use the term "vulnerable rice farms" to refer to Type 4 farms, to avoid focusing on the absence of agricultural machinery.

3.4. Agricultural policies and local initiatives

The support provided to farmers by the Ministry of Agriculture and Cooperatives differed considerably depending on the topic: water issues, agricultural production and marketing, and the increasing age of farmers. There was active support for dealing with water issues in the study areas, in particular, the construction of the Naruebodindrachinta Reservoir in the upstream part of the Prachinburi River Basin. It started operating in 2016 and played a role both in limiting the occurrence of flooding and, by releasing stored water, in reducing salinity in the dry season. Local offices of the Ministry of Agriculture and Cooperatives made some attempts to improve the relations between farmers and other actors of agricultural value chains. Farmers could attend training courses on agricultural practices and, in the framework of the "self-sufficiency economy" programme, the Ministry of Agriculture and Cooperatives distributed tree seedlings and fingerlings to some farmers in the subdistricts in our study areas. However, none of farmers we interviewed had benefitted from such a programme.

Two "large-scale schemes" focused on rice production started in Bang Taen and Bang Kung Subdistricts in 2017. The farmers involved in these two schemes received rice seeds, they attended training sessions (e.g., on rice cultivation techniques and integrated pest management) and the soil of their farm was analysed. However, there was no initiative concerning marketing because of the low quality of the rice they produced. A "large-scale scheme" was also implemented in Bang Pla Ra Subdistrict in 2017, which focused on fish and shrimp production. A market was built so farmers could contact more middlemen, hopefully leading to increased competition between the latter.

However, the successful implementation of proposed "large-scale schemes" involving rice farms faced major challenges. First, these schemes aim to bring about major changes in farming practices and to promote collective action between farmers to jointly negotiate prices of both agricultural inputs and produce. However, many of the farmers with vulnerable rice farms we interviewed who were taking part in the large-scale rice schemes were already old and, especially in Bang Kung Subdistrict, they had no hope of finding a successor within their family. These farmers are likely to have limited interest in undertaking the major changes in their practices that would be required to decrease production costs by 20% and increase their sales by 20%. Second, the activities proposed in the framework of the two "large-scale schemes" focusing on rice may not fully match the priorities of many rice farmers, since half of them declared that their goal was to stop rice monocropping and to diversify. Finally, the offices of the Ministry of Agriculture and Cooperatives in Prachinburi Province had done almost nothing to deal with the issue of helping young people to start farming (see also Phiboon et al., 2019).

Concerning local initiatives, thanks to support provided by a company in the framework of a Corporate Social Responsibility initiative, in 2014, a group of farmers in Bang Taen Subdistrict began producing and marketing organic rice (Faysse and Phiboon (2019)). This group

included both farmers mainly aiming to increase profitability and farmers mainly aiming to produce rice for home consumption.

4. Discussion

4.1. Mainly farming ... until now

The image that emerges from the study of irrigated farms in Prachinburi differs from the one of farms with limited access to land and water in other areas of Thailand in several ways. Much more labour is required by these farms than by the small-scale rainfed farms of the Northeast and North Regions: rice farmers grow two rice crops and often on a much larger area, and fish and shrimp breeding requires daily care. However, most of these farms also brought in sufficient income for at least one household member to farm as his or her main activity. The economic threshold used here would not make much sense in farms where household members dedicate limited time to farming, as documented in many cases in the Northeast and North Regions. In the present case, where farming was the main activity of almost all the interviewees, and the only activity for two thirds of them, it provided an interpretation of differences between farms that largely agrees with differences in the way farm holders saw the future of their farms.

What is more, the average age of fish and shrimp farmers in the present survey was below national average and, on several farms, young family members were also engaged in farming. Higher farm incomes were linked to younger age and higher farmers' assessment of the possibility that a family member would take over the farm in the future. As reported by Zagata and Sutherland (2015) and Davidova et al. (2012) in Europe, one of the key drivers of the processes of ageing farming population and limited installation of young farmers is the income that can be obtained from farming. There is less shortage of young people willing to become farmers when incomes from farming are comparable to incomes young people can obtain from non-farming activities.

Nevertheless, the sustainability of vulnerable rice farms in our study areas appears to be compromised. Kasem and Thapa (2011) and Sirisup and Kammeier (2003) already identified the constraints facing farms in the delta area around Bangkok, such as lack of fresh irrigation water or shortage of labour. Compared to these two studies, which took place eight and 16 years ago, the role of an ageing population in rice farms has become of key importance. What is more, the authors of those studies identified the constraints separately, whereas in the farms surveyed here, these constraints had become much more interrelated.

Fig. 2 shows the interrelations between water resources, the farming system and farm characteristics for the vulnerable rice farms. These interrelations have created a vicious circle of limited profitability, which threatens the sustainability of these rice farms. The vicious circle increasingly discourages farmers from changing their practices and, in the words of Dorward et al. (2009) from "stepping in" to intensify their farming systems.

The role of farming as a key activity for the households surveyed continued despite wider changes at household level and at the level of the study area. At village level, most households were still engaged in farming (Ruiz-Salvago et al., 2019) but several members of each household were engaged in non-farming activities. The presence of factories in the region enabled them to commute daily to these factories, reducing the need for migration. Thus, the study area was much less subject to the changes that have been described in the studies on rural dynamics in the Northeast and North Regions of Thailand, such as the marginalization of farming within a larger set of income-generating activities, and the spread of families over many sites due to migration.

4.2. Uncertain futures

There is still no clear indication of how farms in Thailand with limited access to land and water will evolve in the future, as up to now

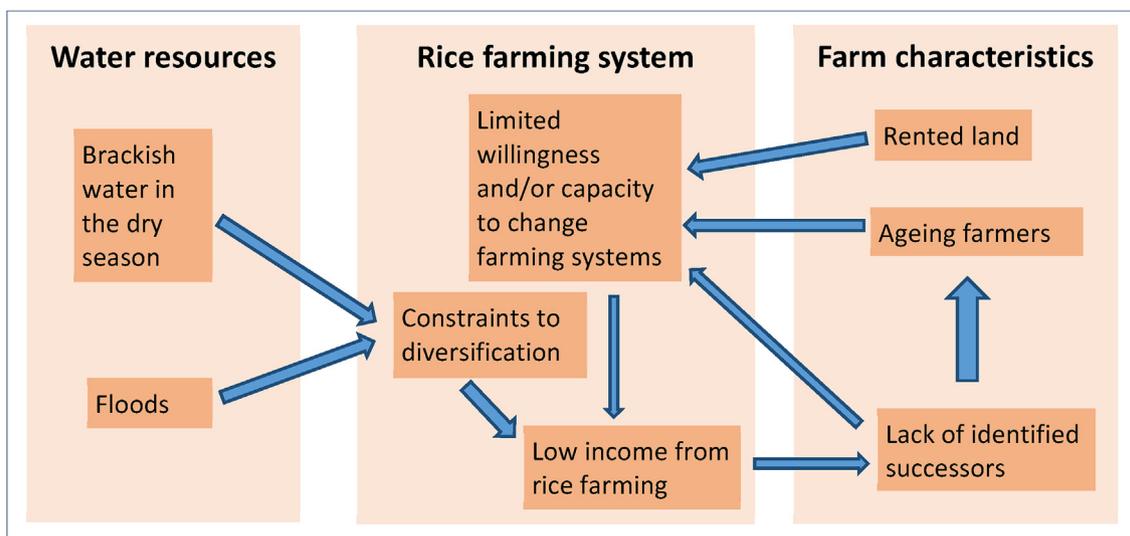


Fig. 2. Constraints to changes in vulnerable rice farms towards more profitable farming.

the adaptive strategies implemented by farm holders have made it possible to put major agrarian changes “on hold” (Rigg et al., 2018). At a broader level, Rigg et al. (2016) proposed four scenarios for the evolution of smallholders in Asia. The first is a business-as-usual scenario in which smallholders remain in rural areas because of the absence of alternative opportunities. The second one amounts to the disappearance of smallholders and a shift towards large-scale farms. This would resemble what took place in most of Western Europe in the second part of the 20th century, whereby the agricultural land of farms for which no successor had been found was taken over by remaining farmers, leading to a continuous increase in farm size (Vidal, 2000). The third scenario concerns an increase in smallholders’ political power, leading to public policies providing substantial support and protection for smallholder farmers. The fourth scenario corresponds to a move towards households continuing to mix farming and non-farm income-generating activities (both locally and thanks to migration). This would prolong the dynamics currently observed on rainfed rice farms in the Northern and Northeast Regions of Thailand.

The first three scenarios proposed by Rigg et al. (2016) do not appear to correspond to the possible future of rice farms in our study areas, at least not in the coming decade. The lack of expected successors for most of the vulnerable rice farms may limit the possibility of a shift towards the first scenario (“remaining smallholders by default”). Concerning the second scenario (“shift towards large-scale farms”), rice farmers who had invested in agricultural machinery did not express any interest in increasing their farmed area, at least using current farm production techniques. Options for increased mechanisation of rice production may exist in the future but were not yet present in the area at the time of the survey. Concerning the third scenario (“policies protecting smallholders”), there is no hint of willingness on the part of the government to strongly support smallholder farmers’ access to national and international markets, especially after the last scheme to support rice prices was seriously criticized (Ricks, 2018).

The fourth scenario (mixing of farming and non-farming income-generating activities) may take place but it would require notable changes in farming systems, since rice farmers are already engaged in the time-consuming activity of growing two rice crops a year, and on larger areas than the ones generally farmed in the Northern and Northeast regions of Thailand. Such a scenario may involve reducing the intensity of farming or leaving land unfarmed.

4.3. The need for comprehensive approaches in Thailand and other newly industrialised Southeast Asian countries

As already pointed out at national level (Faysse, 2017), Thai agricultural policies do not appear to take the diversity of farming situations in the study areas fully into account. They do not distinguish between: (i) currently profitable farming systems which - for the moment - are sustainable at farm level (and for which “large-scale schemes” may be beneficial), and (ii) farming systems which have entered a vicious circle of limited profitability and for which policies such as the “large-scale schemes” alone do not appear to be sufficient to interrupt the vicious circle in which they are trapped. In the short term, public policies could provide support to help rice farms adapt to existing constraints, while taking the diversity of their situations into account. The support provided to organic farming in Bang Taen is a promising example as it provides an opportunity to farmers aiming for increased profitability and to farmers aiming to increase rice production for home consumption. In the longer term, the sustainability of the agricultural sector in the rice production zone will probably not be achieved through limited adjustments, rather, a transformation of farming systems is required (Darnhofer et al., 2010).

Farms in irrigated areas of Malaysia, Indonesia, the Philippines and Vietnam are usually much smaller than the farms in our study area: generally ranging between 0.5 and 3 ha (Man and Sadiya, 2012; Bosma et al., 2012; Mariano et al., 2012; Nathan and Mohamad, 2014; Antriyandarti, 2018). Studies in these irrigated areas mention some aspects of a similar “vicious circle” that could limit the capacities of farms to evolve in the future. In these areas, farmers’ frequent engagement in non-farming activities has been reported (Lorenzen, 2015; Moya et al., 2015; Nathan and Rosli, 2016). The lack of interest of young people in engaging in farming was also mentioned, albeit often based on limited quantitative data (Moya et al., 2015; Ngah et al., 2013; Susilowati, 2014).

This vicious circle could become a major obstacle to the implementation of public programmes to increase rice productivity and production (e.g., in Malaysia, Davidson, 2018). Like in the cases studied in Thailand, programmes that propose a marginal increase in profits from farming may not be sufficient to break the vicious circle. In order to find pathways towards more sustainable farming systems, there is a need for comprehensive approaches tackling economic and environmental issues at the same time as the problem of supporting new generations of farmers. The latter type of support is still incipient in newly industrialised countries of Asia (FFTC-RDA, 2014) but increasingly merits deliberation.

5. Conclusion

Almost all irrigated farms surveyed in the present study provided sufficient income to enable at least one household member to farm as his or her main activity. Apart from this shared trait, the situation of the farms varied widely from being economically sound to very fragile. Moreover, these farms evolve in an environment marked by heavy constraints, particularly in terms of access to irrigation water, flooding and marketing. This limits their capacity to adapt to ongoing agricultural and non-agricultural changes. In rice production areas, up to now, access to irrigation water has enabled farmers to adapt to the increasingly low profitability of rice farming, as did the expansion of non-farming activities in the Northeast Region of Thailand. However, the future of rice farms (both the smaller and the larger ones) is uncertain.

Irrigated areas in newly industrialised countries of Asia (e.g., the “granaries” in Malaysia, the delta area around Bangkok in Thailand, the Mekong River delta in Vietnam) have been described as the “rice bowls” of these countries. The present study shows that the sustainability of rice production can be very fragile even when the farms are relatively large according to Southeast Asian standards. If these systems are to continue playing an active role in national agricultural production and to help achieve national food security, there is a need for new ways of thinking about the future of these areas. Sustainable agricultural systems will likely involve tackling issues such as farm size, the engagement of young farmers, and types of agricultural production, as these “rice bowls” are likely to contain more than rice in the future.

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Declaration of competing interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jrurstud.2019.12.002>.

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