

# Guidelines for Sustainable Agriculture of Thai Farmers in Non-irrigated Areas

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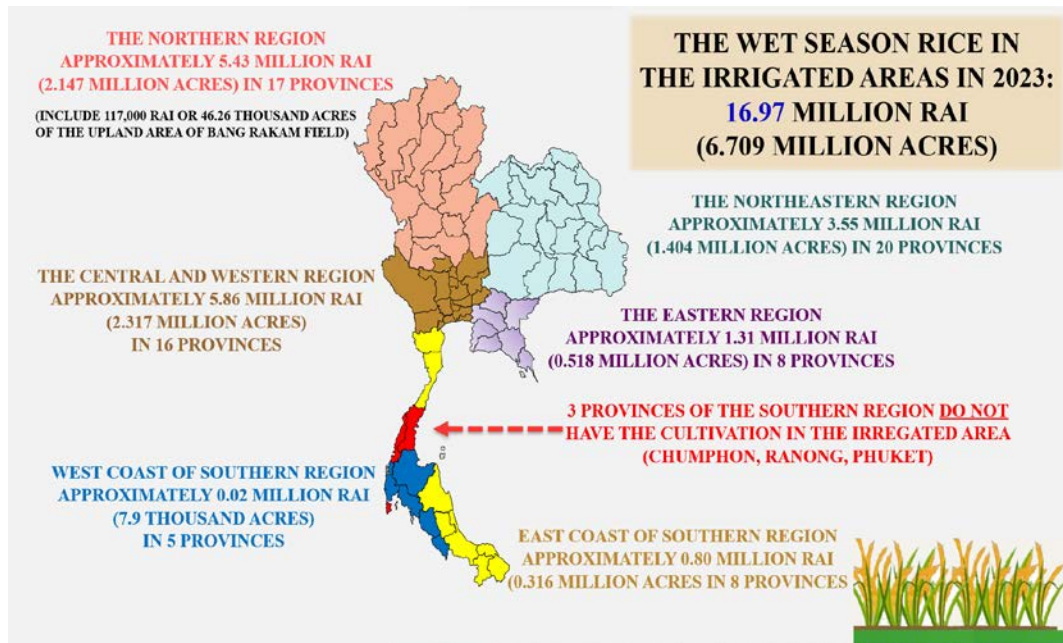
**Abstract** Thai farmers play an important role in the country's food security. The product of rice farmers is rice which is the staple food of Thailand and many countries around the world. Although rice farming is the occupation of most farmers, the solving of problems of farmers from the past to the present has not been able to cover all areas, especially the non-irrigated areas, such as Nong Ya Sai district, Suphanburi province. This area is classified as the recurrent drought area. Because of this challenge, farmers had to struggle to survive in dry, water-scarce areas. Eventually, they won the fight against drought and were praised as professional farmers or brilliant farmers in the field of rice. Findings on lessons learned from success that can be called "Nong Ya Sai Model" contained the important issues that have been summarized into a set of knowledge, namely the concept of '5 Knows', namely Know the Soil, Know the Water, Know the Plants, Know the Micronutrients and Chemicals, and Know Yourself. This concept can be used as a guideline for farmers, including the application in agriculture for both plants and animals. This enables the safe agriculture, the increased productivity, the increased income, and the raise in the quality of life of Thai farmers sustainably.

**Keywords** Sustainable Agriculture, Thai Farmer, Nong Ya Sai Model, Non-Irrigated Area

## 1. Introduction

Thailand is one of the world's top rice producers and exporters. The rice cultivation season is divided into the wet season rice crop and the off-season rice crop. For the year 2023/24 cropping cycle, there are approximately 62.375 million rai (24.661 million acres) of the wet season rice cultivation and approximately 7.76 million rai (3.068 million acres) of the off-season rice of the year 2024, which decreased from the previous year at 0.96% and 34.72% respectively [1]. It can be seen that the off-season rice cultivation areas have decreased more than those of the wet season rice. The causes are the low rainfall, delayed rain, and drought conditions from the El Niño phenomenon. This led to the decrease of amount of water in various water reservoirs, which is not enough for rice cultivation. In addition, it also risks the damage, the growth, the rice production quantity and the rice quality.

The context of rice cultivation areas is divided into the irrigated and the non-irrigated areas. These two types of areas were used to cultivate the wet season rice as the main season. When considering data on the areas of the wet season rice cultivation in the irrigated areas in 2023, it was found that throughout the country in every region of Thailand, there are only 16.97 million rai (6.709 million acres), as shown in Figure 1.



**Figure 1.** The cultivation of the wet season rice in the irrigated areas in 2023 [2]

From Figure 1, it can be seen that the proportion of rice cultivation areas in the irrigated areas is less than 20% of the rice cultivation areas of the entire country; the rest more than 80% are in the non-irrigated areas which most of farmers use for cultivating rice. In the wet season, farmers in the non-irrigated areas only farm once a year, and the rest of the time, the land is left vacant due to a lack of water for cultivation. In addition, there is the impact from El Niño phenomenon, inclement weather, higher temperature, and more severe drought. Agricultural water resources have been limited over the years due to global warming and irregular rainfall in the arid and semi-arid regions [3]. The data from the relevant agencies forecast that Thailand will receive the full impact from El Niño phenomenon in 2024-2025 [4]. This means the group of farmers in the non-irrigated areas is those who receive direct impact; that the non-irrigated farming is agriculture that is under the condition of a serious shortage of water resources [5]; including that biodiversity is being rapidly degraded; climate change is increasing pressure on agricultural land, soils, and freshwater. Increased global temperatures and water scarcity have had long-term adverse effects on farm crops [6]. Moreover, the problem that will occur is not only the insufficient amount of water, but also the inclement weather that causes the error in the production planning, the risk on insect pests and plant diseases such as brown planthopper, fungus, and bacteria. In the past, these caused great damages to rice productivity.

As the farmers' way of life, they have used the natural seasons as the factor for determining the start and the end of the cultivation period. As for the method of cultivation, farmers have used traditional methods as they have done in the past. The problems that farmers encountered are still the same problems from both farmers themselves and

management. For example, a lack of appropriate area management, time management, disguised unemployment, habit of cultivating in the traditional way, unacceptance of changes, a lack of good and sufficient production factors, especially water, productivity that is not at full efficiency according to rice varieties, high production cost, and the debt problems. Furthermore, some non-irrigated areas with the drought condition also encounter the recurrent drought problem and lack the appropriate area and water management, both water reservoirs and water utilization. The farmers in this type of area cannot build large enough water reservoirs. The area of Nong Ya Sai district of Suphanburi province of Thailand is classified as the recurrent drought area. Since the past, farmers in Nong Ya Sai district have faced challenges from low rainfall and drought every year because the area is in the rain shadow zone. Nowadays, these drought problems can be solved and relieved by using the method of soil and water management. Therefore, this study is a lesson learned from the success of Thai farmers in the non-irrigated areas who can adapt themselves, change their mindset, use an idea base that is a set of knowledge appropriate to their own area, and develop themselves to become professional farmers who can overcome the drought problems by continuously managing and developing their career.

## 2. Purposes of This Study

- 1) To extract a lesson learned about the concept of rice cultivation by farmers in the non-irrigated areas of Nong Ya Sai district of Suphanburi province of Thailand.

- 2) To synthesize ideas and knowledge sets from a brilliant farmer in the field of rice of Nong Ya Sai district.

### 3. Literature Review

#### 3.1. Concept about the Rice Cultivation in the Non-irrigated Area

The rice cultivation in the non-irrigated area is one of the eco-systems for growing rice according to the hydrology conditions on the surface of the soil [7] and the use of natural rainwater. The rainfed rice eco-system was classified into 5 types, as follows [8]:

- 1) Shallow and Favorable: it is an area where there is water in shallow rice paddies, similar to the irrigated rice field; the amount of water cannot be completely controlled but the amount of rain is sufficient for growing rice and can be evenly distributed.
- 2) Shallow and Drought-prone: it is divided into 2 types:
  - (1) drought-prone I: a rice field area with a short rainy season in which there is often drought at the end.
  - (2) drought-prone II: a rice field area with a longer rainy season than the first type but the rain often stops for a while in the middle of the season.
- 3) Shallow and Drought-and-submergence-prone: a rice field area that is flooded due to heavy rain or runoff from the river, alternating with the drought. It may occur within one cultivation season or between 2 seasons.
- 4) Shallow and Submergence-prone: a rice field area where water is stagnant throughout the season; which is enough for rice production.
- 5) Medium-deep and Waterlogged: a rice field area with water logged approximately 25-50 centimeters deep.

In Thailand, the rice cultivation in the non-irrigated area mainly depends on seasonal rainfall. Most farmers cultivate rice once a year, and twice a year for some of them whose land is located near the public water sources or who have water reservoirs in their land. Rice cultivation conditions in Thailand mostly receive rainwater from monsoons and depressions. The rain falls in two periods. Firstly, the normal rainy season starts around the middle of May when the southwest monsoon blows from the Indian Ocean passing through the country from mid-July to the end of August; and it will leave a period of drought for about 2-3 weeks. Secondly, as for the rain caused by depressions, they originate in the South China Sea and move west along the monsoon trough. The depressions begin in the northern region in August, passing through the northeast and central region during September, and move south in November. The passing of monsoons and depressions, whether fast or slow, will greatly influence the rice cultivation that depends on rainwater. Due to the

reason that it is hard to control and manage the water in the rainfed rice field area, the cultivation often faces problems, as follows [9]:

- 1) Drought: in the problem area, it was found that the rain falls into two periods; the drought is in the middle. Sometimes, there will be severe damage during the booting stage of rice. This problem is often found in the northern, northeastern and central regions of Thailand.
- 2) Flooding: it was found especially in the northern region where flooding problems are common. In the valleys and plains of the northern region, flooding occurs when it rains heavily. Water in the river will flow and flood the central region. In the southern region, the flash floods may occur in lowland areas without drainage, which can occur at all stages of rice growth.
- 3) Problems with soil: most soil for rice cultivation have problems on either saline soil, acidic soil, or sandy soil. The problem of saline soil is often found in the northeastern region while the acidic soil is often found in the central region. This soil problem has an effect on the decreased rice productivity.

#### 3.2. Concept about Area Management for Rice Cultivation

The condition of the rice cultivation area is the flat area with the ridge around that area to keep water and fertilizer in one rice field, not flowing to the next fields. The ridge will be small or large depending on the area management and the tree planting on the ridge; this can be divided into 3 methods [10]:

- 1) Planting with the forest system: in this system, only wild tree seedlings are used for planting or the mix of wild tree with local trees. Each tree must be planted on the ridge with an appropriate distance. The types of trees that are commonly used are Gurjan tree, Siamese Rosewood, Burmese Rosewood, Iron Wood, Pod Mahogany, as well as local trees, etc. This method of planting creates many benefits; the use of wood and the good ecosystem on the ridge.
- 2) Planting the fruit trees together with the local trees in the same area unit: this is similar to the first method, which is to plant local trees for the use of wood, together with fruit trees. This method enables farmers to have more income generating channels.
- 3) Agroforestry system on the ridge: this method will be an extension of the second method to create more variety by creating an ecosystem on the ridge. This enables to create daily income for farmers by growing vegetables, such as ginger, galangal, lemongrass, shallots, garlic, Chinese kale, Chinese flowering cabbage, morning glory, finger root, watermelon, and cucumbers. These vegetables will be the sustainable option for farmers to live and earn income throughout the year.

### 3.3. Concept about Farmers' Way of Life and the Management of Time and Occupation

The way of life of Thai farmers is influenced by changes in the economy, society, environment, and technology, like other occupations. It is divided into 2 types, as follows [11]:

- 1) Traditional way of life: the living of Thai farmers is the way of life of Thai people who grow rice for consumption in their own families whose nature is an extended family. Therefore, they mainly used labor from their families, cows and buffalos and workers from the community who helped and supported each other without being hired, in the form of gathering for growing or harvesting rice. Traditionally, farmers did rice farming once a year. After the farming season, other crops were planted in rotation. In addition, farmers usually created the easy tools and appliances from natural materials by relying on wisdom, folk knowledge, and expertise of the elders. As for the self-reliance in daily life, they adhered to the principle of sufficiency in easy eating and easy living. Plus, the cost of living in everyday life was low because they could find vegetables and catch fish from rice fields and waterways that were filled with an abundance of both plants and animals. Importantly, they were free from pollution.
- 2) Modern way of life: Thai farmers' way of life has changed both in their lifestyles and farming styles. What is evident is that the number of family members has decreased. Farmers reduce dependency on family labor but they hire labor, use machines instead of human labor, and use technology to control and manage the fields, etc. Therefore, the working style of modern farmers is similar to the field manager who orders contractors to carry out various activities on their behalf. In addition, the goal of rice cultivation is to sell, focusing on the dependence on modern capitalist objects, the use of more agricultural machinery, the use of fertilizers and chemicals, and the use of new rice varieties. Many factors create convenience in rice farming. This enables farmers to receive a large amount of productivity in terms of the quality and quantity of rice and they can do the rice cultivation several times a year because there is a market system support at all times.

### 3.4. Concept about the Management of Time and Occupation

The farming in each cropping cycle, both the wet season rice crop and the off-season rice crop, starts from preparing the area, then plowing the soil, broadcasting or transplanting the seeds, fertilizing, doing the maintenance, spraying the chemicals to control weed, disease treatment, prevention and elimination of insect pests, and harvesting and post-harvest management. It can be seen that various

activities continue as a cycle in a cropping season. During the rice cultivation season, which lasts approximately 110-120 days, farmers will have free time from taking care of the fields to be able to engage in additional jobs alongside farming which is their main occupation. After the rice has been harvested, the fields can also be used to grow vegetables or field crops as well because there are still nutrients remaining in the soil. For example, the case of farmers in Amnat Charoen province of Thailand, when the rice farming season is finished, the rice fields will be transformed into plots for growing various types of short-lived vegetables, such as they group together to grow organic vegetables for selling to those who are interested in consuming healthy vegetables. The profits from selling the vegetables will be used to cover rice farming costs for the following year. Many farmers turn to growing vegetables along with rice farming because it can generate good profits [12]. Another case is farmers in Sing Buri province of Thailand, they have an additional job in raising the bandicoot rats and selling them while waiting to harvest products from rice fields and sugarcane fields. They can generate income from this job almost every day. The food used to feed the bandicoot rats is rice paddy harvested from their rice fields and Napier Grass, which is the food that the bandicoot rats like to eat. In addition, farmers also collect seasonal fruits from their mixed agricultural plots. As for the market and sales, there will be people coming to buy the products at their home [13].

## 4. Lesson Learned about Rice Cultivation of Farmers in Non-irrigated Areas of Nong Ya Sai District of Suphanburi Province

The model farmers have adjusted the structure of rice production within their fields in times of drought and water scarcity by increasing other crop production activities in the area in order to maximize the use of time, labor, and resources to generate additional income. As for the plants that have potential in this area, which are easy to grow and in demand in the market, are cow-pea, chili, eggplant, pumpkin, cowslip creeper, roselle, etc.

Regarding the results of the survey of agricultural household productivity, costs, and income, it was found that the average annual rice productivity increased by 9.21%. The production costs decreased compared to before joining the project, especially in the off-season rice crop, in which the investment rate was lower than the wet season rice crop. This investment decreased at 15.02%. In addition, farmers also learned to use basic production factors economically, especially the use of chemical fertilizers. When evaluating the cash costs, it was found that chemical fertilizer application was greatly reduced at a rate of 36.60% in the off-season rice crop and 30.45% in the wet season rice crop. The farmer group had an average income

increase of 996 baht per rai per cropping cycle [14].

In addition, it was found that this change in production model has been furthered from farmers to farmers through a step-by-step technology transfer system, consisting of 3 sequences, as follows [14]:

- 1) The government gives supports about knowledge sources in various fields about rice, such as knowledge on rice, rice production process, GAP production process, personnel on rice, and various information media for the model farmer group to work to strengthen the group by creating community/group participation, wisdom, geosocial, and also being able to apply various knowledge combining with local production and wisdom from agricultural philosophers to create technology that is appropriate for specific areas; which is relevant to the mindset that rural development requires harnessing existing community assets and expanding local economies while pushing local capabilities to be more efficient and innovative [15].
- 2) The enhancement of farmer teachers to have the potential and ability to convey or communicate to fellow farmers so that they have knowledge and understanding, and are able to be a good example. They should also develop and adapt themselves according to the situation, be open to new knowledge more, and apply it to make themselves academically strong in farming in order to be a farmer teacher and a good example and role model.
- 3) The creation of network and the expansion of masses; at this stage, the farmer teachers must have relationships with the farmer network in a very close manner, like close friends or relatives. They must treat farmers in the community as friends with diverse abilities in order to build confidence and faith in being a farmer teacher, then instill the correct knowledge core to fellow farmers for expanding the network even more.

## 5. The Synthesis of Ideas and Knowledge Sets from a Brilliant Farmer in the Field of Rice of Nong Ya Sai District

Regarding the success in farming career of a brilliant farmer at Nong Ya Sai district of Suphanburi province, named Mr. Sukan Sangwanna, it is found that he has worked as a farmer for more than 30 years in the non-irrigated areas. He has fought against drought, the problems of soil that lacks fertility, also the original thought of people in the community. He has gone through many trials and errors until he has reached his current position where he can be a model farmer with potential in both practice, knowledge transferring and lifelong learning.

His success factors in the farming career come from the wisdom that has been passed down from the past, accumulating personal experience, learning continuously, and self-development all the time. Therefore, this makes him aware of the changes and the crystallize the conceptual basis to be a set of knowledge called “5 Knows” with details as follows:

### 1) Know the Soil (S)

Farmers must know their own soil whether the soil in their land is good or bad, and how fertile it is. In the past, farmers used the land according to its potential and did not amend the soil. They just observed that if the soil is not good, the grass will not grow. Knowing the soil consists of 3 elements that are connected. Firstly, know the structure of soil whether it is clay, loamy soil, or sandy soil. The test is simple by using the ancient wisdom which is the method of molding the soil line by mixing dry soil with water and then molding. If being able to make a very long line, it is clay. If being able to make a long piece, it is clay loam. If being able to make a middle piece, it is loamy soil. If being able to make a short piece, it is sandy loam. If being unable to make it, it is sandy soil. Knowing the structure of soil indicates that the clay is more fertile than loamy soil; loamy soil is more fertile than sandy soil; and sandy soil is the one that lacks fertility. Secondly, check the fertility of soil from its acidity - alkalinity. The plants can grow well in the weakly acidic soil. The optimal for waterlogged plants, the pH should be around 5 or 5.5 (weak acid). Lastly, the biology or life of soil is various microorganisms. If there are living creatures in the soil, such as grubs, insects, and earthworms in the soil, it means the soil is fertile. This is because the food of earthworms is organic matter. Nowadays, soil analysis tools are used; which helps the farmers a lot. Knowing the soil structure, soil chemistry, and soil biology; therefore, knowing the soil is important in order to be successful in farming.

The knowledge about soil is gained when he was a volunteer at the Land Development Department. Therefore, he learned the series name of soil in Nong Ya Sai district, which is called “Doem Bang” soil series. Regarding the analysis result of organic matter in the soil from 3,636 soil samples, conducted by Land Development Department of Thailand by using the method ‘Walkley-Black’, Group 7 of Thailand's soil series consists of Doem Bang soil series (Db), Nan soil series (Na), Nakhon Pathom soil series (Np), Pakkad soil series (Pat), Sukhothai soil series (Skt), Tha Tum soil series (Tt) and Uttaradit soil series (Utt). The average amount of organic matter of Group 7 is 1.52%. The Doem Bang soil series (Db) had the lowest amount of organic matter in the soil, which was 0.77%; while the Pakkad soil series (Pat) had the highest amount of organic matter in the soil, which was 3.69% [16], as shown in Table 1.

**Table 1.** Organic matter in the soil of Group 7 of Thailand's soil series [16]

Data	Organic matter in the soil (%)				
	Minimum value	Maximum value	Average value	S.D.	Coefficient of variation
Properties of soil series groups	0.77	3.69	1.52	-	-
Information on where soil samples were collected	0.01	6.07	1.41	0.86	60.99

The causes of low soil fertility are the land condition which has a slope of about 3-5%. Generally, various minerals are carried from high places to low places, that is from Nong Ya Sai district to the river at Sam Chuk district of Suphanburi province. The organic matter in the soil will be blown away. The solutions are (1) to dig deeper into the soil, and do the pioneering plowing and plant leguminous plants to increase organic matter. (2) To not burn straw since 2001 because the burning will cause the organic matter to decrease. Rice straw and rice stubble are organic matters with average amounts of the main plant nutrients, namely nitrogen, phosphorus, and potassium, at 0.51%, 0.14%, and 1.55% respectively. Moreover, there are average amounts of secondary plant nutrients, including calcium, magnesium, and sulfur, at 0.47%, 0.25% and 0.17% respectively [17].

In each cropping cycle, the straw will be composted along with spraying microorganisms to add organic matter into the soil, together with planting leguminous plants, planting rice mixed with green beans, or planting the sunn hemp and plowing it down. Doing this continuously can improve the soil quality. Regarding the Fabaceae, its average amounts of the main plant nutrients, namely nitrogen, phosphorus, and potassium, are at 2.44%, 0.35%, and 1.5% respectively [18]. It is important that the organic matter must be conserved as much as possible in the land because the organic matter in the soil acts like a sponge which helps retain moisture and nutrients. It will help transform the chemical fertilizers which is a fast-dissolving to becomes a slow-dissolving fertilizer and can be accumulated in the soil for a longer time. The results obtained after applying this method, the organic matter in our soil increased to 1.3%. (3) The plot layout method is to make the wide ridge, dig ponds, and dig irrigation canal to trap sediment. This helps solve the problem of the slope of the land. This results in less leaching and more fertile soil in the area.

## 2) Know the Water (W)

Water is life. It is a very important factor in farming. It serves to dissolve various nutrients, as a process of osmosis into the plant. Therefore, living things cannot lack water. Water quality must be clean; it must not contain heavy metals but can contain organic matter because it is fertilizer.

Water affects the relative humidity which will affect the opening of the plant's stomata. Water also includes moisture in the air and soil as well. Water is also a factor that determines the types of plant to be planted in the land. Therefore, knowing what plants to grow, how to manage water appropriately for plants, what technology to be used to save water and use water efficiently are very vital. Plant strategies to control water status and resist drought are numerous [19].

The area of Nong Ya Sai district is classified as a non-irrigated area and rain shadow area. There will be a problem of water shortage due to little rainfall. Therefore, the management of water is conducted by learning from the guidelines according to the Royal Projects of His Majesty King Rama IX, which is to use "New Theory Agriculture". According to this Theory, the land area should be divided for many activities, one of which is to dig a pond to collect rainwater and drill groundwater to use as a replenishment water system. As for rice farming in 1 rai (0.395 acre) land area, it uses 1,800-2,400 cubic feet of water. If there is a good water management system, it will use only 800-1,500 cubic feet of water. It uses less water but is still able to maintain production and reduce damage. In addition to having water reservoirs, the water use is the second most important issue. When there is a limited amount of water in the area, it must be used to maximum efficiency within the mixed farming plot by (1) leveling the land of the cultivation plot according to the type of crop, that is, the rice paddies are at a lower level than the field crop plot; (2) leveling the land of rice paddies allowing for good drainage, and widening the ridge to grow vegetables; (3) planting the crops that use less water along with growing rice. The way to use water economically is to use water throughout the season at an average of 1500 cubic feet per rai. It starts with bringing water into the rice paddies by carrying through water to create moisture in the soil according to the age of rice. There is no waterlogged like in the past, which would waste a lot of water. In this part, the rice paddies will absorb 30-35% of the water; the remaining 65-70% will flow into the water channel and then to the water reservoir to adjust the eco-system for the water. After that, the water will be pumped from the reservoir to be used in field crops and vegetables according to the needs of each plant, as shown in Figure 2.

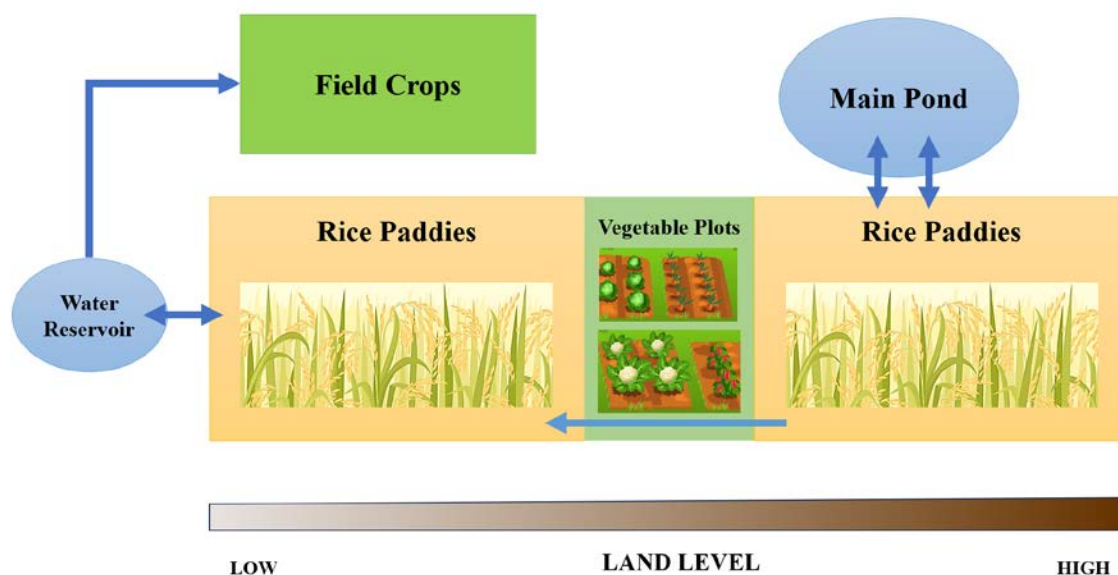


Figure 2. Water management in the rice field (created by researcher team)

### 3) Know the Plants (P)

After knowing the soil and the water, at Nong Ya Sai Model, the plants are grown to meet the needs of one's own lifestyle. In the wet season rice crop, farmers will cultivate the photosensitive rice, which is the white jasmine rice 105 or commonly called 'jasmine rice', which is the number one rice of Thailand. The general average yield is about 35-40 buckets per rai. However, when planting this variety at Nong Ya Sai district, by using his model, he can produce up to 94.6 buckets per rai. The factors are (1) selecting Jasmine 105 white rice variety that the farmer collected by themselves to prevent the adulteration; (2) selecting a method of sowing rice by using 20 kg of rice seeds per rai because it is appropriate for the area condition; (3) After that, sowing the green beans by using 7 kg of seeds per rai in the same paddies in order to use as a green manure crop. While the rice is growing, add nitrogen. When the green bean flowers and form young pods, flood water will be released for approximately 3 days. After the green bean plants die, they decompose into green manure to be the N-P-K nutrients and others; (4) select the most appropriate time for cultivating the in-season rice of the rice varieties, which is to sow seeds at the end of June, before the rains, like making a seed bank in the soil. When it rains, the seeds will germinate and grow immediately. When understanding the potential of rice, this enables farmers to achieve the maximum productivity. The understanding of that type of plant can make the productivity higher than average. Accordingly, in the off-season rice, it is appropriate to cultivate the non-photosensitive rice; therefore, choosing the Khao Hom Suphanburi varieties. In addition, the appropriate number of seed must be used according to each variety. For example, for the varieties with little tillering, farmers will use a large number of seed; but for the varieties with more tillering, less seed will be

used. 20-25 kilograms of seed per rai for the broadcasting field; 8-10 kilograms of seed per rai for the drilling field; and 12 kilograms per rai for the transplanting field.

### 4) Know the Micronutrients and Chemicals (N)

This topic is about the plant care and protection. In order for plants to grow well, they must be taken care about the nutrients and fertilizers appropriately and adequately.

Regarding Nong Ya Sai Model's guidelines, the fertilizer will be applied to plants according to soil analysis results and plant needs, or use the tailor-made fertilizer to suit the soil and the needs of the plants on that land. Due to the knowledge on natural soil structure that has low organic matter, the N-P-K nutrients are also low. When considering the growing of rice that needs 18% of nitrogen, 0.2-0.4% of phosphorus, and 3-5% of potassium, it must use the fertilizer that has 21% of nitrogen, 7% of phosphorus, and 6% of potassium, by applying 15-20 kg per rai and observing the growth of plants. It will help increase the yield by 5-10%. Using too little fertilizer will not enable the plants to reach their full growth potential; using too much fertilizer can cause plant disease. The fertilizer must be applied at the right time according to the time that plants need. For example, the rice growth is divided into 4 stages: Stage 1 – the seedlings, Stage 2 – the tillering stage, Stage 3 – the booting stage, and Stage 4 - the panicle initiation stage. The growth of rice plants takes about 1 month in each phase; therefore, a lot of fertilizer must be applied in Stage 1 and 2 for the plants to accumulate nutrient during its need. The method is to prepare water at a height of 5-10 centimeters in the fields. After the water is still, apply the fertilizer. Nutrients promote plants to grow according to their physical characteristics. It will also affect the insect resistance, meaning more immunity to disease. The plants will be safe when they are free from diseases and insect pests, for example, rice has fungal diseases and bacterial

diseases. It occurs easily in favorable environments, such as heavy rain, little sunlight, high humidity, wind blowing, and friction of the leaves can cause infection.

Regarding the disease and insect management, farmers must pay attention from the beginning of the cultivation process by using the integrated pest management or IPM [20] which is to control the pest in the appropriate amount to not cause damages to the plant. When the rice is 15-20 days old, it is time to apply fertilizer for the first time. Then, there will be borers. Chemicals and microbial must be used to spray to get rid of the mother butterflies to reduce the number of eggs. The farmers should spray the chemicals and microbial to prevent borers and fungus at the same time. During 2<sup>nd</sup> application of fertilizer in the rice fields, 1-2 days after fertilizing, the rice will be plump and give off a good smell. There will be rice leaf worms. Therefore, the farmers should spray the insecticides together with the microbial for eliminating fungus. During the panicle initiation stage and the booting stage, there will be fungal diseases, such as dry leaf edges, leaf blight, rice blast, spotted seeds, and false smut. Farmers must prevent the rice before disease occurs by spraying zinc thiazole on the leaves. This will help protect rice all the way to the panicle initiation stage. There will be no germs to infect the seeds. The rice grains will be of good quality.

Regarding the seasonal insect outbreak that occurs every 10 years in Thailand, the brown planthopper outbreak caused a severe impact in 1988-1989, during that time, the Suphan 60 rice variety was heavily affected. Therefore, farmers stopped growing this variety. In 1998-1999, an outbreak occurred to the Chainat rice variety. In 2008-2009, an outbreak occurred at Hom Pathum rice variety. In 2018-2019, there was a drought; thereby, the outbreak did not spread throughout the country. The next outbreak cycle will occur around 2028-2029, if we know that there will be seasonal outbreak cycles like this, farmers can emphasize the prevention rather than remediation. The guidelines are to keep checking the fields to reduce damage, to choose appropriate chemicals and microbial according to GAP standard, and to choose the type and amount of chemicals and microbial to match the disease and insect pests. If farmers lack this knowledge, spraying chemicals can increase the wasted cost of production.

##### **5) Know Yourself/Management (M)**

This topic is knowing yourself and management, or knowing how to manage the production factors – soil, water, nutrients – to suit their own land. In order to succeed,

these knowledges must be managed accordingly. Farmers must use observation, not just about following through others' methods. Knowing yourself takes time; farmers must consider the statistics, recording, and remembering the past about what happened in each time period, each month, and each year; what the season is like; how the sunlight is; and how to manage it appropriately. For example, for the rice cultivation, farmers must consider the marketing. The customer of rice farmers is the mill which is open all year round. The duty of the farmers is to manage to get the high yields per rai and get worthwhile results. If farmers know themselves, they can raise the level of growing rice from selling only to the mill to the cultivation of rice according to seed production standards which are the selected rice varieties, the main rice varieties, the good rice varieties, and the promoted rice varieties. The promoted rice varieties are suitable for farmers to cultivate and then sell to the mill. This point is the management, which means knowing their level of ability to produce to meet the needs of the market, either a specific market or a market with higher value.

Knowing one's own potential in farming career, farmers must be able to plan the production. For Nong Ya Sai Model, the rice cropping calendar was used as a guideline. At the beginning, on the day of the rice broadcasting, the rice harvest date can be determined. Therefore, the number of days used in farming for each cropping cycle is calculated. Farmers will perform various activities in their fields in only 18 days, as shown in Table 2. The rice cropping calendar allows farmers to manage their time the most efficiently, to reduce the disguised unemployment, and to use the free time for more advantage, to create additional job and extra income during the rice farming season.

Therefore, the Knowing number 5 is to manage one's own resources and to use all 4 Knows for the management. These covers knowing the accounting system, the record keeping of various expenses to be statistics for each year, and the production costs. Generally, the production costs are calculated in the cost per rai. But in fact, farmers should focus on producing high yields and keeping the cost per kilogram low; this is more important. In addition, farmers must be eager to learn about new technologies that can be used to increase rice productivity, to lower the cost per kilogram and to maximize the profits eventually; therefore, farmers' innovative mindset is unavoidable for successful and sustainable agriculture [6].



**Table 2.** The rice cropping calendar.

<b>RICE CROPPING CALENDAR</b>		
<b>Rice Cropping Calendar for 110-day Non-photosensitized Hybrid Rice Varieties</b>		
Time	Age of Rice Plants (days)	Work to Do in the Rice Fields
	Pre-plant	Prepare the plot by plowing the stubble and planting Fabaceae such as Sunn hemp. When it blooms, plow and cover it in order to add nutrients to the soil.
1	1	Broadcasting the rice seeds.
2	2	Removing water from the rice fields.
3	3	Spray butachlor to control weed before they grow.
4	7	Spray butachlor and propanil 50-70%.
5	9	Irrigate the rice fields, keep the water level 5-10 cm. to cover only the weed not the rice plants.
6	16	Irrigate the rice fields again for 1 <sup>st</sup> application of fertilizer.
7	18	1 <sup>st</sup> application of fertilizer in the rice fields.
8	23	Spray BT or Beauveria Bassiana to prevent insect pests.
9	28	Irrigate the rice fields and drop the Trichoderma into the water.
10	30	2 <sup>nd</sup> application of fertilizer in the rice fields.
11	35	Spray Trichoderma and egg hormones.
12	43	Irrigate the rice fields, keep the water level 5-10 cm.
13	45	3 <sup>rd</sup> application of fertilizer in the rice fields.
14	50	Spray BT or Beauveria Bassiana according to the type of insect pests.
15	70	Irrigate the rice fields, keep the water level 5-10 cm.
16	75	Spray Trichoderma, egg hormones and urea fertilizer 0.5%.
17	90	Spray Trichoderma and egg hormones to prevent the diseases that may occur with rice seeds.
18	110	It's harvest time.

## 6. Conclusions

Lessons learned from a model farmer have resulted in the concepts for rice field management, the widening of ridges. It is the development of ideas from a model farmer and passed on to fellow farmers until it became “Nong Ya Sai Model”, the farming and growing vegetable in rotation on ridges, spending free time while waiting for the rice product to create extra income daily, weekly and monthly from vegetables planted on the ridges. It also allows farmers to take care of the rice fields more closely. Even though the area for rice cultivation is reduced and the ridges are widened, it does not affect the rice productivity but helps farmers to have work to do throughout the season. They do not need to look for job outside the area during the cropping season. This helps increase additional jobs along with farming that can create food security for families and communities as well.

In addition, the knowledge of a brilliant farmer in the field of rice at Nong Ya Sai district whose success factors come from a knowledge base about ‘5 Knows’ consisting of (1) know the soil (S): meaning knowing one's own land whether the soil in their land is fertile and suitable for

growing any type of plant, and how to amend the soil to make it fertile. (2) Know the water (W): how to manage water to be sufficient for the plants in terms of both water reservoirs and methods for using water in the fields adequately and worthwhile. (3) Know the plants (P): that is to know how to choose rice varieties that are appropriate for the land, soil and the amount of water available. (4) Know the micronutrients and chemicals (N): meaning knowing and understanding how to take care of plants by using nutrients or fertilizers that are appropriate for the plants, using the fertilizer according to the soil analysis values, inspecting the fields and watching out diseases and insect pests in each age of rice. Farmers should emphasize prevention rather than remediation. And (5) Know yourself/management (M): which is how to apply the 4 Knows in one's own area appropriately according to the principles of safe agriculture or GAP standard in order to create yields that meet the efficiency of the rice varieties, along with accounting the production and marketing costs, as well as continually learning modern technology. These are guidelines for sustainable agriculture of Thai farmers, as shown in Figure 3.

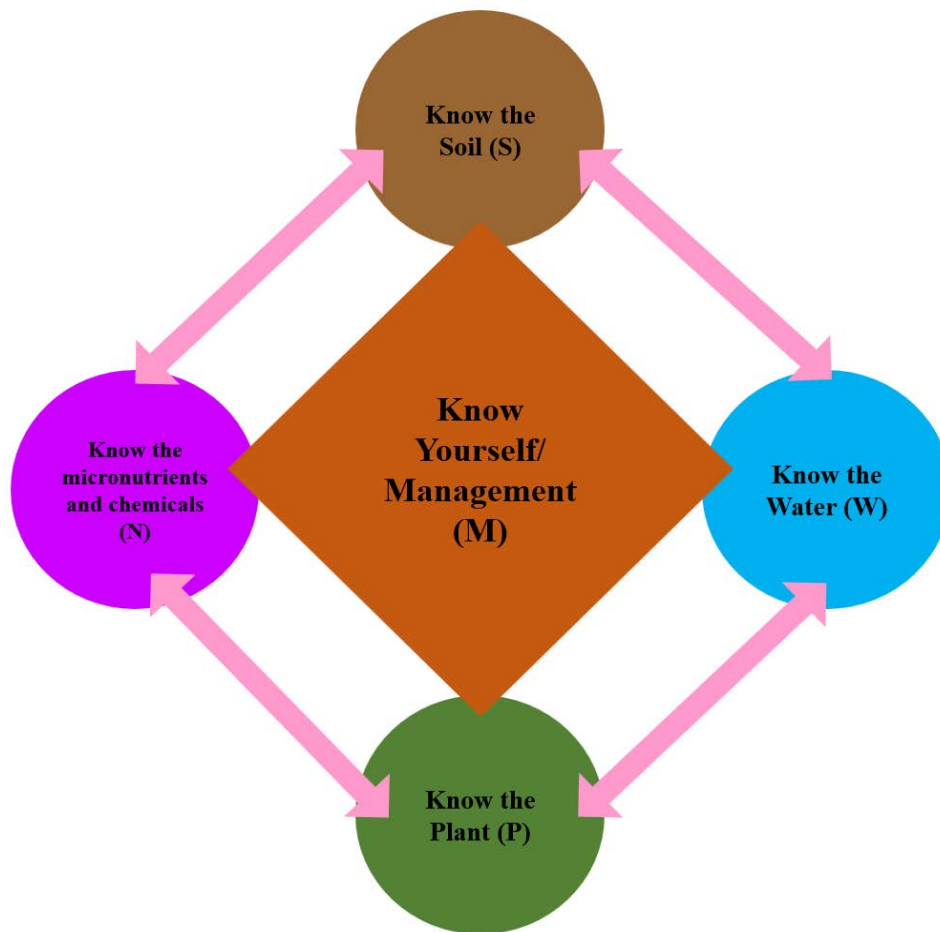


Figure 3. The model of 5 Knows (created by researcher team)

## 7. Recommendations

- 1) The field management model under the ‘Nong Ya Sai Model’ and the ‘5 Knows’ concept should be promoted to be applied and expanded with groups of rice farmers in the non-irrigated areas throughout the country for enhancing the knowledge and understanding of farmers including farmer heirs. The objectives are to build faith in a career that can create stability and a good quality of life for families, in order to preserve the culture and way of life of farmers to remain with Thai society forever.
- 2) The concept of ‘5 Knows’ should be inculcated to the general public, such as youth, working age people, and the elders who are interested in rice farming and other agricultural activities in the dimensions of learning, practicing, and exchanging experiences.
- 3) There should conduct the research and development on the application of ‘5 Knows’ concept in other areas of agriculture to create prototypes in each agricultural category according to the type of plants and animals.

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