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Quality of grain crops – an overview of rice production in Laos

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1. Introduction

Rice is essential to life, particularly in Asia where it is consumed in great quantities. It is significant for basic staple food, culture, and livelihoods, including health care. Due to these factors, as well as the expanding population and economic growth, there is a constant need for rice grains of higher quality. According to (Rubenstein 2024), the world's population is expected to enlarge beginning with 4.7 bazillion within 2023 and become 5.2 bazillion before 2050, highlighting the growing significance of rice as a staple food worldwide. Rice could be cultures, religions, helping to maintain customs while also providing food for millions of people. The harvest appears in works of art, everyday routines, and folklore that impart cultural value. Additionally, Asia's rice farming has been optimised by mild temperatures, copious amounts of rainfall, direct sunlight, fertile floodplain soils, and millennia of farmer experience. The continent's irrigated and rain-fed paddies produce an enormous amount of rice due to photosynthesis and renewable nutrient cycling, which are powered by the hot, humid tropical climate's constant supply of water, heat, and sunlight. For Asians to survive, rice has become everything. In order to sustain this population, the rice harvest's grain output needs to rise. In addition, Asia boasts the world's largest population (Larsen and Karsten Bjerring Olsen 2024). The resources available for food production are diminishing and the amount of arable land is limited. Every year the birth rate increases which means the world population will also increase. At the same time the agricultural land area is the same but the population is increasing which means the whole world and many countries should give more importance to agriculture especially rice cultivation in order to have enough rice for the world's needs. Moreover, most asian people prefer to eat rice in every meal regularly and could not stop even a single day. (Barker 2023) Advanced seed breeding, precision agriculture that uses sensors and satellites, mechanised farming equipment for cultivation and harvesting, controlled-environment farming techniques, artificial intelligence of things (IoT and AI) for better decision-making, and nanotechnology for more efficient use of inputs are just a few examples of the innovations that enable rice farms to sustainably improve productivity, conserve resources, and tailor management, with the potential for substantial high yields. To increase yields, a deeper comprehension of rice production methods is required, particularly the relationship between grain yield and yield components. Technology is commonly used as a tool to better improve yield components, even if research on it is limited to studies of rice grain yield management for rice production in Southeast Asian and Laotian contexts. (Hashim 2024)

Since 2019, which was during the beginning of the Covid outbreak, it caused great damage to the economy, especially the rice export trade to neighbouring countries, especially China and Vietnam. After the outbreak of Covid-19, government had to lock down the country from all foreigners, including the transportation of goods, due to the increasingly severe outbreak, causing deaths every day. For this reason, the economy is in decline, trading is at a loss, and the storage of goods increases every day. However, minimal government compensation did not properly cover the additional expenses of safety, which further constrained farmer profits. The industry for rice was severely shaken by the combined effects. However, movement restrictions obstructed Lao's domestic trade and logistics chains. Reduced tourism activity and softening demand in China and Thailand lowered rice prices substantially. Additional, costs for safety measures cut into declining farmer revenues. Laos' tight budgetary position meant little government relief or stimulus support for the agricultural sector's pandemic losses. Combined impact was disruption across cultivation, post-harvest systems, market accessibility and dramatic fall in farm-gate prices and incomes - challenging recovery for the country's main staple crop that ensures food independence.

Lao population enjoys eating white and glutinous rice. Following COVID-19 pandemic, Lao economy began to rebound in agriculture, particularly in rice production. To optimise grain yields in rice. Moreover, optimal plant nutrients must be obtained since rice is a delicate plant that requires deep understanding especially soil, water, and weather, as well as the use of ratios and amounts of fertilizers for each type of rice and each area of rice cultivation to suit the various ratios according to the needs of the plant. Moreover, it is a basic structure that farmers must have knowledge and understanding about this and the details, no matter how small or large, because everything is important in the growth of plants, including monitoring changes in plants and soil, nutrient levels, groundwater delivery to plants, and weather conditions that are also factors that cause changes to plants. Therefore, knowledge and understanding are very important in helping plants to be efficient and produce according to standards and also sustainable.

For rice and irrigated rice to yield more and satisfy consumer demand, management procedures must be enhanced. The appropriate technology must be used in conjunction with water-efficient management techniques to optimise grain output under certain conditions. It will be helpful for future management decisions to have a greater grasp of how irrigation and water availability affect production and yield components. This thesis's research will contribute to our

understanding of rice grain yield, its constituent parts, and the effects of crop, water regime, environment, and technological elements.

A part of my research was focusing on analysing Laos agriculture concerning the potential influences on future prospects from the fields of environment, management, economy, technology, rural policy, and ethnicity.

2. Literature Review

2.1. Components of Rice Yield Estimates

Various factors related to the agricultural practices used have an impact on rice plant yields in any given agroclimatic setting. These include a porous soil structure that facilitates nutrient access and mobility for simple root absorption, thereby preventing toxicity from excessively concentrated concentrations or deficiencies from compaction that restricts diffusion, and the density of the plant nutrients, which refers to abundant levels of vital nutrients like nitrogen and phosphorus. In addition, water and sunlight are the most crucial components. Growing seasons affect these variables, which are out of the grower's control. Though the response to management measures varies by environment, the goal of tillage, irrigation, nutrient supply, and pest control is to maximise economic production. Rice is popular and in demand all over the world, which is grown for export both domestically and internationally. There are many varieties of rice, both original and improved, especially in Asia, such as India and Thailand, which have been cross breed to create another variety to increase production and high strength. To numerous factors and environments, most rice is usually planted during floods because it helps reduce damage and costs in terms of fertilisation and reduces the amount of weeds that will occur, including pests in the early stages of planting. In each season, there are many different types of rice that are planted and depend on each area of the popularity of rice.

The rice varieties that most people like to plant are Indica and Japonica, which are mostly planted in hot and sub-tropical climates such as India. The Indian rice variety will be long and have a loose texture. But at the same time, Japonica will have shorter grains and are stickier, which are planted in cooler climates such as Japan and Korea. In addition, we also have other varieties that are very popular, such as Jasmine rice and Basmati rice. The popularity of this rice also depends on the needs of consumers and the world market. To be a factor in the production of rice in the future of farmers and try to produce with efficiency and quality standards according to the needs of the world. Asia continues to be the centre of rice production despite its spread to other regions, with several of its nations producing multiple crops in a

single growing season. Few nations divert rice resources for industrial or feed purposes; most use it as a food commodity.

Most of rice is manufactured in China and India. AMIS member countries consist of almost 80 percentage. The 50 million tonnes of rice that are traded globally around 80% for trade. However, compared to the global total, AMIS countries import a significantly smaller percentage of rice (Reshef 2021). Around the world, China population consume the most rice, following by India. (Shahbandeh 2023-2024).

2.2. History of Rice in Laos

In Laos, rice is the main staple of daily living. It is not only a mainstay of our diet, it is who we are. Rice usually makes up a large amount of a plate or bowl and is consumed with all three of the daily meals in Lao culture. In Laos, it is still the main crop farmed, and in smaller rural settlements, annual crop must provide enough to support a family.

Rice is a term used to describe distinctively local celebrations. One of the most significant celebrations of the year is Boun Kongkao, also known as the rice harvest festival. It is a show of gratitude for rice because rice is very valuable to Lao people and it is a way of thanking rice, water and land that give to farmers to produce and support themselves children and their families, as well as generate income from selling rice to farmers. In addition, it can also be a way of asking for blessings from people in the community to live and produce more every year.

The fresh rice is carried by the villagers to temple, where it is spread out on the floor. Every household chooses how much rice to serve. They will sell rice and use money raised to maintain the shrine. Elders from the village and monks perform a Baci ceremony after this. Everyone prays for more fruitful harvest in every year and gives a special blessing in appreciation for the new harvest. A massive feast with an abundance of food and wine that lasts far into the night marks the festival's conclusion. Everyone looks forward to this wonderful occasion with great anticipation. In many societies, the locals organise a unique ritual during festivals, during which they invoke the spirits of the area to guard the hamlet from evil luck.

This year, every village in Phieng district, Xayaboury Province, organised its own Boun Kong Khao Yai rice festival. Families brought milled rice and paddy to temples as a sign of respect for rice. (Sisane 2024)

Fig.2.2.1: **Boun Kong Khao Yai in Phieng district, Xayaboury Province.**

Fig.2.2.2: Families brought milled rice and paddy to monks as a sign of respect for rice.

2.3. Glutinous Rice or Sticky Rice

Glutinous rice has a unique characteristic that it contains a high amount of Amylopeptin, which is a starch that makes the texture of glutinous rice stickier when cooked. Normally, glutinous rice has a soft texture and mouthfeel when eaten. Because glutinous rice has a high amount of Amylopeptin, when cooked, it is mostly steamed or boiled, and you will see the grains stick together tightly. When eating glutinous rice, the body will feel full faster and stay full longer than other types of rice. This is another reason why most Asians prefer to consume glutinous rice because glutinous rice has a unique identity.

More than food, sticky rice is a symbolic representation of wealth and community. It is typically offered at public gatherings, religious ceremonies, and festivals. The labour-intensive process of planting, harvesting, and processing rice unites extended families and communities. This collaborative and cooperative attitude solidified sticky rice's status as an essential cultural element of Lao culture.

Preparing sticky rice for cooking is very important and necessary for those people who would like to eat sticky rice. First of all, you have to soak the sticky rice in water for several hours or one night, which requires patience in waiting then rice can absorb as much water as possible into the grains to make the grains saturated with the soaked water to create a soft, gentle, and fragrant texture while cooking the sticky rice. (Niemeijer 2022)

After sticky rice is soaked in dew for one night, next morning rice is put into a basket, which in Lao language is called “Huad” or a bamboo basket and is a handicraft of Lao people. The bamboo basket is filled with rice and set on a pot of water ready to steam sticky rice. The sticky rice will begin to cook if the cooking method uses the heat from boiling water to send the steam water up onto the basket for an extended period of time. When the rice is cooked, it will end up with soft, sticky grains that are adhering together in clumps with the aroma of cooked rice emanating from the basket.

Another reason why sticky rice is quite famous, especially in Southeast Asia, it is ability to cook sticky rice to go with all types of food, especially spicy and salty food, whether it is meat, grilled vegetables, or food with a strong smell such as papaya salad or called “ Tak Mark Houng” which is a strong-tasting food that is spicy, salty, sweet. All together, it becomes the most outstanding food in this region. Moreover, when eating with sticky rice, it makes more delicious because sticky rice can make the taste more intense than before because it has a fragrant, soft taste from the taste of sticky rice.

In addition, to being used as a seasoning for food, sticky rice also helps to promote love among family members and communities in being one in the same spirit by doing small things together during each meal, which is eating rice together. Mostly, sticky rice, they will start eating rice by making sticky rice into small balls while eating it with other food, which makes the atmosphere very friendly and comfortable. They also start sharing good stories from each person to listen while eating rice. With the value of rice and culture of Lao people make relationship of family members and communities is more being love and stronger. As evidenced from the practice of eating together according to the traditional of Lao people.

Even while Laotian culture still heavily relies on sticky rice, modern times have seen changes in nutrition and lifestyle. The advent of new cuisines and culinary skills brought about by urbanization and globalization has altered the taste buds of Laos' younger generations. Despite these changes, sticky rice remains a reliable and cherished part of many meals (Hang 2024).

2.4. White Rice (Oryza sativa)

White rice or Oryza sativa is one of famous rice in the world, It has been anticipated that 650 million tonnes of rice are produced worldwide, and 165 million hectares are thought to be planted with rice (Shahbandeh M. 2024). Asia produce rice about 90%, making it the world leader in rice production. Since individuals in Asian nations consume more than 75% of the global supply, rice is important to region's food security and expected to increase further same as population. (Khush 2021)

There are several ecotypes or cultivars of Oryza sativa that have been adapted to different environmental situations. It is grown everywhere except Antarctica (Mcdonald 1977). Other extremes in the environment include floating rice and even soils that are saline, alkaline, or acid-sulfate can also be used to cultivate rice. Obviously, it adapts well to a variety of growth environments. (Simon-Kiss 1997)

Table 2.4.1. shows rice production by province in 2020. Approximately 3.5 million tonnes of rice were produced in Laos overall, with 83.6% of that amount being grown in paddy fields during the rainy season. Upland rice output during the rainy season was just 5.5%, compared to 10.9% during dry season on paddy fields. During rainy season, Laos's paddy fields are the primary location for rice production.

Only the middle and southern plains of the mountainous nation of Laos are home to extensive rice fields. In terms of the share of Laos' total rice production, the seven provinces in the north produce 19.0%, the eight provinces in the centre produce 54.3%, and the four provinces in the

south produce 26.7%. When it comes to rice output per province, the central region's Savannakhet province produced the most, accounting for 22.8% of the total. Second place goes to the southern province of Champasak (12.2%), and third place goes to the southern province of Salavan (11.2%). Fourth place (8.5%) goes to the central region's Vientiane capital; fifth place (7.9%) goes to Khammouane province; and sixth place (7.6%) goes to Vientiane province. (Sanyu 2023).

	Total		Lowland Rainfed		Dry Season		Upland	
Province	**Production (ton)**	**Percentage (%)**	**Harvested Area (ha)**	**Production (ton)**	**Harvested Area (ha)**	**Production (ton)**	**Harvested Area (ha)**	**Production (ton)**
Phongsaly	51,670	1.5	8,211	35,822	48	211	8,719	15,637
Luangnamtha	58,123	1.7	9,610	40,364	640	2,859	8,847	14,900
Oudomxay	83,458	2.4	14,779	60,215	564	2,439	9,752	20,804
Bokeo	72,417	2.1	13,052	55,286	709	3,168	7,240	13,963
Luangprabang	103,739	3.0	13,181	54,864	1,811	7,845	26,959	41,030
Huaphanh	103,123	2.9	13,554	64,020	1,658	7,745	14,699	31,358
Xayabury	192,254	5.5	35,574	157,864	2,262	10,292	11,839	24,098
Northern Total	**664,784**	**19.0**	**107,961**	**468,435**	**7,692**	**34,559**	**88,055**	**161,790**
Vientiane. C	297,928	8.5	51,921	235,862	14,074	62,066	0	0
Xiengkhuang	82,928	2.4	16,329	70,151	161	727	7,430	12,050
Vientiane	267,168	7.6	54,547	229,145	8,030	35,623	1,600	2,400
Borikhamxay	143,595	4.1	35,438	134,749	1,699	6,625	1,189	2,221
Khammuane	278,659	7.9	70,494	234,271	12,112	44,209	112	179
Savannakhet	798,140	22.8	161,679	685,519	30,602	112,621	0	0

Xaysombuon	36,963	1.1	7,868	27,588	110	405	3,431	8,970
Central Total	**1,905,381**	**54.3**	**398,276**	**1,617,285**	**66,788**	**262,276**	**13,762**	**25,820**
Salavan	391,625	11.2	75,776	342,741	13,740	48,884	0	0
Sekong	35,886	1.0	6,800	29,240	794	3,446	1,720	3,200
Champasack	428,339	12.2	117,238	399,185	6,650	29,154	0	0
Attapeu	80,797	2.3	22,471	75,614	529	1,863	1,677	3,320
Southern Total	**936,647**	**26.7**	**222,285**	**846,780**	**21,713**	**83,347**	**3,397**	**6,520**
G.Total	**3,506,812**	**100.0**	**728,522**	**2,932,500**	**96,193**	**380,182**	**105,214**	**194,130**

Fig.2.4.1. **Shows rice production by province in Laos, 2020**

Source: Agricultural Statistics Yearbook 2020

2.5. Rice Composition

2.5.1. Morphology

The Poaceae family, the height approximately a half or two metres, while some kinds reach considerably higher of six to nine metres. Mostly, rice grows in water, especially during the initial flooding period because it allows the rice to grow faster than in areas without water. However, the main components of rice during the growing period are mainly two components, which are the root system of the rice plant and the shoot system that comes out from the rice plant. (Chang 1965)

2.5.1.1. Root System

Plant roots perform a variety of tasks such as obtaining nutrients and water and providing structural support. To produce rice with yield potential that can be sustained and to create novel rice ideotypes that are more suited to harsh environments, it is essential to analyse the genetic and molecular processes governing rice root growth. Root system is particularly important in plant growth because root system can anchor the plant and absorb groundwater and nutrients in the soil to nourish the rice plant for daily growth. A root system's internal genetic program and biotic and abiotic stresses both affect its architecture. (Dievart 2009).

The sheath, or coleorhizae, appears when a rice grain germinates in well-drained highland soil. Coleoptile arises before coleorhizae if it germinates in low-lying, flooded areas. It emerges through the coleorhiza shortly after it develops, including the major embryonic roots (radicle). Two or more secondary roots that eventually produce lateral roots grow after this. Subsequent adventitious roots originating from the culm's subterranean nodes eventually replace the dying embryonic roots. (Pucciariello 2020)

2.5.1.2. Shoot System

2.5.1.2.1. Culm

Culms are the hollow stems found in rice plants that act as the essential skeleton of structural support. Culms have longer hollow internodes and solid nodes arranged in rows. The main rice culms' nodes produce tillers that branch out. Culms are composed of an epidermis, thick layers of sclerenchyma tissue for support, parenchyma tissue for pith, and vascular bundles that span the length of the plant to carry nutrients and water. Rice culm elongation mostly takes place in the intercalary meristem, which facilitates quick internode growth that determines the overall height of the plant. After elongation, culm thickness and strength are crucial to avoid lodging or breaking, which can cause a large yield loss. The multipurpose rice culm system is taken together, offers architecture, streamlines resource flows, and directly affects grain yield. Furthermore, rigidity of basal culm is also influenced by its carbohydrate constituents, which include cellulose, starch, soluble sugar, and lignin. (Bhavan 2016)

There are numerous internodes and nodes that make up the culm, or stem.

2.5.1.2.2. Leaves

In an alternate phyllotaxy pattern, rice leaves emerge from stem nodes with a broad blade, enclosing sheath, ligule, and claw-like auricles gripping stems. Air gaps and vascular bundles comprise the interior structure, together with photosynthetic chlorenchyma. Through vegetative growth, leaves continuously arise, equipped with specialised adaptations such as buoyant air chambers that tilt blades upright. As the main photosynthetic organ, rice leaves supply the sugars required to sustain grain filling. Proper expansion and display of the leaf area maximises light interception. As leaf stages advance from lower to upper canopy layers, photosynthetic activity and yield outputs are maximised. Leaves will sprout in each note of the rice stalk until reaching the last leaf surrounded by an inflorescence that we call the inflorescence leaf. However, leaves are another very important part of the plant because leaves are responsible for absorbing sunlight energy and producing carbohydrates so that the plant receives sufficient nutrients to help the plant grow to its fullest potential. Using its leaves, the plant emits oxygen

and sweat. Leaf architecture varies from variety to variety and plays a major role in solar radiation absorption, it might be upright, oblique, or drooping. (Benin 2009) (Nonthaxay. 2004)

2.5.1.2.3. Panicle

Rice inflorescences are composed of panicles. This is the uppermost portion of the rice plant, located at the final internode. The main ramifications (small branches) of panicles are responsible for carrying the secondary branches that in turn carry the pedicels that contain the spikelets. Species and variation influence the quantity of primary and secondary ramifications. Between 50 and 500 spikelets can grow on a single panicle; however, in most cultivated cultivars, only 150 to 350 spikelets are produced. There are numerous variations in the panicles' length, form, and angle.

2.5.1.2.4. Spikelet

When a panicle reaches maturity, it is basic flowering unit is called a spikelet. Through a stalk (pedicel), it is fastened to the branch node. After two pairs of sterile glumes that is basic glumes and empty glumes form, it is composed of a single floret (Itoh 2005). Positioned slightly above each other, the two primitive glumes at the base of the spikelet protrude from the tip of the stalk. Basic glumes do not have axillary buds. Among the grass family, rachilla, a short stem axis, produces florets that are encased in one or more flowering glumes that follow the basic glumes.

A spikelet is the basic reproductive unit of the rice inflorescence or flowering head called the panicle. It consists of two sterile bracts called glumes enclosing one or more florets. Each floret contains reproductive organs - the stamens (male) and pistil (female). After pollination the ovary develops into rice grain or what we call caryopsis which is surrounded by lemma and parea bracts until it reaches maturity. However, the number of spike per inflorescence and the number of seeds per spike determines the overall production of the rice plant. Understanding the structure for rice breeding for higher yield is very essential for farmers who would like to increase the yield of their rice plants.

2.5.1.2.5. Grain (caryopsis)

Knowing by its formal name, a caryopsis, the rice grain is rice plant's edible fruit and the end product of its reproductive cycle. Once the ovary has been successfully pollinated and fertilised, this complex structure forms inside the protective shell of the spikelet's fertile floret.

At the core of the caryopsis is the embryo and the endosperm, and this embryo sometimes called the germ, which is a small, undeveloped plant inside the grain. It has genetic blueprint and ability to germinate into a new rice plant under the right conditions, and it is surrounded by the

embryo, the endosperm, which is a tissue that stores starch and can form the mass of the rice grain inside it. (Liu 2016)

The outer layer of the caryopsis, which comes from the rice grain, is very important to protect the relatively delicate inner part of the rice grain, which consists of two parts: the lemma and the palea bracts, to defend grain through external stresses from environment such as pests, moisture and various physical damages. When the rice husk is removed, what is inside is the rice grain, starting with the rice bran, which consists of several layers such as pericarp, which is a wall that acts as a shield to protect the inner seed. The second is seed coat, which has the function of surrounding and protecting the embryo from external elements, and third is Aleurone layer, is the outermost ridge of the endosperm, which is full of nutrients such as vitamins, proteins, minerals, and digestible food. At the same time, it is important for germination process. (Árpád Székely 2023)

The endosperm of the grain builds up protein and starch produced from the nutrients that are drawn from the plant's vegetative sections as it ages. Grain filling is the procedure that defines the rice grain's weight and content. The texture and stickiness of cooked rice are influenced by key quality attributes such grain shape, chalkiness (opaque patches in the endosperm), and amylose content, which are influenced by genetic and environmental variables throughout this crucial period.

The rice caryopsis is harvested when it reaches full maturity, and the edible endosperm is separated from the inedible hull and bran layers during the milling process, resulting in white rice. Some rice types, like brown rice. On the other hand, keep the nutrient-rich bran layers, which provides further health advantages.

Rice is a remarkable achievement of nature that has managed to encapsulate a huge genetic diversity for future generations to studies and development. Moreover, it has a complex structure resulting from multiple evolutions and selections that may take thousands of years. Furthermore, a deeper understanding and study of this plant species is especially important as it can contribute to global food and economic security.

2.5.2. Growth and Development

A single seed becomes a mature plant that produces many grains. Millions years of evolution have moulded this complex trip, which demonstrates the adaptability and tenacity of this important crop.

Rice seed germination begins when the caryopsis absorbs water fully which stimulates the embryo inside to germinate and when the rice seed receives full moisture the stimulated embryo gradually expands and begins to grow inwards and outwards which is a sign that we can see the emergence of the seminal root and the coleoptile, which is the protective covering that surrounds the first leaf and is the beginning of journey towards maturity of the plant in growth.

The initial phases, when the seedling starts to grow by forming a network of secondary roots and extra leaves are critical because they mark the change from depending on the finite resources in the endosperm to using the limitless potential of the environment by starting photosynthesis. The absorption of sunlight and its conversion into photosynthetic energy plays a very important role in helping plants grow more efficiently.

As the plant matures, it enters the tillering stage, where side shoots called tillers emerge from the nodes along the main stem. These tillers, each with the potential to bear a grain producing panicle are the foundation of the plant's reproductive capacity and yield potential.

Stem elongation stage, whereby rapid growth of the main stem and the budding, with internodes or spaces between notes lengthening in preparation for reproduction. However, changes will occur at the tip of each stem as it changes from vegetative growth to reproductive growth, which is another signal in the formation of paniculate, the basic incipient structures that will develop into inflorescences or flowering structures.

After the rice plant enters head stage or known as flowering stage where the inflorescence emerges from the protective sheath of the emergence of this is considered the beginning of flowering and each inflorescence opens to reveal the reproductive organs, the stamens (which produces pollen) and the pistil (which receives pollen). From this point, pollination occurs by wind dispersal or self-pollination. To understand the fertilization of the egg and grain production, this process is quite important for grain production and the continuity of the variety because it will lead to the development of future generations of rice grains are better than the previous generations.

After successful pollination, the fertilization that takes place and fertilized ovary inside the flower begins to transform into seeds or caryopses, and this is the beginning of the grain production process, where the developing grain begins to accumulate starch and other essential nutrients that are absorbed from different parts of the rice plant such as the leaves and stems. Moreover, this step is of utmost importance as it directly affects the weight and final quality of the rice grain.

The colour grains will begin shift to a dark brown or golden yellow when they reach full maturity, which may be a sign that the rice is ready to be harvested. At the same time, it can also be observed the leaves of the rice plant will turn yellow and dry. These signals indicate the completeness of the life cycle of rice plant in growing to its fullest potential until the final point is the readiness of the rice grains for harvesting for farmers.

Each stage of rice growth takes a different amount of time, depending on the type and environmental conditions including sunlight, water availability, and temperature. Germination, stem elongation, flowering, and full seed maturity are indicators of how quickly or slowly the plant can grow. (Dunand and Saichuk 2001)

The growth process of rice is a complex and delicate process that requires continuous and endless development. Moreover, the plant's remarkable flexibility and ability to adapt to a variety of environments make it one of the most important crops and attracts much attention worldwide as a cereal crop that is essential for the survival of people around the world.

2.6. Quality of Rice Grain

A number of interrelated elements, such as the rice grains' appearance, texture, aroma, and cooking qualities, all work together to determine the quality of the rice grains and demonstrate that they fulfil the necessary standards. However, genetics is another important component that determines standard of grains.

Grain should have a low percentage of broken grains because it may affect the quality, beauty grains and reduce the standard of the rice grain products due to the reduced processing ability and not meeting the desired standards. Moreover, these negative effects may result in reduced income value for farmers. (Cuevas and Valerien O Pede 2016)

The texture is also important for indicating standard of grain, especially for certain types of cooking, which depends on each area, cultural traditions and preferences of each region. For example, in Lao cuisine there is a preference for grains to stick together or form clumps like sushi rice. Therefore, variety of rice and diversity of cultures are factors in promoting the quality of the texture, which varies depending on the preferences of each area and also includes different methods of cooking rice, and must maintain the integrity of the cooking consistently without being too sticky or mushy. (Mihály Jancsó 2019)

The freshness of rice is also a factor in indicating the quality of rice grains because the longer the time passes, the rice may lose its flavour and the cooking characteristics are not as delicious

as fresh, especially if stored in a humid or unsuitable place. Rice will absorb moisture or various odours in that area, which affects the flavour and texture during cooking. However, proper storage of rice grains should be kept in a dry place and a cool environment that can help maintain the quality of the rice for a longer period of time.

2.6.1. Rice seed selection

First of all, selection of seeds meet the suitability and various conditions in the specific characteristics of seeds can be seen from the potential for high yield, the quality of rice seeds, resistance to various diseases and specified period. The selection of various varieties must be suitable for the local climate for cultivation, soil conditions and the intended purpose such as consumption, export or various processing because it is important to achieve the best results in terms of production and quality of rice seeds.

After selecting the right seed and knowing the clear production factors, it is very important to find seeds from producers certified by government agencies or reliable research institutes to ensure that the seeds are true to their variety, free from contamination and meet the specified quality standards. Because seeds have been certified and strictly inspected meet the specified standards for purity, germination rate and other quality indicators. Because this certification helps farmers to be confident that the seeds they choose through inspection will help ensure the growth of strong plants and achieve the desired yield.

When choosing a seed, its purity is crucial since good seed should be devoid of physical impurities like grass and other noxious seeds. Because it guarantees rapid development and efficiency, maintaining this purity is crucial for preserving the genetic traits of the chosen seed.

Germination rate and vigorous of rice grains are also another important factor and the germination rate is generally 80% or more to ensure good crop production. This germination test can help farmers check the efficiency of rice seeds before planting because if seeds are not good quality, they will have low germination rate and uneven plant growth, followed by reduced yield. In addition, vigorous and germination ability of rice grains can produce strong seedlings even under unsuitable environmental conditions such as low humidity or poor soil quality, and if seeds are strong, they will be able to grow under this environment. (Odisha 2020)

Seed treatment is one way to help maintain the quality of seeds from fungi, especially in areas with excessive moisture and to prevent various pests that may cause damage to seeds. This treatment will help to maintain quality of seeds so they are still strong and can still grow seedlings efficiently.

The storage condition of seeds is very important to maintain the quality of seeds until planting. Proper storage should be at a cool temperature, low humidity and must be in a tightly closed container to prevent seed deterioration and maintain germination efficiency.

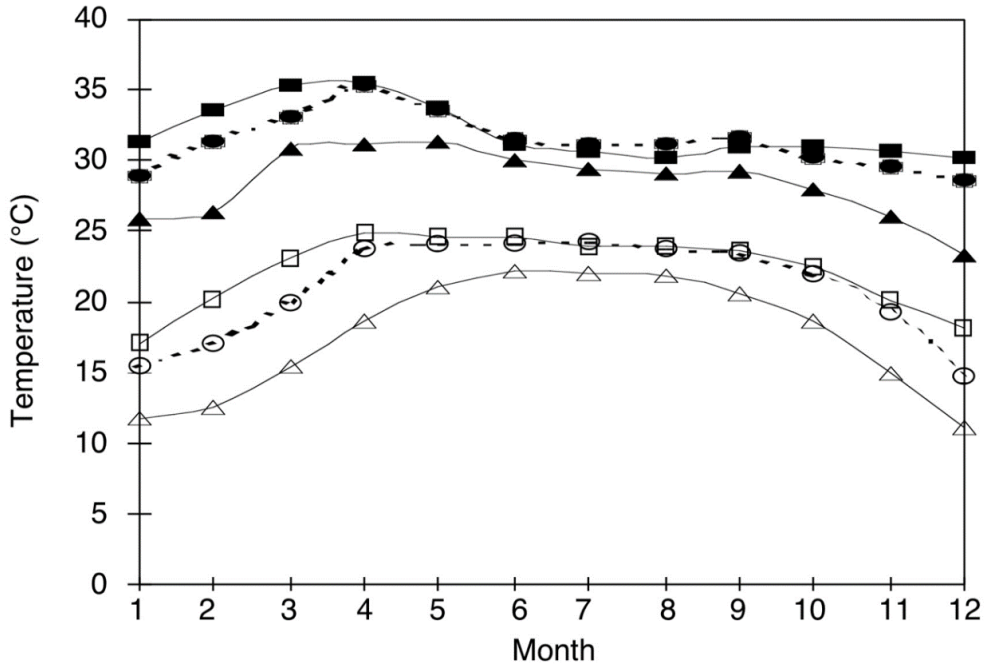
Last but not least, grain selection requires deep understanding for rice seed varieties, climate, seed purity, vigorous, treatment and proper storage. These elements are important for farmers to be aware of the basic information before starting rice cultivation in order to gain a deep understanding and be able to cope with the challenges that may arise. Moreover, understanding the correct seed selection can result in higher rice quality, higher yield, increased profits and food and economic security for the family.

2.7. Climatic risks

The rainfed rice-growing region faces many challenges, such as an unfavourable and unstable climate, severe drought and flooding, and insect pest infestations that can reduce productivity. During the beginning and middle of the rainy season, severe and flood-related problems can occur in the Central and Southern regions due to excessive rainfall and water release from dams. Furthermore, rice bug has caused severe damage to some paddy fields in the Central and Southern parts of our nation, which is a major concern for farmers. (Soukkhy 2015)

2.7.1. Temperature

Temperatures are generally consistent and between 20° to 30°C, which is said to be ideal for rice farming, throughout the wet season, which runs from May to October. Nevertheless, due to a considerable drop in both night and daytime temperatures in the late of growing season, the maturation time of types typically cultivated in the central and southern areas can be extended by 20 to 40 days in much of the northern agricultural zone (Mukamuhirwa 2019) (Figure 2.7.1.1.). It is thought that maturity time, not growth capacity, is primarily impacted by this. On the other hand, longer maturation times may make it impossible to grow a second crop in dry-season irrigation circumstances. (Schiller 2001)



Source: Department of Meteorology and Hydrology

Fig.2.7.1.1. The average monthly temperature in each of the following three regions of Laos is shown as follows: the southern region (circles) represents Attapue, Sekong, Saravane, and Champassak Provinces; the central region (squares) represents Vientiane, Savannakhet, Xiengkhuang, Vientiane Capital, Xaysomboun, Borikhamsay, and Khammuane Provinces; the northern region (triangles) represents Oudomxay, Luangnamtha, Bokeo, Phongsaly, Luangprabang, Huaphan and Xayabuly Provinces.

2.7.2. Water Loss

Preparing the land, evapotranspiration, seepage, and percolation all require water. The elements of water use are allocated as follows:

Most of the water needed for field preparation is lost through drainage through soil fissures. Additionally, evapotranspiration shows how much water the rice plant uses effectively. Farmers must try to meet the evapotranspiration needs of their crops in order to maximise rice plant development and yield potential while using less water overall.

On the other hand, seepage and percolation cause another significant amount of the water required to irrigate rice to be lost. Horizontal water flow into or out of soil is known as seepage. The process by which water seeps are called percolation. (Savva 2020)

2.8. Soil condition requirements

Numerous types of soil are suitable for the cultivation of rice. The best soils are those that can hold onto water well, these are primarily clay soils with high levels of organic matter. However, silty soils can also be useful and sand soils are not ideal for rice production.

Clay is very important for plants because it can retain water well, which can nourish plants to grow to their full potential. However, if it keeps too much water, the root will lack of oxygen and could not grow efficiently. This is a precaution that farmers should prevent and observe at all times. (Ikram Ganetri 2021)

3. Rice Agriculture in Northern region

3.1. Agriculture

In the northern part of Laos, agricultural techniques are unique in this region of the country due to the steep terrain, ethnic variety, and distant position. The agricultural sector in this area. However, confronts many obstacles, such as poor infrastructure, market accessibility, and environmental sustainability.

In northern Laos, subsistence farming is the predominant agricultural practice, with farmers primarily cultivating foods for their own consumption as opposed to exporting them. The primary crop is rice, particularly upland or dry rice. The north's rugged terrain makes it difficult to establish large-scale rice farms, in contrast to Laos' lowland regions where the crop is widely grown. On slopes or terraces, however, small-scale rice farming is typical. Other crops including maize, beans, and vegetables are frequently produced as complements to rice provide food independence. Rice is still main dietary staple.

Slash-and-burn farming, or shifting cultivation, is a traditional method that has been essential to northern Lao agriculture. This approach involves farmers clearing a portion of forest,

planting crops for a few years, and then letting the area heal naturally before moving on to a new plot. This method has been sustainable in the past when population pressure was lower, but contemporary issues including the effects of climate change and rising land demand have prompted questions about its consequences on the environment. Deforestation, degraded soil, and biodiversity loss have all been connected to shifting farming. The Lao government is pushing for more sustainable agricultural methods in the area such as agroforestry and permanent farming systems, with the help of foreign organisations as a result of these problems.

Cash crops have become more important in recent years as a way to increase revenue and diversify farming operations. In places with good market access, some farmers are switching to rubber plantations, although maize, cardamom, tea, and coffee are still significant income crops. This change is the result of increased demand for these crops, especially from nearby nations like China and Thailand. While growing cash crops opens up new avenues for economic expansion, there are concerns associated with it as well. These include unstable market pricing and a greater reliance on single-crop systems, both of which can jeopardise long-term food security.

An additional essential element of agricultural activities in northern Laos is livestock farming. Pigs, poultry, cattle, and buffalo are grown for labour and as a source of wealth in addition to being consumed. Livestock plays a vital role in cultural customs and provides a vital safety net for rural people by acting as a source of income during hard times. However, cattle farmers still face difficulties related to disease outbreaks, grazing land availability, and restricted access to veterinary care.

The lack of adequate infrastructure in northern Laos is one of the main obstacles to agriculture in the area. Because of the steep terrain, it is challenging to create transportation networks and build roads, which makes it more difficult for farmers to reach markets and sell their goods. Farmers in isolated places are frequently forced to use antiquated equipment and labour-intensive methods, which reduces output. (Gneun 1999)

3.2. Mean Temperature of air and Humidity

The temperature in the north of Laos is based on the topography of the north because the north is a high area with many forests and mountains, rich in natural resources. Hence, compared to the Central and Southern regions, the North experiences colder temperatures. This is another reason why the North is unable to produce a lot of rice because of the colder climate and region, which makes rice cultivation inefficient and unable to produce as much as it ought to. (Ba 2020)

Fig.3.2.1. Mean Temperature of air **Unit: Celsius**

Northern region	Mean Average			
Province name	**2019**	**2020**	**2021**	**2022**
Phongsaly	21,6	20,8	20,2	19,9
Luangnamtha	25,3	25,0	24,4	24,6
Oudomxay	24,9	24,6	24,2	24,4
Bokeo	27,5	27,3	26,6	26,6
Luangprabang	26,4	26,4	26,2	26,3
Huaphanh	22,4	21,9	21,6	21,2
Xayabury	25,8	25,9	25,3	25,2

Source: Department of Meteorology and Hydrology, 2022

There are two seasons in terms of Laos, these variations in humidity can directly affect daily life and agriculture. The relative humidity is 50–70% during dry season and 70–90% during wet season.

Fig.3.2.2. Mean humidity of air **Unit: Percentage**

Northern region	Mean Average			
Province name	**2019**	**2020**	**2021**	**2022**
Phongsaly	73	77	82	86
Luangnamtha	74	75	82	82
Oudomxay	69	71	73	75
Bokeo	63	64	70	71

Luangprabang	71	71	73	76
Huaphanh	75	76	77	79
Xayabury	79	80	82	81

Source: Department of Meteorology and Hydrology, 2022

3.3. The ratio of sticky rice and white rice planted area, Improved variety, and local variety in northern of Laos

3.3.1. The ratio of sticky and white rice planted area

Glutinous in northern of Laos, known as sticky rice, it is primarily food staple in Lao culture, it is important to serve with all menus in every day. Apart from being consumed directly, sticky rice is also utilised as a raw material to make snacks, sticky rice flour for the food sector, and local spirits. Because sticky rice helps you feel fuller and lasts longer than non-glutinous rice, it is evident that people in the North prefer to consume it. Glutinous cultivation is mostly concentrated in upland rain-fed areas, where following as traditional practice have been passed down through generations in northern region. Moreover, Glutinous covers about 80%, which is obviously higher than non-glutinous.

Two essential ingredients of non-glutinous rice are amylopectin and amylose, which together make it lighter and fluffier than glutinous rice. In non-glutinous rice, amylopectin accounts for 64–92% of the starch content and is the cause of the sticky texture of glutinous rice. The second ingredient, amylose, makes anywhere between 8% and 36% of the seed's total weight. Non-glutinous rice is also naturally occurring in terms of taste, colour, and scent, in contrast to other aromatic rice kinds like jasmine rice. However, non-glutinous covers only 20% in northern region of Laos.

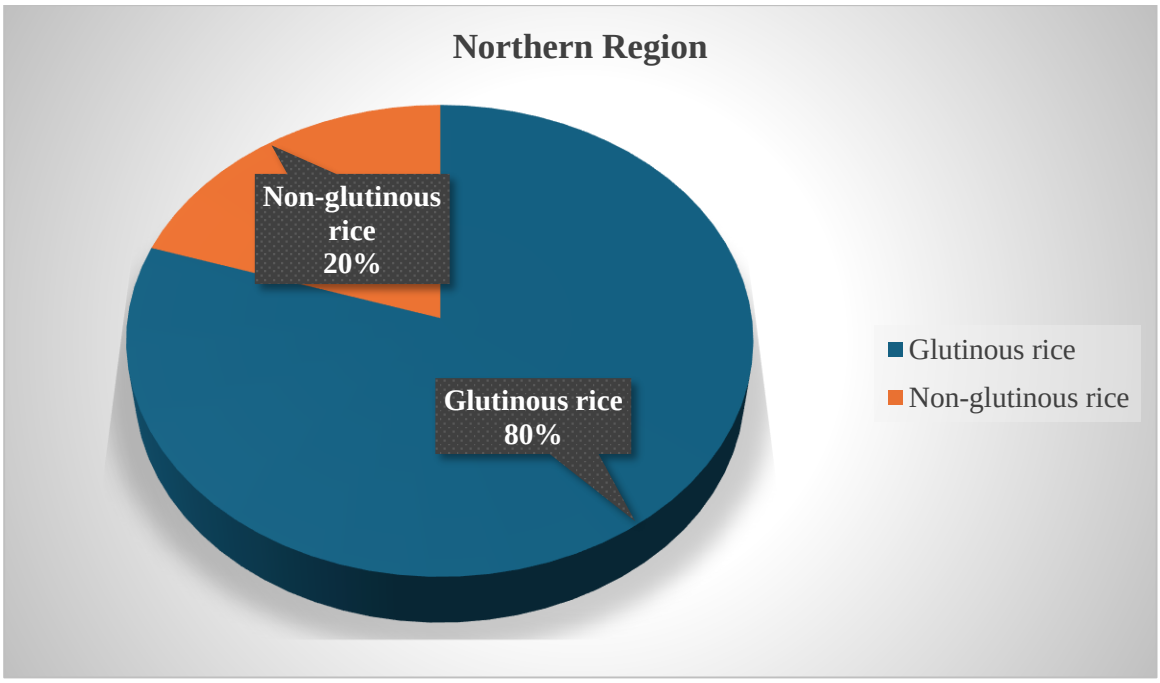


Fig.3.3.1.1. Percentage of Glutinous and Non-glutinous rice in northern region

Source: Estimated by CAS, DOPC, 2022

3.3.2. The ratio of Improved variety and local variety in northern region

To produce high-quality rice cultivars, improved variety is crucial because humans have a natural desire to acquire better and better things, rice improved variety has been practiced since ancient times. However, people now are more knowledgeable about a wider range of topics than they were in the past, improved variety practices have changed significantly. As a result, modern rice improved variety techniques are superior to those used previously.

For instance, enhanced variation Khao Niew Hom Tha Dok Kham 8 is highly well-liked in Laos. But Khao Niew Hom Tha Dok Kham 8 is a different story. It has a powerful scent, grows quickly, produces a large harvest, and matures between 130 and 135 days. The plant is medium-short with sturdy stems that resist falling. Since this type of rice is not light sensitive, it is appropriate for planting in northern of Laos such as Bokeo, Luang Namtha, Xayabury, Oudomxay, and parts of the south and central regions of Laos, as well as in Luang Prabang. (Tujinda 2020)

Local rice varieties are rice have been passed down from the original in each region and area, depending on the type of rice. Some native rice varieties are soft, fragrant and delicious, have a lower cost than improved rice varieties and do not require high fertilizers because most are

left to nature, or in some areas use dust from animal dung, for example, cows, chickens, ducks and pigs. However, it has the disadvantage of low yield and less amount of rice than improved rice varieties. (Singh, Singh and Mahama 2023)

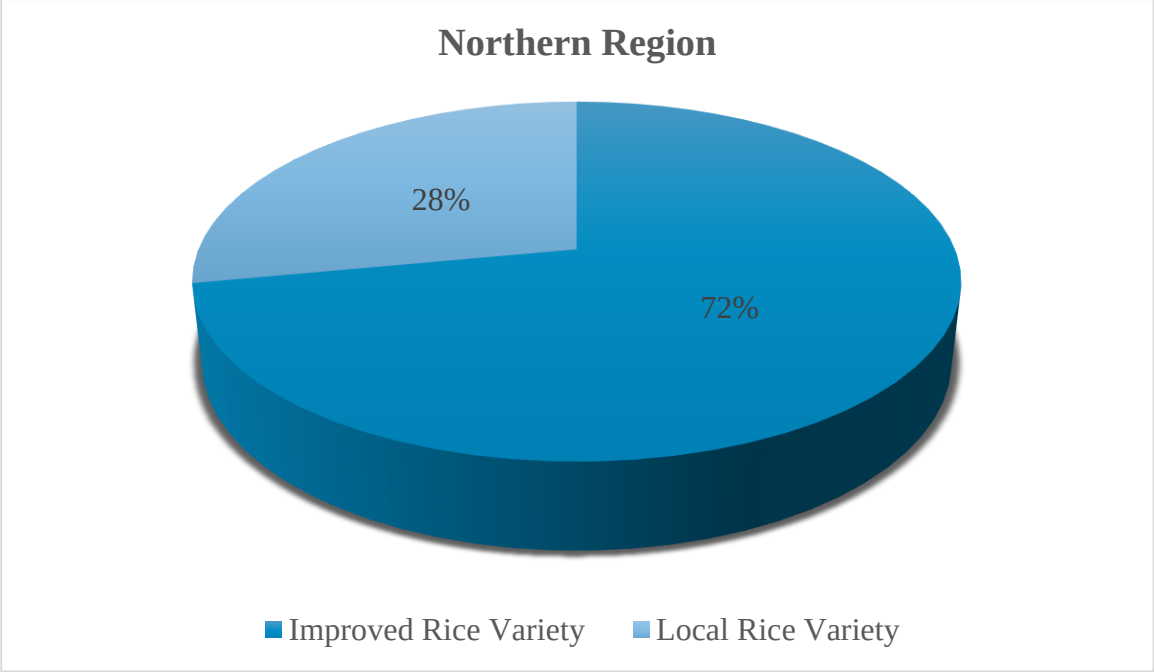


Fig.3.3.2.1. Percentage in Northern Region

Source: Estimated by CAS, DOPC, 2022

3.4 The ratio of glutinous and non-glutinous rice planted area by regions and provinces

In the northern part of Laos, there are eight provinces: Phongsaly, Luangnamtha, Oudomxay, Bokeo, Luangprabang, Huaphanh, Xayabury. These eight provinces give importance to agriculture, especially rice cultivation, whether glutinous rice or non-glutinous rice, which are essential and valuable. Farmers give importance to them more than other crops. Of these eight provinces, Luang Prabang is the province which largest area of sticky rice cultivation. The next largest is Xayaburi, which is not too much different, only 1940 hectares in the area of sticky rice cultivation. In addition, white rice is also second most popular after glutinous rice. Xayaburi has the largest province of white rice cultivation in the eight provinces of northern region, at 13411 hectares. The province with the least white rice cultivation in the eight provinces is Bokeo, which has only 1320 hectares (Sisoulit. 2021) as following in table.

Province name	Total rice paddy planted area (ha)	Glutinous rice planted area (ha)	Non-Glutinous rice planted area (ha)	Total rice (%)	Glutinous rice (%)	Non-glutinous rice (%)
Northern region	**181.071**	**143.679**	**37.391**	**18,87**	**14,98**	**3,90**
Phongsaly	15.950	9.342	6.607	1,66	0,97	0,69
Luangnamtha	19.799	12.398	7.401	2,06	1,29	0,77
Oudomxay	20.961	18.555	2.406	2,18	1,93	0,25
Bokeo	14.570	13.250	1.320	1,52	1,38	0,14
Luangprabang	43.524	38.755	4.770	4,54	4,04	0,50
Huaphanh	16.039	14.563	1.476	1,67	1,52	0,15
Xayabury	50.228	36.817	13.411	5,24	3,84	1,40

Fig.3.4.1 The ratio of glutinous and non-glutinous rice in eight provinces, 2022

Source: Estimated by CAS, DOPC

3.5. The use of agricultural machinery by region and provinces, 2022

The mechanization of agriculture in Laos has played a significant role in transforming traditional agricultural practices, with the primary objective of increasing the productivity of farmers. However, country's topography is very diverse, with a mix of fertile lowlands and rugged plateaus, and in some areas extensive plateaus, which can result in varying degrees of mechanization depending on the region and province in Laos. Nevertheless, mechanization of agriculture must take into account the differences between the lowlands and the plateaus as a special consideration in determining the variety of agricultural machinery. (Sonethavixay 2021)

Provinces in northern are characterized by high mountains, which limit the use of large agricultural machinery. In addition, most farming methods are traditional in the area. For instance, these regions still see a lot of slash and burn farming. Furthermore, compared to the lowlands, agriculture has been slower to adopt mechanisation. Large gear is not recommended in these highlands; hand tractors or power tillers are more appropriate for the rocky terrain and

smaller land parcels. Agriculture has steadily absorbed small-scale machinery, despite the fact that these fields still require a lot of hand effort. However, manual work is still frequently used, especially when gathering sticky rice and white rice. However, topography of these regions also hinders the spread of agricultural machinery, as on-site maintenance and machinery transport are still far behind the capabilities of current technology.

Province name	**Tractor (75-108 CC)**	**Tractors (57-70 CC)**	**Tractors (24-150 CC)**	**2 weel Tractors**	**Transpa -ntors**	**4 weel Transp -antors**	**Harves tors**
Northern region	1.806	525	511	67.923	-	3	51
Phongsaly	19	19	47	10.479	-	-	1
Luangnamtha	62	18	232	3.848	-	1	16
Oudomxay	176	3	1	6.613	-	-	1
Bokeo	93	22	19	11.465	-	-	29
Luangprabang	27	-	6	3.607	-	-	-
Huaphanh	21	350	186	8.233	-	-	-
Xayabury	1.408	113	20	23.678	-	2	4

Fig.3.5.1. Use of agricultural machinery in each province

Source: Department of Agriculture Extension and Cooperative, 2022

3.6. SWOT Analysis

Business organisations and people utilise SWOT analysis, a fundamental strategic planning technique, to evaluate their existing circumstances and more precisely identify the internal and external variables that could make or break their company. The four primary areas of study are Opportunities, Weaknesses, Strengths, and Threats. Nonetheless, it demonstrates the authority of every component of the company and is crucial for strategic planning and decision-making in every industry. SWOT meaning:

- Strength: Advantage.

- Weaknesses: Disadvantage.
- Opportunities: Growth or development.
- Threats: Challenges or risks.

Agriculture in Laos is quite abundant and has a variety of crops, whether rice, vegetables, fruits, or even livestock, because Laos is quite geographically located in the eastern part of Asia, with a temperature between 30 degrees Celsius and 40 degrees Celsius, which is very suitable for growing crops because it is a hot country. Since all crops including rice, vegetables, and trees need sunlight to thrive, sunlight is vital for crop growth. Additionally, agriculture is the main industry in Laos due to the large number of farmers and the fact that food, which is required for consumption and comes from agriculture as a fundamental basis for creating results, it is included in every meal. On the other hand, rice is a staple food in Lao culture and cannot be neglected, not even for a single day. For this reason, rice cultivation is highly valued by the Lao people. Rice cultivation is therefore extremely valuable to the Lao people.

Strength	**Weakness**
• Strong indigenous knowledge and practices of rice cultivation. • Wide variety of rice varieties suitable for each local ecosystem in the North. • Very low cost of production factors due to organic farming methods using animal manure. • Cultural importance of rice ensures that it remains in constant demand.	• Limited mechanisation capability due to the predominantly mountainous terrain. • Vulnerability to climate change and rainfall variability. • Poor infrastructure and access to markets. • Soil degradation due to bushfire and slash-and-burn farming, particularly in the north.
Opportunities	**Threats**
• Demand for rice in the market is increasing both domestically and internationally. • Rice varieties are being improved continuously to produce more yields every year.	• The effects of climate change, like floods and droughts. • A labour problem because the majority of today's youth dislike working in rural agriculture.

• Use of chemicals in rice cultivation is less, mostly organic rice, which is in high demand in the market. • Traditional farming in the North is considered a way to preserve traditional culture and also indirectly strengthens the ecosystem.	• Growing rivalry on a national and worldwide scale. • The restrictions on the use of technology in agriculture.

Results:

Our SWOT analysis systematically and impartially demonstrates to us what we have, what we need to work on the projects we have, and how to proceed with them. Next, we developed a strategy that would highlight our best qualities and take advantage of climate-related vulnerabilities in the agriculture sector.

Suggestion:

If we talk about problems in rice cultivation, there are probably many issues, such as climate change and soil erosion. However, there is still one thing that local people can change to have a positive effect on the climate, the environment, and the future of their children, which is the change of slash-and-burn of rice cultivation. These changes are:

- Grow other crops instead of just growing one type of rice.
- Farmers should see disadvantages more than the benefits in the long.
- It is not just rice farming that is in demand all the time, but animal farming is also in high demand same as rice farming.

4. Rice Agriculture in Central region

4.1. Agriculture

Agriculture in our central region is particularly important to livelihood of people. There are seven provinces: Vientiane Capital, Xiengkhuang, Vientiane, Borikhamxay, Khammuane, Savannakhet, Xaysombbuon. All seven provinces are in our central region. Moreover, most of central region has very fertile land because it is near the Mekong River. The weather is also very suitable for growing vegetables, fruits and raising animals because it is a tropical climate.

Most of population from many regions migrate to the central region, especially Vientiane Capital because it is the capital or central of Laos. In addition, farming and raising animals, it also has a great impact on the work of most people because most of good education, job seeking and large organisations are in Vientiane Capital. Therefore, many people from most regions in Laos would like to live in Vientiane Capital or the central region of Laos. (Lengsavad 2011)

In the central region, agriculture is also popular and most of the paddy rice is grown in the lowlands and on the plateaus. It is very widespread because the central region has the availability of irrigation, especially from rivers and streams such as the Mekong River, the Ngum River. It is an important part of the country's rice production to increase trading and export to neighbouring countries such as China, Vietnam and Thailand. However, rice cultivation in central region still faces problems and challenges of soil degradation and farming techniques are still outdated compared to neighbouring countries such as China. Outdated farming limits the amount of production for farm owners in that area.

Apart from rice cultivation, animal husbandry is another important agricultural activity in the central region, especially buffalo, cow, fish, pig and many other poultry such as chicken, duck and geese, which serve as both a source of food and income for people. However, animal husbandry while growing rice is very popular for every family in Laos. In addition, animals can provide manure for farmers to use in crops, especially rice and other crops. Importantly, animal manure is a natural fertiliser and free from chemical residues. It is good for plants and for consumers of grain crops that use animal manure to grow vegetables and rice. Domestic animals such as cows and buffaloes are quite valuable because they are in high demand in both local and regional markets. They also generate additional income for farmers. They also serve an important financial role, especially in difficult times when these animals can be sold at any time when we are struggling financially. However, there are still concerns for these animals, especially access to veterinarians and techniques for treating animals when they are sick, because the knowledge and techniques for treating animals are still very outdated compared to those in Europe.

4.2. Mean Temperature of air and humidity

In the central part of Laos, which includes seven cities in total, but the main ones are Vientiane and Thakhek or called as Khammouane. The tropical climate is warm and humid. Currently, the temperature in this region is between 29 degrees and 31 degrees Celsius, which is around 84°F to 88°F. However, the humidity in this region is between 74% and 82%.

The months of November through February are the ideal times for travelers to travel in Laos because of the colder, drier weather, which is acceptable for international visitors and not too chilly in comparison to Europe. The average temperature throughout this time will be between 10 and 29 degrees Celsius, or 50 and 85 degrees Fahrenheit. Despite being referred to the winter season, there is still plenty of sunlight and milder temperatures throughout this time, making it ideal for taking in the landscape and engaging in outdoor activities without being too hot or cold. Ideal for travelers who enjoys outdoor pursuits. (Kremer 2024)

CENTRAL REGION MEAN AVERAGE

PROVINCE NAME	**2019**	**2020**	**2021**	**2022**
VIENTIANE C.	27,9	27,6	27,3	27,0
XIENGKHUANG	22,7	22,3	21,9	21,8
VIENTIANE	28,3	27,9	27,6	27,4
BORIKHAMXAY	28,3	27,6	27,6	27,3
KHAMMUANE	28,8	28,4	27,9	27,7
SAVANNAKHET	27,6	27,1	26,6	26,3
XAYSOMBBOUN	22,6	22,7	22,0	21,9

Fig.4.2.1. Mean Temperature of air in Central Region **Unit: Celsius**

Source: Department of Meteorology and Hydrology, 2022

Throughout the year, average humidity in central Laos often ranges from 70% to 85%, particularly in the Vientiane region where the country's tropical monsoon climate, which results in distinct wet and dry seasons, has a significant impact on humidity levels. Because of the intense rains and atmospheric monsoon winds, the humidity frequently reaches 80%. However, temperature and humidity during this season can directly affect both locals and visitors, their means of subsistence, and their ability to see the center area.

Central region	Mean Average			
Province name	**2019**	**2020**	**2021**	**2022**
Vientiane C.	72	73	72	74
Xiengkhuang	72	74	76	76
Vientiane	70	73	73	75
Borikhamxay	69	71	68	70
Khammuane	71	69	69	69
Savannakhet	69	69	70	74
Xaysombboun	70	72	75	77

Fig.4.2.2. Mean humidity of air in central region **Unit: Percentage**

Source: Department of Meteorology and Hydrology, 2022

4.3. The ratio of sticky rice and white rice planted area, Improved variety, and local variety in central region of Laos

4.3.1. The ratio of sticky and white rice planted area

In central Laos, rice cultivation is also an important part of the agricultural landscape compared to other landscapes in the north or south. In percentage terms, glutinous rice accounts for 95% of the total area in the central region alone. At the same time, we also have a total area of non-sticky rice, which is only 5% of the total area. However, although non-sticky rice is less prominent than sticky rice, it still plays an important role in agriculture, especially for export purposes in areas where non-sticky rice is more popular than sticky rice.

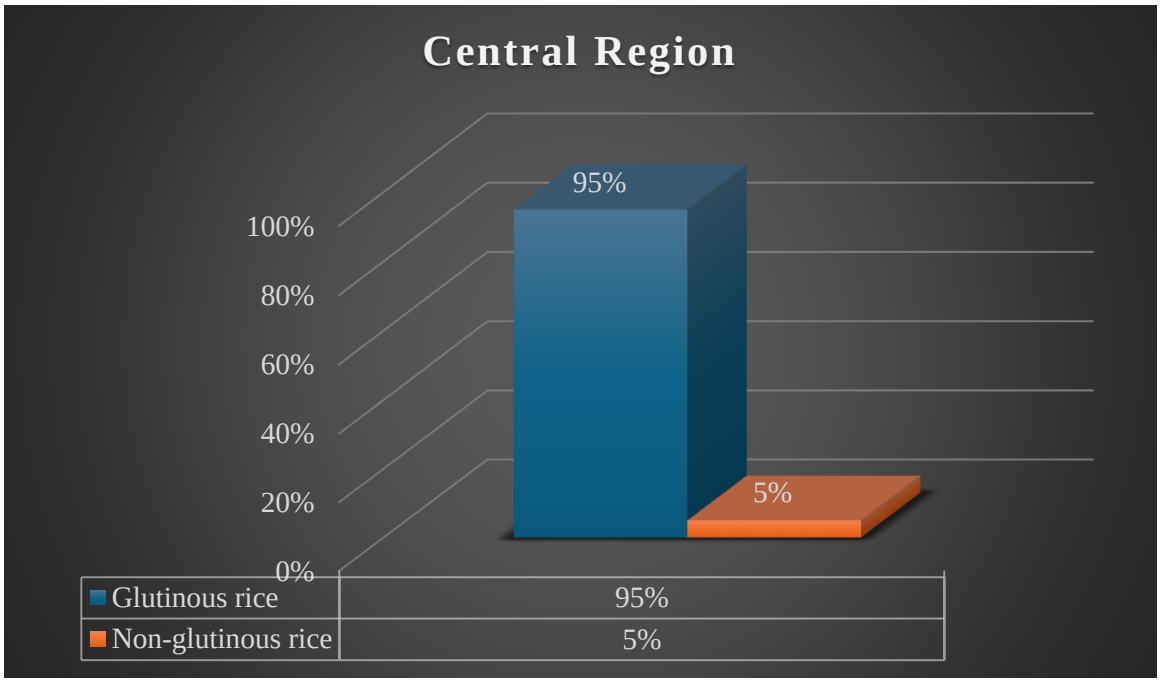


Fig.4.3.1.1. Percentage of Glutinous and Non-glutinous rice in central region

Source: Estimated by CAS, DOPC, 2022

4.3.2. The ratio of Improved variety and local variety in central region

Basically, rice cultivation consists of both improved and local varieties. Improved varieties is introduced to increase yield and be more resistant to weather conditions, whether drought or flood, and to resist various parasites occur in rice cultivation. We could see the improved varieties are 88% of the total area and only 12% for local varieties. However, Savannakhet, Khammouane are more than other areas because these areas have better access to irrigation and agricultural production factors to promote better yields than other areas.

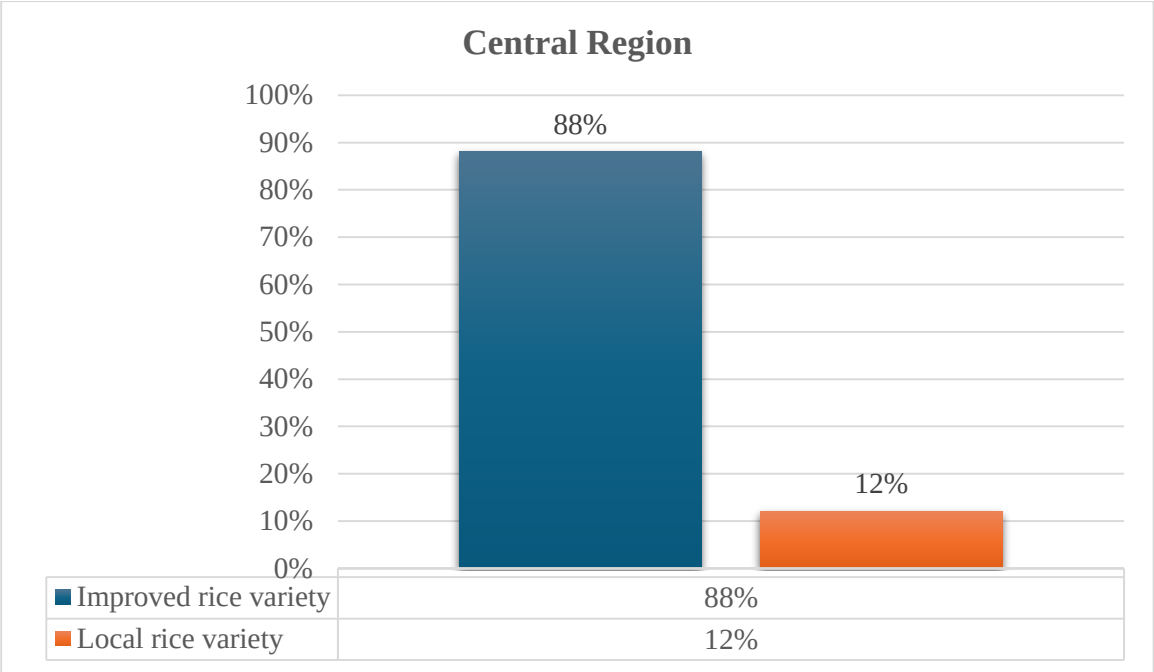


Fig.4.3.2.1. Percentage in Central Region

Source: Estimated by CAS, DOPC, 2022

4.4. The ratio of glutinous and non-glutinous rice planted area by regions and province

In the central region of Laos, there are seven provinces: Vientiane, Xieng Khouang, Vientiane, Borikhamxay, Khammouan, Savannakhet and Xaysombboun. For these seven provinces, the province with the largest area for glutinous rice cultivation is Savannakhet, followed by Khammouan and then Vientiane Capital. These three provinces are quite famous for growing glutinous rice the most in the central region. Meanwhile, for non-glutinous rice, the first place is Vientiane province, which has the largest area for non-glutinous rice cultivation, followed by Khammouan and then Savannakhet. However, when compared to the area for glutinous rice cultivation, they are still far apart in order to balance the rice demand in each province.

Province name	Total rice paddy planted area (ha)	Glutinous rice planted area (ha)	Non-Glutinous rice planted area (ha)	Total rice (%)	Glutinous rice (%)	Non-glutinous rice (%)
Central Region	**536.554**	**507.287**	**29.267**	**55,93**	**52,88**	**3,05**
Vientiane C.	65.933	61.646	4.287	6,87	6,43	0,45
Xiengkhuang	23.045	19.122	3.922	2,40	1,99	0,41
Vientiane	66.542	59.129	7.413	6,94	6,16	0,77
Borikhamxay	40.177	36.332	3.845	4,19	3,79	0,40
Khammuane	96.005	91.429	4.579	10,01	9,53	0,48
Savannakhet	236.562	232.044	4.518	24,66	24,19	0,47
Xaysombboun	8.290	7.585	703	0,86	0,79	0,07

Fig.4.4.1. The ratio of glutinous and non-glutinous rice in seven provinces, 2022

Source: Estimated by CAS, DOPC

4.5. The use of agricultural machinery by region and provinces, 2022

As a result of the region's efforts to modernise rice farming methods, the use of agricultural machinery has been steadily growing in the central region of Laos, particularly in Savannakhet Province, Vientiane Province, Vientiane Capital, and Khammouane have followed suit, introducing large tractors with a capacity of 75-108 CC. Private investment and government programs aimed at boosting productivity are important for widespread adoption of machinery, including as tractors, rice threshers, and harvesters, in every province, but particularly in Savannakhet and Vientiane Provinces. These developments enable small-scale farmers to decrease physical labour, boost production, and switch from labour-intensive to more efficient farming methods. Incorporating mechanisation into agriculture directly promotes economic stability in the region and increases efficiency, which in turn boosts production and expands income distribution in the future. (Beneo 2023)

Province name	Tracto-r (75-108 CC)	Tracto-rs (57-70 CC)	Tractors (24-150 CC)	2 weel Tracto-rs	Transpa-ntors	4 weel Transpan-tors	Harvest-ors
Central Region	**1.954**	**1.439**	**915**	**171.328**	**52**	**32**	**373**
Vientiane C.	406	206	79	17.720	33	-	74
Xiengkhuang	179	95	104	14.831	1	-	2
Vientiane	460	195	43	26.690	11	14	40
Borikhamxay	163	342	22	15.181	3	3	12
Khammuane	227	165	-	35.885	-	7	209
Savannakhet	503	434	-	57.734	4	8	36
Xaysombboun	16	2	667	3.287	-	-	-

Fig.4.5.1. Use of agricultural machinery in each province

Source: Department of Agriculture Extension and Cooperative, 2022

4.6. SWOT Analysis

Agriculture in the Central region is outstanding compared to the North, especially rice cultivation. In the Central region, there is a large area for rice cultivation, and production volume is also high. The advantage of the Central region has access to more modern machinery for agriculture than North and South. In addition, Lao government has paid great attention, especially in the Central region, to increase production every year to export to neighbouring countries such as Thailand, China, and Vietnam to increase the growth of the Lao economy. In addition, Savannakhet, Khammouane, and Borikhamxay are also more advantageous than other areas because they are adjacent to the Mekong River, which allows for greater access to irrigation and protection from floods and droughts caused by the changing weather conditions each year.

Strength	**Weakness**
• Ability to easily access machinery for farming. • Good irrigation to control water to create more benefits than disadvantages. It is a centre of the country, which has received attention from the government and foreign countries to cooperate in developing the agricultural economy, mostly starting from the central region. • Most of the area is a fertile plain and is next to the Mekong River, which is very suitable for agriculture, especially rice cultivation.	• Limited access to modern farming technology remains limited in some non-urban areas. • Vulnerability of irrigation that caused severe flooding. • Most crops are rice-only and other crops must be imported from neighbouring countries. • Mostly rely on agriculture but not prominent in industry.
Opportunities	**Threats**
• Initiatives in agriculture, especially sustainable organic farming. • Opportunities for foreign investment in energy infrastructure, especially electric power, and hydropower. • Opportunities for foreign trade, both in Asia and Europe.	• Environmental degradation from deforestation. • Climate variability may affect agriculture. • High competition with neighbouring countries for investment, such as Thailand and Vietnam. • Currency depreciation that may affect agriculture in the long run.

Results:

From our analysis, we show strengths, weaknesses, opportunities and threats. By showing these points, we can understand the central region has both advantages and disadvantages in each point and can tell the future progress for the central region, especially the points that are

opportunities for foreign trade to help increase the stability of the country's economy. However, the analysis also indicates what the government should fix, adjust, and add policies for some areas to cause the least negative effects possible.

Suggestion:

If we talk about the problem of currency depreciation that may affect agriculture and the economy in the long run, the first thing the government should pay attention is reducing the import of goods from foreign countries, especially neighbouring countries. Promoting and supporting Lao products to be used more within the country. Thirdly, increasing taxes on goods imported into the country.

5. Rice Agriculture in Southern Region

5.1. Agriculture

Agriculture in the southern part of Laos is another important foundation of the domestic economy. Basically, the region consists of only four main provinces: Saravan, Sekong, Champasak and Attapeu. The southern region has a tropical climate but also has very fertile soil and is close to the Mekong River, all of which contribute to the agricultural potential for good results. Although, southern region may have some natural advantages, it still faces challenges such as vulnerability to weather conditions, limited infrastructure and mostly traditional farming practices. These have led the government to try to develop strategies and also have international support for agriculture so our southern agriculture will have opportunity to growth.

Crops in the Southern part is rice, which is both the country's staple food and remains an important economic crop for local farmers, and also helps generate income for the Lao economy. Rice in the South can be grown in two systems: rainwater system and irrigation system because the Mekong River plays an important role in supporting rice cultivation through various irrigation projects. In addition to rice, southern region is also famous for coffee production, especially in the highlands in Champasak Province. This highland area has a cooler climate and fertile volcanic soil, making it ideal for growing high-quality Arabica and Robusta coffee beans. It has become another important product of Laos, generating income for farmers in large numbers in the countryside and has received international recognition for the quality of coffee beans from southern part of Laos.

Along with rice and coffee, the South is also home to rubber plantations, particularly in the provinces of Champasak and Attapeu, which have experienced a significant increase in rubber-

related enterprises in recent years. China and Vietnam, two nearby nations that are significant in this field, have increased their investment as a result of this. The fruit known as durian has also drawn a lot of attention and is highly costly. Its distinct flavor fragrant, mellow, and soft on the outside, crispy on the inside and its pleasant scent for those who enjoy it make this fruit extremely popular, particularly with Chinese people. Additionally, they greatly aid in the cultivation of durian in order to meet demand and export it, primarily to China. (Baird 2010)

5.2. Mean Temperature of air and humidity

The temperature in our southern region is influenced by the tropical monsoon climate which leads to warm weather throughout the year with seasonal changes in the rainy and dry seasons. However, the south is mixed with consistent heat, high humidity and rainfall that follows the seasonal pattern in each period. The usual average temperature in the South is often between 20 and 25 degrees Celsius at night and between 25 and 35 degrees Celsius during the day. This figure is maintained throughout the year. These typical temperatures, however, might vary based on the time of year and the local topography, with each province having a varied elevation.

Fig.5.2.1. Mean Temperature of air in Southern Region **Unit: Celsius**

Southern region	**Mean Average**			
Province name	**2019**	**2020**	**2021**	**2022**
Saravan	27,2	27,2	26,6	26,5
Sekong	26,9	26,9	27,2	26,2
Champasack	28,3	28,2	27,7	27,4
Attapeu	29,7	29,8	29,5	29,3

Source: Department of Meteorology and Hydrology, 2022

Essentially, high-altitude areas such as the Bolaven Plateau experience slightly lower humidity levels than those near the Mekong River. The impacts of humidity on agriculture, daily life and infrastructure are profound, shaping the way people live and work in southern Laos. While high humidity is another factor supporting the growth of key crops, it also brings its own challenges, such as fungal diseases, infrastructure degradation, health risks and balancing of benefits. These challenges of a humid environment are important for sustainable development in the southern region. (Khampheng 2023)

Fig.5.2.2. Mean humidity of air in Southern region **Unit: Percentage**

Central region	**Mean Average**			
Province name	**2019**	**2020**	**2021**	**2022**
Saravan	76	76	78	79
Sekong	73	73	72	77
Champasack	69	69	71	75
Attapeu	68	67	68	70

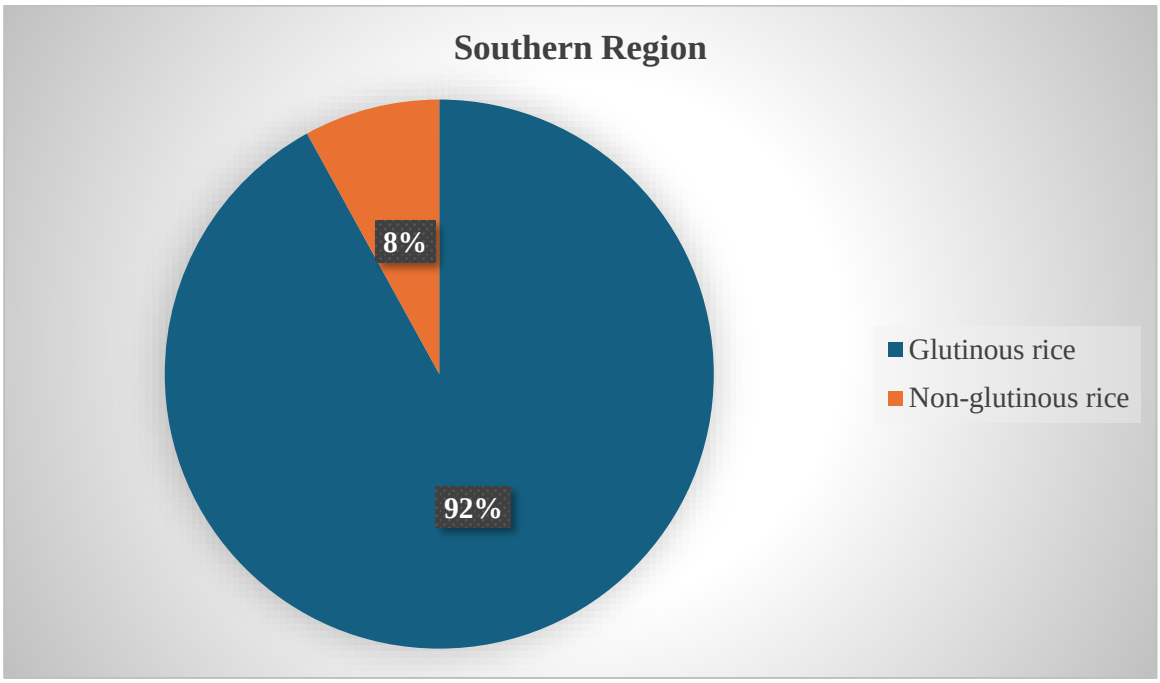
Source: Department of Meteorology and Hydrology, 2022

5.3. The ratio of sticky rice and white rice planted area, Improved variety, and local variety in southern region of Laos

5.3.1. The ratio of sticky and white rice planted area

The majority of people in the south, like those in other areas, like growing sticky rice. Sticky rice farming in the south is up to 92% on average, whereas non-sticky rice is only 8%. This indicates that north is consistently the top rice-growing region in Laos, regardless of whether it is in the north, central, or south.

Fig.5.3.1.1. Percentage of Glutinous and Non-glutinous rice in southern region

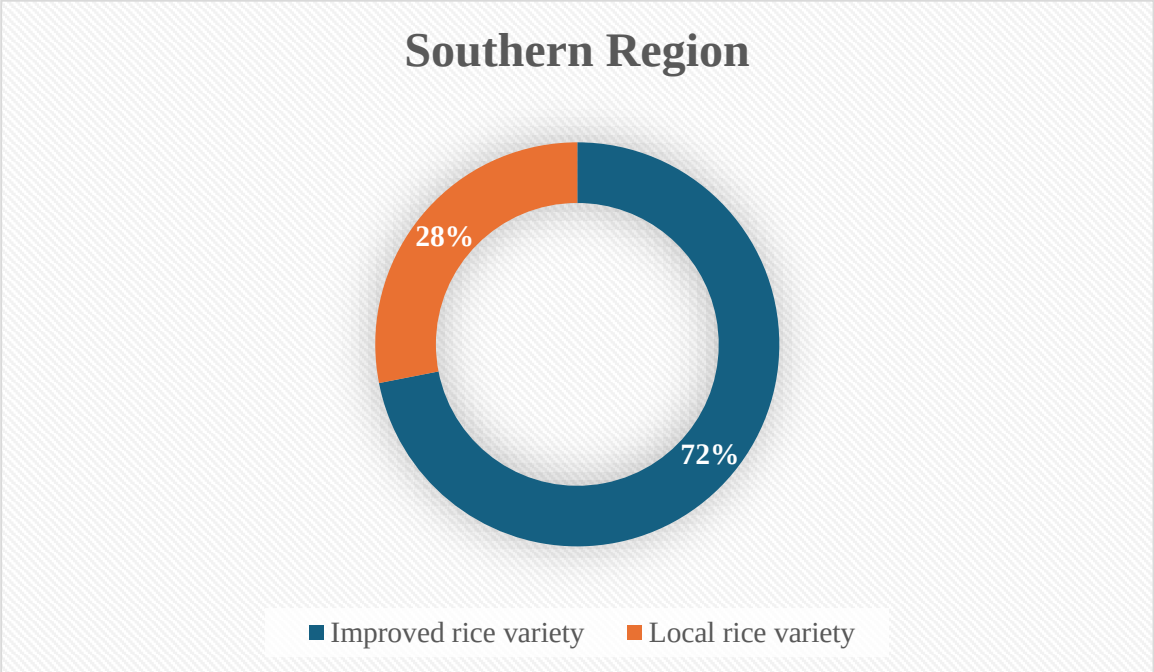


Source: Estimated by CAS, DOPC, 2022

5.3.2. The ratio of Improved variety and local variety in southern region

On average, in the South, about 74% of improved varieties along with 26% is native varieties. The figures show that the South also likes to plant improved rice varieties to get the highest yield, but there are still some areas that prefer to plant native rice varieties to maintain the unique identity of the original rice.

Fig.5.3.2.1. Percentage in Southern Region



Source: Estimated by CAS, DOPC, 2022

5.4. The ratio of glutinous and non-glutinous rice planted area by regions and provinces

In the South, there are four main provinces: Salavan, Sekong, Champasak and Attapeu. Of these four provinces, Champasak is the most prominent in having a sticky rice planting area of approximately 109.422 hectares. And then, Salavan and Attapeu and finally Sekong, which has a sticky rice planting area of only 8.850 hectares. Meanwhile, for the non-sticky rice planting area, which is ranked first, followed by Salavan, Champasak and Sekong. However, we can see Sekong province has the least sticky rice and non-sticky rice planting area of the four provinces because the soil quality is mostly poor, the irrigation system is not fully developed and most of them rely on traditional farming methods more than other areas.

Fig.5.4.1. The ratio of sticky and white rice in four provinces, 2022

Province name	Total rice paddy planted area (ha)	Glutinous rice planted area (ha)	Non-Glutinous rice planted area (ha)	Total rice (%)	Glutinous rice (%)	Non-glutinous rice (%)
Southern Region	**241.779**	**224.367**	**17.412**	**25,20**	**23,39**	**1,81**
Saravan	90.928	87.673	3.256	9,48	9,14	0,34
Sekong	10.368	8.850	1.517	1,08	0,92	0,16
Champasack	112.551	109.422	3.128	11,73	11,41	0,33
Attapeu	27.932	18.421	9.511	2,91	1,92	0,99

Source: Estimated by CAS, DOPC

5.5. The use of agricultural machinery by region and provinces, 2022

Compared to the North, Central and South, the South is region uses the least amount of agricultural machinery in these three regions. There are only 280 tractors of 75 - 108 CC, which is a small number and far apart from the North and Central regions. However, on average, Salavan has more tractors than other regions such as Champasak, Attapeu and Sekong. However, the South still needs more development in using more machinery for agriculture to make it more convenient for farmers and reduce labour, as well as increase efficiency in increasing production.

Fig.5.5.1. Use of agricultural machinery in each province

Province name	Tractor (75-108 CC)	Tractors (57-70 CC)	Tractors (24-150 CC)	2 weel Tractors	Transpan-tors	4 weel Transpan-tors	Harvest-ors
Southern Region	**280**	**188**	**400**	**66.869**	**5**	**18**	**42**
Saravan	117	21	12	59.096	-	10	28
Sekong	43	30	41	394	-	-	-
Champasack	85	135	346	4.025	5	8	8

Attapeu	35	2	1	3.354	-	-	6

Source: Department of Agriculture Extension and Cooperative, 2022

5.6. SWOT Analysis

It is rich soil in southern region of Laos offers numerous prospects for development, particularly in the field of agriculture. Additionally, it has borders with Vietnam, Thailand, and Cambodia, which can help in trade with nearby nations. Nonetheless, it continues to encounter challenges that could impede progress, chief among them poverty and access to challenging regions, which is another crucial aspect that needs to be enhanced and developed to positively affect the future way of life for people residing in these regions.

Strength	**Weakness**
• Abundant natural resources. • Directly borders its neighbouring countries, Thailand, Vietnam and Cambodia. • Good traditions in agriculture, especially coffee and other crops. • Healthy and undisturbed natural ecosystems	• Poor transport, roads, and infrastructure are all present. • Irrigation system is not yet complete. • Inability of people in the South to afford sophisticated farming equipment is another barrier. • Labour system is less popular.
Opportunities	**Threats**
• Opportunities for trade with neighbouring countries. • Opportunities for foreign investment in agriculture. • More income from other agricultural crops such as durian and coffee. • Rice production may contribute to environmentally friendly land use.	• Over-reliance on agriculture. • Unstable economic conditions, particularly with regard to currency values. • Susceptibility to natural disasters such as droughts and floods. • Inadequate level of systematisation in agriculture for efficient management.

Results:

From the analysis results, we can see that even though the South has fertile areas that are very suitable for agriculture, there are still shortcomings in accessing modern agriculture. We can also encounter challenges such as natural disasters, the use of labour systems, and limited access to information, especially in rural areas.

6. Conclusion and Recommendations

Rice cultivation in Laos reflects the multi-dimensional geography that is beneficial and is an important factor in increasing efficiency and quantity to meet international standards. Each area is different, whether it is the North, Central, or South, all of which rely on the topography and fertility of the soil as the main principle for agriculture, especially rice cultivation, which requires appropriateness of the soil, minerals, and microorganisms that affect the yield of rice cultivation. However, each area must face different challenges, depending on the various environmental factors in each area.

❖ Northern Region

In the north, most of the region is mountainous and short hills, which is another major challenge for rice cultivation because most of region is rough and soil quality is not good and most of the agriculture is based on traditional farming, slash and burn for rice cultivation, which has an impact on reduced yield and soil height over a long period of time. However, government should focus on this issue by training people in that area to have more knowledge and understanding about the long-term impacts, which may be part of impact on the annual climate change and may cause global warming in the long term.

❖ Central Region

The fertile soil next to the Mekong River, as well as good irrigation system, all contribute to the more efficient rice cultivation because of the advantages in terms of resources and environment, including access to modern machinery for farming, which is more than in other areas. Therefore, in the central region, there are many conducive factors make the yield of farmers in the central region quite high every year. However, it still faces challenges such as occasional flooding, especially during the rainy season, which may have a small impact on rice

yields. However, this can be overcome by farmers building drainage channels in their fields to reduce flooding in their fields, which may affect the yields in each year.

❖ Southern Region

The production of rice and coffee in particular, as well as its rich soil have made the South famous. It can trade more readily than other regions because it shares borders with neighboring nations like Thailand, Vietnam, and Cambodia. The irrigation system which is still underdeveloped in comparison to the Central area, and infrastructure such as highways, which are crucial for the transportation of commodities, including diverse agricultural machinery, are still issues need to be addressed. However, by working together, public, government, and business sectors can tackle these issues and encourage the development of these places like other areas.

Recommendations:

- More training and education on using agricultural technologies to lower labour costs should be made available to farmers.
- Monitoring and updating fresh data regarding enhanced seed varieties in order to meet consumer demand.
- Support the use of certified seed by farmers.
- Making safe sewer and water supply systems available for irrigation in order to prepare for climate change and security threats.
- Improve transboundary co-operation in foreign commerce management.
- Pest management techniques should be disseminated within farmers.
- Promote farmers to use more organic fertilizers for sustainable agriculture.
- Improve soil health to maintain organic matter, essential nutrients.

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