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Impacts of agricultural chemical use and health effects

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Abstract

Designing mixed research methods with Documentary and Correlation Research Data Methodologies were reviewed, analyzed, and synthesized on agricultural productions for exporting agricultural productions in Thailand, which 46% of Thailand's land is used for agriculture, and employs over 30% of the workforce and contributes significantly to the country's gross domestic product, which are the key sectors of the economy with GDP, increasingly. Agricultural production commodities include rice, durian fruit, cassava, rubber, grains, sugar, seafood, and frozen shrimp with the Parties Ratifying the Paris Agreement, legally. Using chemicals and pesticides has increased in agricultural processing Thailand's major role as a leading exporter of the world. Without pesticides, fruit production could drop by 78%, vegetable production by 54%, and cereal production by 32%. The widespread and poorly regulated use of pesticides presents a potential risk to the health of farmers, farm families, and general populations, and the environmental soil and water surface risks in the food chain. Farmers who use pesticides have higher cholesterol, body fat, and waist circumference than organic farmers. Creative the 30-item *Questionnaire on the Impact of Agricultural Chemical Use on Fresh Food Consumption* (QIACFC) on five scales and the 10-item *Attitudes Towards Agricultural Products as Raw Materials for Food has an Impact on Health* (AARFIH) research instruments are valid and reliable and assessed 300 people's perceptions in five options. They thought that food is poisoned by chemicals including fresh vegetables, dried food, fresh fruits, frozen seafood, and fresh meat food contaminated with chemicals can have serious health effects, respectively. The R^2 value indicates that 64% of participants' perceptions of the food contaminated with chemicals affect the health of a food ingredient's physical health to its impact of pesticide use in agriculture, significantly.

Keywords: Agriculture in Thailand, agricultural food consumption, agricultural production to export, food contaminated with chemicals, physical health and its impact.

Introduction

After the Neolithic Revolution, the societal structure in the region transitioned from hunting and gathering to Agro cities, eventually leading to state-religious empires. Since around 1000 CE, the cultivation of Tai wet glutinous rice has been a pivotal aspect of the local administrative structures, reflecting the pragmatic nature of a society that consistently produced a surplus suitable for trade. This agricultural system, which remains significant, underscores the ongoing importance of rice agriculture for Thailand's national security and economic prosperity. The Neolithic Revolution, also known as the First Agricultural Revolution, was the wide-scale transition of many human cultures during the Neolithic period in Afro-Eurasia from a lifestyle of hunting and gathering to one of agriculture and settlement, making an increasingly large population possible (Pierre & Appel, 2011). These settled communities permitted humans to observe and experiment with plants, learning how they grew and developed (Pollard, Rosenberg, & Tigor, 2015). This new knowledge led to the domestication of plants into crops (Lewin, 2009). The first farm animals also included sheep and cattle. These originated in Mesopotamia between 10,000 and 13,000 years ago. Water buffalo and yak were domesticated shortly after in China, India, and Tibet (Smithsonian Magazine, 2024).

Agriculture in Thailand can be traced back to historical, scientific, and social aspects. The immigration of Thais led to a markedly more sustainable approach to agriculture than most other agricultural practices in the world. Since 1543, the Tai people's glutinous rice production culture has defined a social governance structure that producing a marketable surplus. To this day, this system has been integrated with national security and economic well-being. Recent developments in agriculture mean that since the 1960s unemployment has fallen from over 60% to below 10% by the early 2000s. In the same period, food prices have halved, hunger has declined (from 2.55 million households in 1988 to 418,000 in 2007), and child famine has fallen dramatically (from 17% in 1987 to 7% in 2006) (Leturque & Wiggins, 2010).

Agriculture in Thailand can be divided into several areas: *Rice farming* is practiced in every region, with the central region having the most rice farming as it has the largest rice-growing area in the country. *Rubber plantations* in the Southern and Eastern coast of the Gulf of Thailand. *Oil palm plantations* are also planted. *Fruit farming*, such as longan, durian, mangosteen, longan, orange, pineapple, watermelon, banana, jackfruit, mango, sapodilla, jujube, grape, custard apple, and langsat. *Strawberries* are popular in the north because of the cold weather. *Field crops*, such as corn, sugarcane, jute, cotton, kapok, castor, coconut, cassava, tobacco, pepper, palm, and various beans. *Animal farming:* pigs, cows, buffalo, ducks, chickens, geese, silkworms, elephants, horses, donkeys, and mules. Later, sheep and goats were introduced, most of which were meat-producing sheep. *Crocodiles* were also raised for trade (Falvey, 2022) (Figure Caption 1).

Rice farming

Rubber plantations

Fruit farming

Field crops

Animal farming

Crocodile farming

Figure Caption 1: Examples of agriculture in Thailand can be divided into several areas

Source: Ministry of Agriculture and Cooperatives of Thailand (2021).

Agriculture in Thailand has grown more than the population over the past 50 years, at rates of over 4% in a year initially, later slowing to 2% a year. This has taken place within an economy that has become more industrialized and urbanized. The Thai story is a good example of managing a transition: from a situation in which agriculture could grow by putting underused factors of production to work, with only limited improvements in productivity; to a later stage, in which land and labor had become increasingly scarce and growth could continue only through improved returns to these factors. Thai agriculture now produces highly competitive exports, based on increasingly diversified and specialized farming. Overall, agricultural growth has contributed to falling rural poverty and better food security and nutrition. Much of what has taken place has been down to private initiative, both from farmers and from agribusiness, facilitated and encouraged by strategic public investments (Wiggins, 2018). The 20-year Agricultural and Cooperatives Strategy (2017-2036) focuses on promoting farmer institutions, increasing farming efficiency, and balancing agricultural resource use with sustainability (Cramb & Thepent, 2022).

Agriculture in Thailand has been recorded in historical evidence in the stone inscriptions from the Sukhothai period (starting from 1257 AD). These stone inscriptions illustrated King Ramkhamhaeng's state policies to promote agriculture development notably people's freedom to pursue their professions according to their skills and the land used for cultivation which would eventually become the property of farmers who cultivated it. This land could then be passed down as an inheritance to their descendants. During this period, the land was fertile, clean water was available for consumption throughout the year, and there was sufficient water for agricultural use. Overall, the Ministry of Agriculture played a crucial role in advancing agricultural practices, supporting farmers, and managing natural resources to foster economic growth and development in Thailand (Ministry of Agriculture and Cooperatives, 2021) (Figure Caption 2).

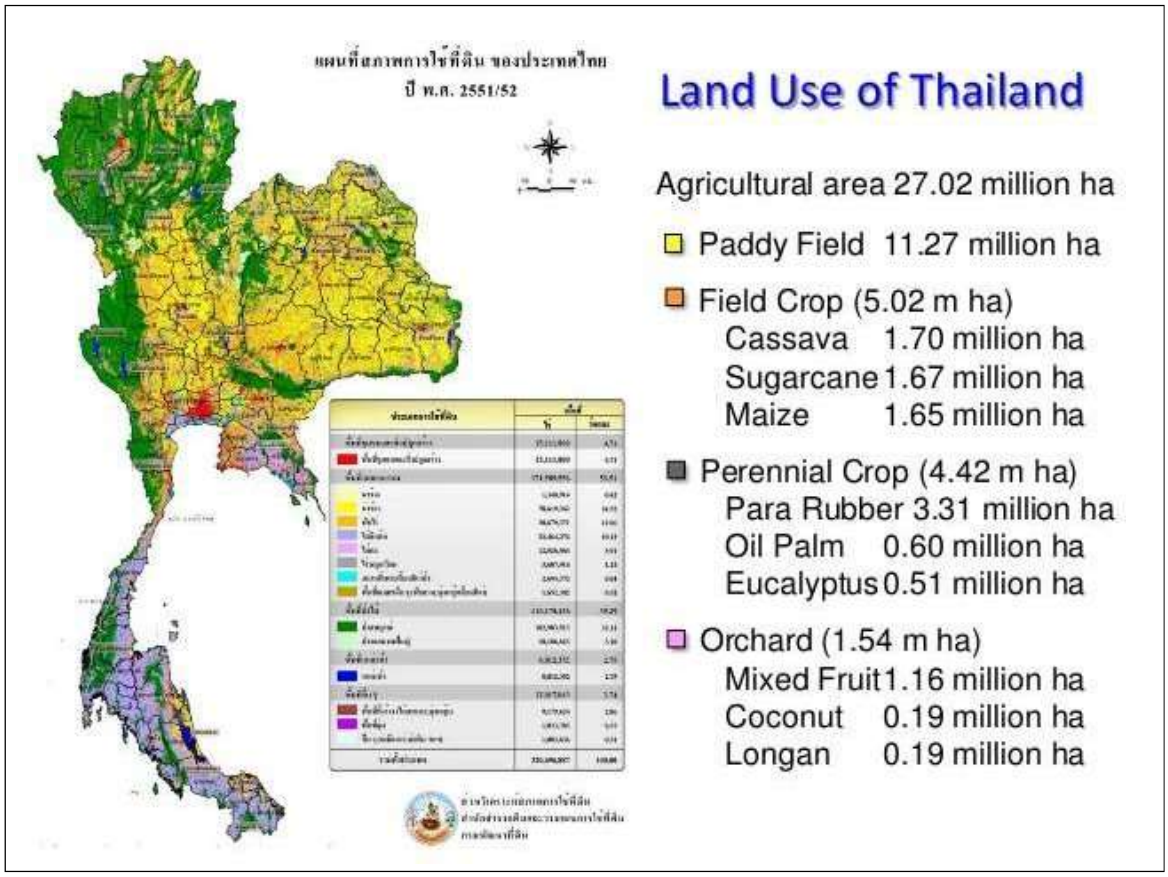

Figure Caption 2: Agricultural areas map of Thailand

Source: Department of Land Development (2022)

Figure Caption 1 shows some 20.4 million hectares (50.4 million acres) of farmland, of which about 10 million hectares (24.7 million acres) are under rice cultivation, Thailand continues to rely heavily on agriculture, although the country has suffered from declining export prices in recent years. Rice is the major crop grown; Thailand is the world's biggest rice exporter. Rubber, also a major export, is grown on the peninsula and, to a lesser extent, on the southeast coast. Total production in 1999 was 2,198,000 tons, the highest in the world and accounting for 34% of all production that year. Sugarcane production reached 52.8 million tons, while the output of cassava (tapioca), traditionally important in Thailand, totaled 16.5 million tons (Department of Land Development, 2022).

Thailand's agriculture is diverse and competitive, with various crops and exports. Rice: Thailand is a major rice producer and exporter, with about 60% of the country's farmers growing rice. Other crops: Thailand also grows rubber, sugarcane, cassava, shallots, potatoes, garlic, and onions. Exports: Thailand is the world's largest exporter of tapioca products, rubber, canned tuna, and canned pineapple. Labor force: Agriculture employs about one-third of Thailand's labor force. GDP: Agriculture accounts for about 6% of Thailand's GDP. Here are some other characteristics of Thailand's agriculture: Most farms are small and family-owned, with the average farm size being 4 hectares per household. Only 17.5% of Thailand's farmland is currently under irrigation. Farmers are increasingly using drones for seeding, spraying, and precision fertigation with agricultural technology. The 20-year Agricultural and Cooperatives Strategy (2017-2036) focuses on increasing farming efficiency and adopting product standards. Agriculture accounts for only six percent of Thailand’s GDP, but the sector employs around

one-third of the country's labor force. Thailand is the world's largest exporter of tapioca products, rubber, canned tuna, and canned pineapple (The International Trade Administration, 2024).

The main agriculture of Thailand: Rice is not only the main staple crop of the country but also the primary agricultural export. Thailand has for decades been one of the world's largest rice exporters (Britannica, 2024). The most well-known products made in Thailand are rice, coconut milk, and electronics. There is a real chance that the hard disk is made in Thailand (van Cutsem, 2024). The top five agricultural products exported by Thailand were rice (168.685 billion baht), fresh durian (130.352 billion baht), natural rubber (95.927 billion baht), processed chicken (87.009 billion baht), and dog or cat food (79.071 billion baht) (The Nation Thailand, 2024).

The rice sector plays an important role in the social, economic, and environmental development of Thailand. Half of Thailand's cultivated land is devoted to rice farming and one in five Thai households produce rice. Thailand is a major rice exporter, providing around a quarter of world exports. Domestically, rice and rice landscapes have deep cultural significance. Rice production is integrally dependent on the services and resources of nature and impacts upon them. Thai rice fields provide a complex livelihood system: trees, crops, and livestock are connected. The intensification of rice production over the last 40 years has had significant environmental impacts. Farmers and rural communities suffer health problems associated with exposure to chemicals used in agriculture and increases in fine particulate matter (PM2.5) in the air from burning rice straw in the postharvest season. Thailand's outdated and unproductive agriculture needs a shake-up. The natural abundance, farmers remain poor amid rising investment costs and low prices. Droughts and floods from climate change have also increased their production risks, making farmers' lives much more difficult (Thailand Development Research Institute, 2022).

Agriculture in Thailand is highly competitive, diversified, and specialized and its exports are very successful internationally. Rice is the country's most important crop, with 60% of Thailand's 13 million farmers growing it on almost half of Thailand's cultivated land (SCB Economic Intelligence Center, 2017). Thailand 4.0 is the Thai government's new economic model the country out of the middle-income trap. For agriculture, it means a seven-fold increase in the average annual income of farmers from 56,450 baht to 390,000 baht within the next 20 years, a difficult extremely if not impossible objective to be achieved task that would require a drastic shift in strategy to encourage adaptation ad adoption of modern technologies (Poapongsakorn & Chokesomritpol, 2017). Thailand is a major exporter in the rice market world. Rice exports in 2014 amounted to 1.3% of GDP the effect of prolonged Thailand drought threatens global rice shortage (Lee, 2015). Whole agricultural production accounts for an estimated 9%–10.5% of Thai GDP. The World Bank reported that Thailand's agriculture gross value added (GVA) growth rate in December 2016 was 2.452% (The World Bank, 2016).

In terms of the sector's impact on Thailand's economic growth, the share of GDP from the agricultural sector was the smallest compared to other sectors. There has been growth in recent years, however, it has been relatively slow. Despite some economic downturns, Thailand has been a successful agricultural society due to the country's well-endowed natural resources, from diverse crops to farming and fisheries (Walderich, 2024). Agriculture, forestry, and fishing, value added (% of GDP) in Thailand was reported at 8.5712 % in 2023, according to the World Bank collection of development indicators, compiled from officially recognized sources. Thailand - Agriculture, value added (% of GDP) - actual values, historical data, forecasts, and projections were sourced. Forty percent of the population work in agriculture-related jobs. The farmland they work for was valued at US$2,945/rai ($18,410/ha; $7,450/acre) in 2013. Most Thai farmers own fewer than eight ha (50 rai) of land (The World Bank, 2023).

Thailand's agricultural sector is vulnerable to natural disasters, including droughts, floods, and extreme weather events. Thailand's agricultural sector is sensitive to droughts, which can have severe consequences. The Thai government has introduced drought-resistant seeds to help adapt to climate change, but these seeds can be expensive and are not reusable. Thailand has experienced more frequent and severe flooding in some areas. The country has developed a model to assess flood damage using satellite radar photography. Climate change is causing more frequent and severe extreme weather events, such as heavier downpours in the rainy season. Rising sea levels are expected to increase the impact of storms and flooding, and may permanently inundate some areas. Climate change is having different effects on different crops. For example, heavy rain may damage cassava plants in the north, while a decrease in rain might damage rice and cane sugar in the central region (National Disaster Prevention and Mitigation Committee, 2024).

a) Rice Field Drought Disaster

Source: Krisanaraj, J. The Nation Thailand (2024)

b) Flooded Agricultural Area in Thailand

Source: FREEPIK Company (2024)

c) Rice Security

Source: Yokying & Promkhambut (2024)

Figure Caption 3: The Drought, Flood, and Rice Security factors would inflict damage on the economy in terms of productivity and quality, resulting in negative sentiment on people's quality of life and economic slow growth

In fact, agricultural land (% of land area) in Thailand was reported at 46 % in 2021, according to the World Bank collection of development indicators, compiled from officially recognized sources. agriculture in Thailand: Land use: About 40% of Thailand's land is used for agriculture. Labor force: Around one-third of Thailand's labor force works in agriculture. Thailand faces the grim prospects of a drought in the first half of the year and floods in the second half, inflicting losses of around 56 billion baht on the economy, according to Kasikorn Research. Major crops: Thailand is a major producer of many crops, including:

- Rice: Thailand is one of the world's top ten rice producers.
- Sugarcane: Thailand is the fourth largest producer of the world sugarcane.
- Cassava: Thailand is the second largest producer of the world's cassava.
- Natural rubber: Thailand is the world's largest producer of natural rubber.
- Mango: Thailand is the third largest producer of the world's mango.
- Pineapple: Thailand is the fourth largest producer of the world's pineapple.
- Coconut: Thailand is the ninth largest producer of the world's coconut.
- Exports: Thailand is a major exporter of tapioca products, rubber, canned tuna, and canned pineapple.

Gross production value: In 2024, Thailand's agricultural gross production value is projected to be US$28.93 billion. Import value: Thailand's agricultural import value is projected to be US$6.783 billion. Export value: Thailand's agricultural export value is projected to be US$9.6 billion (Walderich, 2024).

a) Contaminated vegetable and fruit crisis: urged to reduce and stop as targeted by 2030

b) To gather knowledge by collaborating with partner organizations and farmers.

c) Effective biocontrol product

Figure Caption 4: Using chemical substances in cultivation areas for pest control, with the majority of these chemicals being imported from foreign countries, significantly

Source: The National Science and Technology Development Agency (NSTDA) (2024).

Thailand uses chemicals in agriculture to increase crop yields and quality and protect crops from pests. The most common chemicals used are herbicides, fungicides, and insecticides (Tirado et al., 2008). *Use:* Pesticides are used to increase crop yields and quality, and to protect crops from pests. There are various types of chemicals, including Herbicides, fungicides, insecticides, plant growth regulators (PGR), and others. *Importation:* Thailand imports pesticides, with herbicides being the most significant import. *Regulation:* Thailand has a policy to promote pesticide industries, and two Acts control the production and trade of pesticides. *Health risks:* The widespread and poorly regulated use of pesticides can pose a risk to the health of farmers, farm families, the general population, and the environment. *Eco-friendly alternatives:* Thailand is using eco-friendly control agents, such as fungi, bacteria, and viruses, to control pests and plant diseases (The National Science and Technology Development Agency (NSTDA), 2024).

Research Methodology

Designing mixed research methods with Documentary and Correlation Research Data Methodologies were reviewed, analyzed, and synthesized on agricultural productions for exporting in Thailand, which employs over 30% of the workforce and contributes significantly to the country's gross domestic product, which are the key sectors of the economy. Import and use of pesticides have increased in agricultural processing products over the past decade due to Thailand's major role as a leading exporter of the world. The widespread and poorly regulated use of pesticides presents a potential risk to the health of farmers, farm families, and general populaces, the environmental risks, and the attitudes' perceptions toward the impacts on public consumption health are associated.

Research objective

1. To analyze and synthesize the impacts of agricultural chemical use and health effects using the Documentary Research Data Methodology are reviewed.
2. To associate Thai general people's perceptions of fresh food consumption with their attitudes toward the impacts of agricultural chemical use on food production

Research procedures

Documentary Research Data Methodology

Proportion of agricultural area in Thailand: According to the World Bank, 46% of Thailand's land is used for agriculture. Here are some other facts about agriculture in Thailand. Agricultural sector: The

agricultural sector is a key part of Thailand's economy, employing about a third of the country's workforce. Crops: Rice is the most important crop in Thailand, covering about half of the country's cultivated area. Other major crops include cassava, corn, sugarcane, oil crops, and rubber. Exports: Thailand is the world's largest exporter of tapioca products, rubber, canned tuna, and canned pineapple. Irrigation: Only about 17.5% of Thailand's farm land is currently under irrigation. Land ownership: According to 2017 farmer registration, 40% of farm households do not own their land. Farm size: In 2017, half of farming households owned less than 10 rai of farmland.

However, Thailand's agricultural industry relies heavily on chemicals, including pesticides and fertilizers, to increase crop yields and regulate plant growth. However, the use of these chemicals has had negative consequences: Environmental damage: Pesticides can harm ecosystems, and toxic residues can remain in crops. Human and animal health: Pesticides can harm humans and animals. Drug-resistant pests: Prolonged use of pesticides can lead to drug resistance in pests. Bio-products: Researchers are developing bio-products to control pests, weeds, and plant diseases. These products can be used in a variety of crops, including fruit trees, vegetables, and rice. Sustainable agricultural products: The WWF is promoting the establishment of a local market for sustainable agricultural products. This could help make these products more affordable for consumers. Regulations: Thailand has a Hazardous Substances Act that controls all types of pesticides. The act requires pesticides to be tested in Thailand, and it gives people who possess hazardous chemicals responsibility for any damage to people, animals, crops, or the environment (Bangkok Tribune, 2020).

The use of chemical fertilization

The use of chemical fertilizers in Thailand started to increase, exponentially in the 1970s; between 1961 and 2004 fertilizer use increased more than 100 times, a spectacular increase from 18 thousand tons in 1961 to 2 million tons in 2004. Chemical fertilizers are a key part of agriculture in Thailand, where they are used to increase crop yields in the face of declining arable land: *Fertilizer types*: The most common chemical fertilizers in Thailand are nitrogen-based and phosphate-based. Urea is the most commonly used nitrogen fertilizer. *Fertilizer use*: Around 47% of fertilizer in Thailand is used on rice. Farmers use chemical fertilizers because crops can absorb the minerals faster and at higher concentrations than with organic fertilizers. *Fertilizer imports:* Thailand imports most of its chemical fertilizers from countries such as China, Saudi Arabia, and Canada. Thailand's limited supply of raw materials for fertilizer means it can't produce enough to meet domestic demand. *Fertilizer regulation*: The Department of Agriculture (DOA) regulates the importation and use of fertilizers in Thailand. The Fertilizer Act B.E. 2518 (1975) and amended Fertilizer Act B.E. 2550 (2007) require that all fertilizers produced and distributed in the domestic market are licensed and checked for quality. *Fertilizer demand:* Demand for chemical fertilizers in Thailand is increasing due to rising cultivation levels. However, some farmers are switching to organic or biofertilizers, which could impact demand.

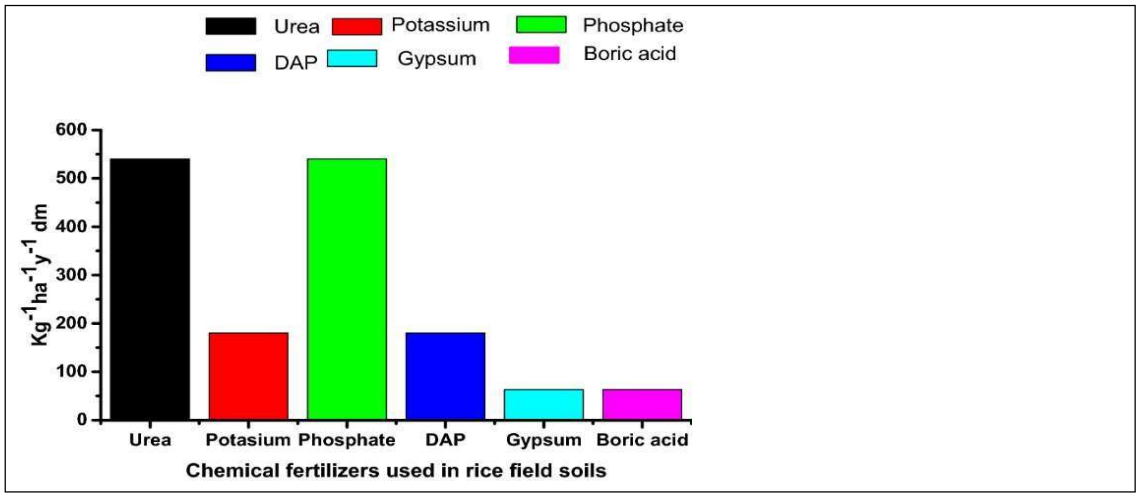

Figure Caption 5: The use of chemical fertilizers in Thailand

Source: Department of Agricultural Extension. (2024).

The impacts of agricultural chemical use

The use of agricultural chemicals in Thailand has had many impacts, including:

Health issues for farmers

Research shows that farmers who use pesticides have higher level of cholesterol, body fat, and waist circumference than organic farmers. They also have higher thyroid hormone levels, and the number of days they spray pesticides is linked to depression of the cortisol rhythm and disruption of the hypothalamic-pituitary-adrenal (HPA) axis. Laboratory studies have shown that common pesticides like chlorpyrifos and glyphosate may increase the risk of cancer and act as endocrine disrupters.

Water pollution

The agricultural sector uses about 95% of Thailand's surface water, and paddy rice farming is a major contributor to water pollution. Excess nitrogen fertilizer from crops runs off into rivers, groundwater, and coastal areas, contaminating drinking water and posing health risks, especially for children.

Reduced biodiversity

Large-scale pesticide use can reduce biodiversity and cause bioaccumulation in the food chain.

Regulation

Thailand has a Hazardous Substance Act (HSA) to regulate the use of hazardous chemicals, including pesticides. However, the country has dropped plans to ban glyphosate, citing concerns over the chemical's impact on human health.

Research data collections

Documentary research is a research method that involves analyzing existing documents to gain insight into a research question or problem. It's used by researchers to assess documents for their historical or social value. Documentary research data collections can include a wide variety of documents, both written and non-written, such as:

Written documents: Newspapers, diaries, letters, articles, books, official reports, government publications, research entitled, and archival materials.

Non-written documents: Photographs, audio recordings, videos, digital documents, maps, stamps, handbills, directories, paintings, gramophone records, tapes, computer files.

Research Instruments

The Questionnaire on the Impact of Agricultural Chemical Use on Fresh Food Consumption (QIACFC)

Consumers worldwide are increasingly aware of the products they consume daily – their nutrition and origin. People often hear that it's best to rinse their veggies and fruits before eating because of the chemicals in fresh food. Fresh food consumed in the markets has still been largely contaminated with chemicals. Creative the 30-item *Questionnaire on the Impact of Agricultural Chemical Use on Fresh Food Consumption* (QIACFC) on five scales, namely: Fresh Vegetables, Fresh Fruits, Fresh Meat, Frozen Seafood, and Dried Food for consumption in five options: Always, Often, Sometimes, Seldom, and Never levels. The QIACFC assessed general people who are consumers, and still buy raw materials such as fresh vegetables, fresh fruits, fresh meat, frozen seafood, and dried food for cooking for consumption.

The Attitudes towards Agricultural Products as Raw Materials for Food have an Impact on Health (AARFIH)

Designing the 10-item *Attitudes Towards Agricultural Products as Raw Materials for Food Has an Impact on Health* (AARFIH) assessed the general people's perception of their attitudes towards agricultural products as raw materials for having food an impact on health in their daily life by Thai agricultural products.

Participants

A sample size consists of 300 Thai general people aged 18 and over who are the participants and able to respond via information technology necessary to answer the questionnaires that were sent back to the researcher teams, perfectly.

Results

Agriculture in Thailand

Agriculture in Thailand is highly competitive, diverse, and distinctive. Thai exports are very successful internationally. Rice is the country's most important crop. Thailand is a major exporter to the world rice market. Other agricultural commodities include fish and fish products, cassava, rubber, grains, and sugar. Exports of industrially processed foods such as canned tuna, pineapple, and frozen shrimp are increasing. However, intensive integrated production systems of sustainable agriculture also offer efficiencies, not just financial, but also social benefits that are now being considered as both a social and economic sector in planning. With a growing awareness of environmental and cultural values, "career farmers" accounted for 19.5% of all farmers in 2024.

Currently, Thailand joined the Asian Forest Cooperation Organization on January 8, 2019. The European Commission has given it a "green card" or recognition as a country that cooperates in combating illegal, unreported, and unregulated fishing. As one of the Parties ratifying the Paris Agreement in September 2016, Thailand put forward its' target to achieve low carbon emissions and a climate-resilient society through Nationally Determined Contributions (NDCs). For the energy, transport, waste, and industry sectors, the target of reducing greenhouse gas (GHG) emissions is earmarked at 20-25% by 2030. The agriculture sector is defined as one of the priority areas for adaptation but its mitigation targets have not yet been defined to support the assessment of mitigation and adaptation potential of the agriculture sector, notably rice farming, and in developing its first

Measurement, Reporting and Verification (MRV) system for GHG emissions in the rice sector (Figure Caption 6).

a) Thai-German Climate Program– Agriculture

Source: German Cooperation (2020)

b) Thai agriculture needs reform from the ground up

Source: Craig Keating (2022)

c) Agricultural Machinery in Thailand

Source: Market Insight (2023)

Figure Caption 6: The Agricultural Revolution of Thailand needs reform to Agricultural Machinery

Agricultural area of Thailand

Currently, the agricultural area of Thailand is mainly used for rice farming, 65.41 million rai, accounting for 43.68% of the total agricultural area in the country, followed by orchards and trees (39.38 million rai), field crops (30.89 million rai), vegetable, flower and ornamental plant gardens (1.1 million rai), and other uses (12.96 million rai).

In the present agricultural industry, it must be admitted that “chemicals and pesticides” are widely used “to help increase the amount of production and beautiful physical appearance” to be able to compete in the market. This has resulted in the import of this group of chemicals increasing continuously every year. Agricultural area forecasts for Thailand in 2024: Sugarcane: The harvested area is expected to be around 9.57 million rai. The 2024/25 cane crush is expected to reach 110 million tons. Rice: The planted area for major rice is expected to be 62.3 million rai. Agricultural machinery: The market is expected to improve from 2024 to 2026, with an average annual growth of 3.0-4.0%. Thailand's agricultural sector is expected to face challenges and constraints, but there are also many opportunities. Some of the challenges include drought situations and disasters, but some actions can be taken to address these, such as effective water management.

Planting of the 2024 main maize crop was completed in early July, with a slight delay due to dry weather conditions in April and early May improved precipitation amounts from late May in the Northern Region, where maize cultivation is concentrated, supported planting operations, and early crop development. Overall, the area planted is estimated at an above-average level, driven by strong demand from the livestock sector. Planting of the 2024, second maize crop will take place from January to March 2024 (Food and Agriculture Organization Thailand, 2024) (Figure Caption 7).

Note: 1 rai = 400 square wa; 1 rai = 1600 square meters; 1 rai = 0.0016 square kilometers; 1 rai = 0.3333 acres

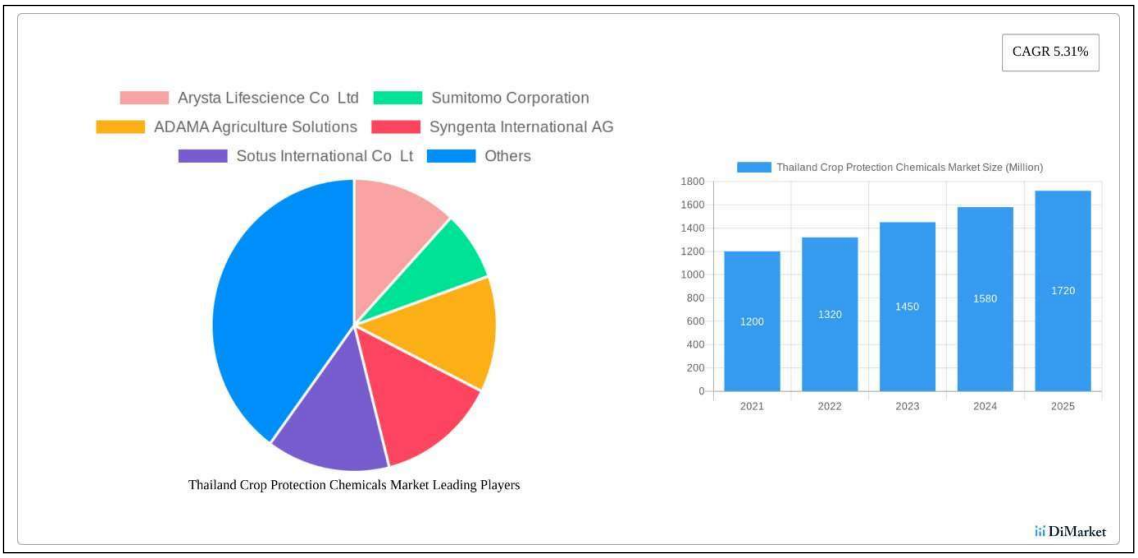

Figure Caption 7: Thailand Crop Protection Chemicals Market Analysis 2024 and Forecasts 2032: Unveiling Growth

Agricultural production in Thailand 2023-2024

Information about agricultural production in Thailand in 2023 and 2024. The results are reported in Table 1.

Table 1: Agricultural production in Thailand 2023-2024

Trial	**Agricultural production**	**Note**
GDP growth	In 2023, the agricultural sector's GDP grew by 0.3%. In 2024, it's expected to grow by at most 1.7%	Thai Economic Performance in Q3 of 2024 and the Outlook for 2024 - 2025
Crop production	The crop branch contracted in 2023 by 1.3% due to less rain than the previous year. However, the USDA Foreign Agricultural Service (FAS) forecasts that rice and corn production will increase in 2024/25 due to improved yields and more acreage.	
Food exports	In 2023, food exports grew by 3.2%. In 2024, exports are expected to increase further due to the Thai economy improving and new markets opening up.	
Livestock production	The livestock sector expanded by 4.7% in 2023 due to continued demand for livestock products.	
Agricultural price index	The Agricultural Price Index expanded in 2024 due to increased prices for major agricultural products like rubber, fruits, palm oil, white shrimp, and mixed chicken eggs. However, some major agricultural products had decreased prices, including cassava, poultry, and paddy	
Agriculture accounts	Agriculture accounts for about 9–10.5% of Thailand's GDP, and 40% of the population work in agriculture-related jobs.	

Agriculture, forestry, and fishing sectors	Declined by 0.5 percent, a continuous decrease from a 1.9-percent decrease in the previous quarter. Major agricultural products with production contraction included paddy (-4.7 percent), rubber (-0.4 percent), and maize (-0.6 percent). Conversely, major agricultural products with production expansion included palm oil (4.1 percent), cattle (7.8 percent), poultry (6.5 percent), swine (33.9 percent), and white shrimp (0.3 percent).	
Agricultural Price Index	Expanded by 7.4 percent, following increased price index of major agricultural products e.g., rubber (56.4 percent); fruits (4.0 percent); palm oil (8.7 percent); white shrimp (19.8 percent), and mixed chicken egg (4.0 percent). Nevertheless, some major agricultural products with decreased prices included cassava (-31.9 percent), poultry (-6.1 percent), and paddy (-2.1 percent).	
Increasing the agricultural price resulted	An expansion of the farm income for the third consecutive quarter, growing by 7.7 percent. In the first nine months of 2024, agriculture, forestry, and fishing sector decreased by 1.8 percent	

Source: The Office of the National Economic and Social Development Council (NESDC) (2024)

The situation of farmers in Thailand 2023-2024

The situation for farmers in Thailand in 2023–2024 is reported in Table 2.

Table 2: The situation of farmers in Thailand 2023-2024

Trial	**The situation of farmers in Thailand 2023-2024**	**Note**
Rice production	The USDA Foreign Agricultural Service (FAS) forecasts that rice production will increase in 2024/2025 due to improved yields and more acreage. However, krungsri.com expects a 5–6% decline in overall output in 2024.	The livestock sector in 2023 expanded by 4.7 percent as a result of continued demand for livestock products.
Rice exports	The FAS forecasts that Thai rice exports will decrease by 7% in 2024. However, krungsri.com expects exports to increase by 0.5–2.5% due to India's export restrictions.	
Wheat imports	The FAS forecasts that wheat imports will decrease in 2024/2025 due to high inventories and improved corn production	
Corn production	The FAS forecasts that corn production will increase in 2024/2025 due to higher off-season acreage and improved yields	Farmers have standardized farm management and have good control and
Agricultural machinery	The agricultural machinery market contracted in 2023 due to El Niño, lower farm yields, and high household debt. However, the market is expected to improve in 2024–2026 as the climate moves into La Niña conditions	

Livestock	The livestock sector expanded by 4.7% in 2023 due to continued demand for livestock products.	monitoring of epidemics.
Fisheries	The fisheries sector expanded by 2.2% in 2023, with increased production of farmed marine shrimp. Because farmers There is good farm management, which is the main production cost of marine fishing, is still high. and the weather conditions are variable For tilapia and catfish, there was a decrease in production. Due to the problem of animal feed costs and the weather conditions are not conducive to farming.	Farmers still face the problem of high production costs and in some areas there are still outbreaks of shrimp diseases.
Agricultural service sector	The agricultural service sector expanded by 0.6% in the first half of 2023. The weather conditions are generally favorable and there is sufficient water. As a result, there has been an increase in hiring services for preparing soil and harvesting such crops. In the second half of the year, some areas face the problem of lack of rain and drought. This causes the activity of hiring services for preparing the soil and harvesting important crop products to decrease. Especially, rice and cassava.	Causing farmers to expand their area for growing second-season rice and animal feed corn.
The forest sector	In 2023 expanded by 2.5 percent, with an increase in rubber trees. Eucalyptus wood has increased in line with demand for use in the pulp and paper industry both within the country and abroad. It is affected by the dry weather, don't conducive to growth.	Farmers are cutting down more old rubber plantations.

Source: Office of Agricultural Economics, Ministry of Agriculture and Cooperatives (2024)

Accelerating agricultural productivity with chemicals for farmers

Farmers use pesticides to: protect crops from insect pests, weeds and fungal diseases while they are growing. prevent rats, mice, flies and other insects from contaminating foods whilst they are being stored. safeguard human health, by stopping food crops being contaminated by fungi. Why do farmers use chemical? The questions are reported in Table 3.

Table 3: Accelerating agricultural productivity with chemicals for farmers

Trial	**Causes**	**Note**
Chemical kinds	Fertilizers and pesticides are used in agriculture to improve crop yields and protect crops and livestock	Understanding how these chemicals are used is important for sustainable farming and global food security. However, they
Fertilizers	Synthetic nitrogen fertilizers have increased rapidly, from 12 million metric tons in 1961 to 112 million metric tons in 2020. Fertilizers are used to obtain good yields from crops.	
Pesticides	Pesticides are used to control weeds and insects, and protect crops from disease. Without pesticides, fruit	

	production would be lost by 78%, vegetable production by 54%, and cereal production by 32%.	must be managed carefully to minimize environmental impact.
Insecticides	Insecticides are often the only practical way to control the insects that spread deadly diseases such as malaria.	
Improved crop	The growth of total factor productivity in agriculture has historically been driven by research, development, and the dissemination of technologies such as improved crop and animal genetics and precision farming tools and sharing the knowledge to use these tools.	
Top 10 Chemicals for Agriculture Industry	Lime, Sulfur, Calcium nitrate, Ammonium nitrate, Potassium chloride, Phosphate rock, Magnesium, Urea, Glyphosate, and Herbicides.	

Source: Keith Fuglie, Stephen Morgan, and Jeremy Jelliffe (2024)

However, the use of agrochemicals can have negative side effects and raise the costs of food production. Pests can develop resistance to chemicals, requiring higher amounts and new chemical compounds to be used each year. These chemicals can contaminate food and disperse in the environment.

Impacts agricultural productivity with chemicals for farmers

Chemical inputs, such as pesticides and fertilizers, have increased agricultural productivity, but they also have negative impacts on the environment and human health. Why farmers continue to use chemicals for their agriculture development, pesticide application, and its impact on the environment. This condition is detailed in Table 4.

Table 4: Impacts agricultural productivity with chemicals for farmers

Trial	**Impacts agricultural productivity**	**Note**
Increased crop yields	Pesticides help control pests, weeds, and diseases, which can increase crop yields. Without pesticides, fruit production could drop by 78%, vegetable production by 54%, and cereal production by 32%.	To balance the benefits of pesticides with their environmental and health risks, farmers can use responsible practices like integrated pest management.
Environmental damage	Pesticides can damage agricultural land, fisheries, and wildlife. They can also pollute groundwater, which can take years to clean up.	
Human health risks	Pesticides can increase the risk of human mortality and morbidity, especially in developing countries.	
Pests becoming resistant	Pesticides can cause pests to develop resistance, which means the pesticides are less effective at controlling them.	

Loss of beneficial predators	Pesticides can unintentionally destroy predators of pests, which can increase the virulence of the pests.	

Source: Ahmad et al., (2024)

Pesticides are chemical constituents used to prevent or control pests, including insects, rodents, fungi, weeds, and other unwanted organisms. Despite their advantages in crop production and disease management, the use of pesticides poses significant hazards to the environment and public health. Pesticide elements have now perpetually entered our atmosphere and subsequently contaminated water, food, and soil, leading to health threats ranging from acute to chronic toxicities.

Impact health effects agricultural productivity with chemicals for farmers in Thailand

Currently, Thailand's agricultural sector focuses not only on domestic consumption but also on production for export. As a result, Thai farmers increasingly use chemical pesticides and plant disease killers to increase agricultural productivity. According to the reports by the Department of Agriculture in 2022, the volume and value of agricultural hazardous substance imports were as high as 0.114 million tons, an increase of 16.32 percent from 2020, when the total imports were 0.098 million tons. Most pesticides used domestically are imported, which tends to increase in volume every year. As a result, there is a large amount of pesticide residues in agricultural products and in the environment. Especially, accumulation in soil and water, including in the food chain. This is considered an environmental problem that should be aware of. The use of chemicals in agriculture can have significant health impacts on farmers in Thailand that impact on health is affected to detail in Table 5.

Table 5: Impacts and health effects of agricultural chemical use

Trial	**Impact risks**	**Note**
Exposure	Farmers are often exposed to pesticides through the skin or by inhalation, which can lead to health issues.	The long-term use of high levels of agrochemicals can make it difficult to sustain the same rate of productivity growth.
Health effects	Exposure to pesticides can cause a range of health issues, including Poisoning, Headache, Nausea, Vomiting, Diarrhea, Pinpoint pupils, Dizziness, Fine muscle twitching, Chronic neurodevelopmental impairment, and Cancer	
Contamination	Pesticides can contaminate soil and water, which can then pollute the food chain and natural environment.	
Personal protective equipment	Some farmers in Thailand do not use personal protective equipment, such as masks, gloves, shoes, and goggles, when applying pesticides.	
Other factors	Other factors that can contribute to the health impacts of agricultural chemicals include: Improper chemical handling, Heavy reliance on pesticides, and Pesticides being applied throughout the crop calendar.	

Source: Office of Natural Resources and Environmental Policy and Planning (2024)

At present, farmers are increasingly using agricultural chemicals to increase their yields and meet market demand. Farmers' solution is to use more chemicals. However, it was found that the use of agricultural chemicals has health effects when pesticides are ingested into the body, as well as environmental effects, such as spreading into the air, accumulating in water sources and soil, and

affecting beneficial insects or natural organisms. The above information indicates that agricultural practices that use chemicals cause the accumulation of heavy metals from pesticide use, which causes plants to absorb chemicals from the accumulation of chemicals in contaminated soil (Office of Natural Resources and Environmental Policy and Planning, 2024).

Impact health effects agricultural productivity with chemicals for consumption

Impacts of agricultural chemical use and health effects: Agricultural chemicals can have several negative health effects on people and the environment. The effects are detailed in Table 6.

Table 6: Impact health effects agricultural productivity with chemicals on consumption

Trial	Impact health effects on consumption	Note
Human health impact	Exposure to agricultural chemicals can cause short-term and long-term health effects, such as: • Headaches, skin rashes, and eye irritations • Nausea, vomiting, diarrhea, dizziness, and pinpoint pupils • Chronic effects like cancer, endocrine disruption, and birth defects	Agriculture in Thailand, which employs over 30 percent of the workforce and contributes significantly to the country's gross domestic product, is a key sector of its economy. 
Environmental impact	Agricultural chemicals can contaminate soil, water, and air, and can also upset the balance of ecosystems: • Soil contamination: Long-term use of chemical fertilizers can reduce microbial activity and imbalance the pH of the soil. • Water contamination: Pesticides can mix with water sources through leaching, drift, or run off, harming aquatic wildlife. • Ecosystem imbalance: Pesticides can kill predators of pests, or make them less effective at controlling the prey population.	
Pesticides are either natural or chemically synthesized compounds that are used to control a variety of pests.		Current status of pesticide effects on environment, human health and it's eco-friendly management as bioremediation
How farmers in Thailand are adapting to climate impacts	Farmers in Thailand find themselves having to deal with unpredictable and extreme weather events that have become more frequent. Droughts, flooding, and rising temperatures are affecting their food production systems. Farmers spraying fertilizer on crop in farm.	Toto Sompong (2022)

Source: Ghazi et al., (2023)

Summarize the current situation on pesticide use and regulation in Thailand on the potential health and environmental impacts of pesticide use, as well as highlight gaps that could play an important and influential role in future policy initiatives on pesticides. Although Thailand has made remarkable progress in improving agricultural health and safety and similarly strong research and policy programs are being developed in other countries in the region, there are still significant gaps in agricultural policy that need to be filled.

To associate Thai general people's perceptions of fresh food consumption with their attitudes toward the impacts of agricultural chemical use on food production

Associations between Thai general people's perceptions of fresh food consumption using the 30-item *Questionnaire on the Impact of Agricultural Chemical Use on Fresh Food Consumption* (QIACFC) on five scales, namely: Fresh Vegetables, Fresh Fruits, Fresh Meat, Frozen Seafood, and Dried Food for consumption in five scales: Always, Often, Sometimes, Seldom, and Never levels with the 10-item Attitudes Towards Agricultural Products as Raw Materials for Food Has an Impact on Health (AARFIH) assessed the general people's perception of their attitudes towards agricultural products as raw materials for having food an impact on health in their daily life by Thai agricultural products in five options: Always, Often, Sometimes, Seldom, and Never levels. The results are reported in Tables 8-9.

Validity and reliability of the QIACFC and AARFIH

In statistics, the creative internal consistency (Cronbach alpha reliability) coefficient was analyzed for the two research instruments: The QIACFC and AARFIH. The results are reported in Tables 7 and 8.

Table 7: Internal consistency (Cronbach alpha reliability) coefficient, Scale means, Std. Deviation, Variance, Grand means, F-test, and p-value for the QIACFC

Scale	α-reliability	Scale mean	Std. deviation	Variance	Grand mean	F-test	p-value
Fresh Vegetables	0.811	20.080	3.447	11.887	3.347	2.844*	.011
Fresh Fruits	0.800	19.940	3.309	10.953	3.323	5.878***	.000
Fresh Meat	0.853	19.607	3.609	13.029	3.268	3.105**	.009
Frozen Seafood	0.804	19.777	3.408	11.619	3.269	2.681*	.020
Dried Food	0.798	20.010	3.424	11.929	3.335	9.955***	.000
Total	0.949	99.413	15.092	227.768	3.318	4.503***	.000

*N=300, *p<.05, **p<.01, ***p<.001*

Table 7: Internal consistency (Cronbach alpha reliability) coefficient, Scale means, Std. Deviation, Variance, Grand means, F-test, and p-value for the AARFIH

Scale	α-reliability	Scale mean	Std. deviation	Variance	Grand mean	F-test	p-value
AARFIH	0.765	34.303	4.784	22.894	3.430	8.629***	.000

*N=300, *p<.05, **p<.01, ***p<.001*

Table 7 shows the internal consistency (Cronbach alpha reliability) coefficient ranging from 0.798 to 0.853, which means a high Cronbach's alpha value indicates that the items are consistent and likely measure the same characteristic, acceptable for the QIACFC. Table 8 shows the Cronbach alpha reliability coefficient as 0.765, which means a high Cronbach's alpha value is a high value for acceptance for the AARFIH. The results indicate that the research instruments (the QIACFC and AARFIH) are valid and reliable in this research study. The perceptions of the sample group to their opinions on food consumption are poisoned by chemicals including fresh vegetables, dried food, fresh fruits, frozen seafood, and fresh meat, respectively.

Designing statistics was analyzed between the independent variables (the five scales of grand means of the QIACFC) and dependent variables (the grand mean of the AARFIH is correlated using simple and multiple correlations, and the standardized regression weight validity coefficient was predicted and associated. The determination predictive value (R^2) coefficient is a statistical measurement that indicates how well a model predicts an outcome or fits data and measures the proportion of variance in a dependent variable that a model can explain using independent variables. The results are reported in Table 9.

Table 9: Simple and multiple correlations, the standardized regression weight validity coefficient, and the determination predictive value (R^2) coefficient in a dependent variable (AARFIH) that associations with independent variables (QIACFC scales)

Independent variable scale	Simple correlation (r)	Standardized regression weight validity (β)
Fresh Vegetables	0.339***	0.318***
Fresh Fruits	0.206***	0.221**
Fresh Meat	0.287***	0.249***
Frozen Seafood	0.254***	0.217**
Dried Food	0.241***	0.255***
Multiple correlations (R)	0.797***	
Determination predictive value (R^2)	0.636***	

*N=300, *p<.05, **p<.01, ***p<.001*

A given result in Table 9 indicates that the correlations between the independent and dependent variables are relationships with simple correlation (p<.001). Standardized regression weight validity (β) is a statistical estimate that represents the average change in a general people's perception of their attitudes towards agricultural products as raw materials for having food an impact on health in their daily life Thai agricultural products (dependent variable) for each standard deviation increase in the impact of agricultural chemical use on fresh food consumption (independent variables) are correlated, significantly (p<.01). The multiple correlations (R) are a measure of the goodness of fit of the regression model, the R-value indicates 0.797 (p<.001), which means yield the maximum degree more relationships of the impact of agricultural chemical use on fresh food consumption of participants'

perceptions and their attitudes towards the agricultural products as raw materials for food has an impact on health. An R^2 value indicates 64% which is generally considered relatively strong, which means general people trust and are believable in the effects of agricultural chemical use and its impacts on their health to its impact of pesticide use in agriculture, significantly.

Discussions

Thailand's rural areas are home to more than 70% of the Thai population and these people are heavily dependent on agriculture as their main source of income. At the end of 2019,37.5 million (56.7% of the total population of Thailand) were in the workforce and 11.7 million (~31% of the workforce) were employed in the agricultural sector (National Statistical Office, 2022). Data on the occupational accident and injury rates of agricultural workers in Thailand is scant and likely underreported since the majority of them work in the informal economy. As such, the diverse set of working activities conducted by farmers are not covered or are insufficiently covered by the Thai labor laws and the social security system. In general, agricultural work is physically demanding, with tasks varying according to the seasonal needs of planting, nurturing, and harvesting. During these work processes, agricultural workers are exposed to various hazardous work conditions that put their health and safety at risk, particularly from accidents, musculoskeletal disorders, heat stress, and the use of pesticides (International Labor Organization, 2021). The discriminant and overuse of pesticides should also be considered a risk factor for the health of rural farming families and the local ecosystem (Aktar, Sengupta, & Chowdhury, 2009).

Agriculture accounts for only six percent of Thailand's GDP, but the sector employs around one-third of the country's labor force. Thailand is the world's largest exporter of tapioca products, rubber, canned tuna, and canned pineapple. Thailand is the world's largest exporter of tapioca products, rubber, canned tuna, and canned pineapple. Thailand was the 20th largest export market for U.S. agricultural products (including seafood and forestry products) and the 12th largest supplier to the United States of agricultural imports in 2022 (Thailand - Agriculture - International Trade Administration, 2024). Thailand has capitalized on its abundance of natural resources and become the world's foremost producer and exporter of high-quality rubber. The country accounts for 40% of global rubber production, with an annual export value of US$13 billion. Thailand is well established as an export manufacturing hub, especially for companies in Japan and the US. In recent years, there has been growing interest among global manufacturers in investing in ASEAN countries as a means of developing alternatives to China as a production base. Within the ASEAN bloc, Thailand is not considered a particularly low-cost production base, although the country is competitive in a number of different regards, including its business environment, logistics infrastructure, abundant natural resources and well-established industrial base (Hong Kong Regular Alert Research, 2017).

Pesticides are indispensable in agricultural production. They have been used by farmers to control weeds and insects, and their remarkable increases in agricultural products have been reported. The increase in the world's population in the 20th century could not have been possible without a parallel increase in food production. About one-third of agricultural products are produced depending on the application of pesticides. Without the use of pesticides, there would be a 78% loss of fruit production, a 54% loss of vegetable production, and a 32% loss of cereal production. Therefore, pesticides play a critical role in reducing diseases and increasing crop yields worldwide. Thus, it is essential to discuss the agricultural development process; the historical perspective, types and specific uses of pesticides; and pesticide behavior, its contamination, and adverse effects on the natural environment. The review study indicates that agricultural development has a long history in many places around the world. The history of pesticide use can be divided into three periods of time. Pesticides are classified by different classification terms such as chemical classes, functional groups, modes of action, and toxicity. Pesticides are used to kill pests and control weeds using chemical ingredients; hence, they can also be toxic to other organisms, including birds, fish, beneficial insects, and non-target plants, as well as air,

water, soil, and crops. Moreover, pesticide contamination moves away from the target plants, resulting in environmental pollution. Such chemical residues impact human health through environmental and food contamination. In addition, climate change-related factors also impact on pesticide application and result in increased pesticide usage and pesticide pollution. Therefore, this review will provide the scientific information necessary for pesticide application and management in the future (Tudi et al., 2021).

This research is reviewed to explore a comprehensive summary of pesticides regarding their updated impacts on human health and advanced safety concerns with legislation. Implementing regulations, proper training, and education can help mitigate the negative impact of pesticide use and promote safer and more sustainable agricultural practices. Why did people think that food is poisoned by chemicals including fresh vegetables, dried food, fresh fruits, frozen seafood, and fresh meat, respectively. The R^2 value indicates 64% of participants' perceptions of the food contaminated with chemicals affecting the health of the body as a food ingredient on physical health to its impact of pesticide use in agriculture, significantly. Chemical contaminants can be found in food naturally or added during processing, packaging, or storage. Food contact materials can also migrate chemicals into food. An estimated 600 million – almost 1 in 10 people in the world – fall ill after eating contaminated food and 420,000 die every year (World Health Organization, 2024).

Conclusion

Thailand has an agricultural area of 153,184,527 rai or 47.77 percent of the total area of Thailand to support 5.8 million farmer households, as well as being a source of agricultural and food products for the country and exporting to foreign markets, enabling Thai people to have food security and income to Thailand, which can compete with other countries with stability and sustainability. Therefore, the factors of land suitability, irrigation system development, and agricultural infrastructure are used to determine the appropriate into three areas: (1) Agricultural zones with good production potential, covering an area of 42,647,558 rai or 13.30 percent of the total area of Thailand, consisting of rice-growing areas covering an area of 22,327,130 rai or 6.96 percent; field crops, fruit trees and perennial trees covering an area of 17,690,527 rai or 5.52 percent; and areas with plant indications certified by the European Union covering an area of 2,629,901 rai or 0.82 percent: (2) Agricultural zones with good production potential, covering an area of 42,647,558 rai or 13.30 percent of the total area of Thailand, consisting of rice-growing areas covering an area of 22,327,130 rai or 6.96 percent; and areas with plant indications certified by the European Union covering an area of 17,690,527 rai or 5.52 percent. High production potential, covering an area of 73,193,948 rai or 22.83 percent, consists of rice farming area of 33,726,836 rai or 10.52 percent, and field crops, fruit trees and perennial trees area of 39,467,112 rai or 12.31 percent. (3) Agricultural areas with low production potential, covering an area of 37,343,021 rai or 11.64 percent of Thailand's area. The characteristics of the area have a relatively low suitability for agricultural production or are not suitable for agricultural production because the yield is not worth the investment or there may be a risk of natural disasters. The use of the area for agriculture requires area development and improvement, using measures and suitability together.

Almost 40% of Thailand's land is classified as agricultural. Forty-two percent of the working population is engaged in agriculture, and the country is one of the world's largest exporters of rice. Forty percent of the population work in agriculture-related jobs. The farmland they work was valued at US$2,945/rai ($18,410/ha; $7,450/acre) in 2013. Most Thai farmers own fewer than eight ha (50 rai) of land (. Crop destruction is the deliberate destruction of crops or agricultural products to render it useless for consumption or processing. It can be made by burning, grinding, dumping into water, or application of chemicals. It should not be confused with crop residue burning, which burns non-edible parts of the crop. Production risks stem from the uncertain natural growth processes of crops and

livestock, with typical sources of these risks related to weather and climate (temperature and precipitation) and pests and diseases.

Agriculture is one of the most important economic sectors in Thailand as it employs approximately 30% of the country's labor force. However, the Thai agricultural sector is facing structural challenges, especially labor shortage and lack of production planning and management. The labor shortage is evidenced by several indicators such as the ratio of elderly to the total population, and employment in agriculture (% of total employment). The latter challenge is clearly shown by agricultural total factor productivity. The structural problems mentioned above highlight an investment opportunity of farming companies for both large agricultural companies and AgTech. For example, large agricultural companies and AgTechs (most of them are drone technologies) lack other relevant advanced technologies such as crop seeding and weeding robots.

Creative the 30-item *Questionnaire on the Impact of Agricultural Chemical Use on Fresh Food Consumption* (QIACFC) on five scales and the 10-*item Attitudes Towards Agricultural Products as Raw Materials for Food has an Impact on Health* (AARFIH) research instruments are valid and reliable and assessed 300 people's perceptions in five options. They thought that food is poisoned by chemicals including fresh vegetables, dried food, fresh fruits, frozen seafood, and fresh meat, respectively. 64% of participants' perceptions of the food contaminated with chemicals affect the health of the body as a food ingredient on physical health to its impact of pesticide use in agriculture, significantly. The perceptions of the sample group to their opinions on food consumption are poisoned by chemicals including fresh vegetables, dried food, fresh fruits, frozen seafood, and fresh meat, respectively.

Thus, this highlights business opportunities for entrepreneurs and technological companies. In terms of production planning and management challenges, digital technology, especially enterprise resource planning (ERP) can be applied to mitigate such challenges by re-engineering business processes, and better management of all activities along the supply chain. Furthermore, it can be a strong ground for advancing their business models to smart farming. Despite the high demand for Agri-ERP technologies, there are still a handful of Thai Agri-ERP companies. The agricultural companies, technological companies, and investors, who are interested in such investment opportunities may be eligible to enjoy investment incentives from the investment promotion organizations in Thailand. For example, the Digital Economy Promotion Agency (DEPA) provides funding for AgTech and agricultural companies aiming to transform their businesses with digital technology. Thailand Board of Investment (BOI) provides investment incentives including exemption of corporate income tax, import duties on machinery, import duties on raw materials used in R&D, import duties on raw materials used in production for export, and non-tax incentives. 03 Disclaimer: This report was analyzed and collected information before the coronavirus pandemic.

The recent ban on three farm chemicals seen as highly hazardous has raised public debates to another level; whether the country's long-time chemical-based farming should shift to something else. That was in 2014, during the decade in which the country saw the use of pesticides climb up continuously. According to the statistics by the Department of Agriculture and the Agricultural Economics Office, in 2014 alone Thailand had imported around 147, 400 tons of pesticides, being worth around 22.8 billion baht. Over the past five years from 2014 to 2018, Thailand imported nearly 827,000 tons of pesticides, worth nearly 127 billion baht, according to the same offices, which released the figures last year. Imports and uses of pesticides in the country would not have attracted attention from the public at large if there have been no reports of harmful effects of herbicides Glyphosate and Paraquat, and insecticide Chlorpyrifos, both on the environment and public health.

References

Ahmad, M. F., Ahmad, F. A., Alsayegh, A. A., Zeyaullah, M., AlShahrani, A. M., Muzammil, K., Saati, A. A., Wahab, S., Elbendary, E. Y., Kambal, N., Abdelrahman, M. H., Hussain, S. (2024). Pesticides impact human health and the environment with their mechanisms of action and possible countermeasures. *Heliyon, 10*(7): e29128. https://doi.org/10.1016/j.heliyon.2024.e29128

Aktar, M. W., Sengupta, D., Chowdhury, A. (2009). Impact of pesticides use in agriculture: their benefits and hazards. *Interdisciplinary Toxicology, 2*(1):1–12. doi: 10.2478/v10102-009-0001-7

Bangkok Tribune. (2020). A ban on toxic farm chemicals: Thailand's long road to food and farm safety. *Thai Health*. November 9. https://bkktribune.com/a-ban-on-toxic-farm-chemicals-thailands-long-road-to-food-and-farm-safety/

Britannica. (2024). Agriculture, forestry, and fishing in Thailand and the economy. *ABC News (Australia)*. October 12. https://www.britannica.com/place/Thailand/Agriculture-forestry-and-fishing

Cramb, R., Thepent, V. (2022). Evolution of Agricultural Mechanization in Thailand. *Communities & Collections*. January 12. https://cgspace.cgiar.org/server/api/core/bitstreams/content

Department of Agricultural Extension. (2024). The use of chemical fertilizers in Thailand. *Rural Technology (Technology Chaoban)*. July 28. https://www.technologychaoban.com/agricultural-technology/article_246076 Department of Land Development. (2022). *Agricultural areas in Thailand*. Land Use Policy and Planning Division. September 30. https://webapp.ldd.go.th/lpd/node_modules/img/Download/zonmap/zonmap2/agri_zone_th.pdf

Falvey, L. (2022). Thailand's progress in agriculture: Transition and sustained productivity growth. The Wayback Machine. Kasetsart University Press. ISBN 974-553-816-7.

Food and Agriculture Organization Thailand (2024). Area planted to 2024 main paddy crop forecast average. *FAO/GIEWS Earth Observation for Crop Monitoring Level.* August 2. https://www.fao.org/giews/countrybrief/country.jsp?code=THA&lang=ar

Fuglie, K., Morgan, S., Jelliffe, J. (2024). Global changes in agricultural production, productivity, and resource use over six decades. *Feature: Agricultural Research and Productivity.* Economics Research Service. US Department of Agriculture. September 30. https://www.ers.usda.gov/amber-waves/2024/september/global-changes-in-agricultural-production-productivity-and-resource-use-over-six-decades/

German Cooperation. (2020). Thai-German Climate Program – Agriculture. August 20. https://www.thai-german-cooperation.info/en_US/thai-german-climate-programme-agriculture/

Ghazi, R. M., Yusoff, N. R. N., Halim, N. S. A., Wahab, I. R. A., Latif, N. A., Hasmoni, S. H., Zaini, M. A. A., Zakaria, Z. A. (2023). Health effects of herbicides and their current removal strategies. Bioengineered, 14(1): 2259526. DOI: 10.1080/21655979.2023.2259526

Hong Kong Regular Alert Research. (2017). ASEAN in Focus: Prospects for production bases in Thailand. Thailand: An increasingly attractive manufacturing base. *Analysis and News*. March 14. https://research.hktdc.com/en/article/Mzg1NTc4ODc4

International Labour Organization. (2021). ILO Code of Practice: Safety and Health in Agriculture. *Geneva: International Labour Office 2021*. March 28. https://www.ilo.org/safe-work/info/standards-and-instruments/codes

Keating, C. (2022). Thai agriculture needs reform from the ground up. *Nikkei Asia.* March 23. https://asia.nikkei.com/Opinion/Thai-agriculture-needs-reform-from-ground-up

Krisanaraj, J. (2024). How sustainable agriculture can help Thailand cope with climate change. The Nation Thailand. April 25. https://www.nationthailand.com/sustainability/esg/40037538

Lee, B. (2015). Prolonged Thailand drought threatens global rice shortage. *Science and Development Network.* July 21. https://www.eco-business.com/news/prolonged-thailand-drought-threatens-global-rice-shortage/

Lewin, R. (2009). The origin of agriculture and the first villagers. Human Evolution: An Illustrated Introduction (5 ed.). Malden, Massachusetts: John Wiley & Sons: 250. ISBN 978-1-4051-5614-1.

Leturque, H., Wiggins, S. (2010). *Thailand's progress in agriculture: Transition and sustained productivity growth.* The Wayback Machine. London: Overseas Development Institute.

Market Insights. (2023). Agricultural Machinery in Thailand. *YAMADA Consulting Group Co. Ltd*. December 19. https://www.yamada-spire.com/agricultural-machinery-in-thailand/

Ministry of Agriculture and Cooperatives of Thailand. (2021). *Historical Background of agricultural evolution of Thailand*. https://www.moac.go.th/moaceng-history

National Disaster Prevention and Mitigation Committee. *His Majesty the King's Royal Guidance (1963) on the problem with agriculture in Thailand*. Ministry of Defense. March 31. https://www.disaster.go.th/upload/download/file_attach/584115d64fcee.pdf

National Statistical Office. (2022). Labour Statistics 2022. [Online]. *Ministry of Digital Economy and Society*. March 28. http://statbbi.nso.go.th/staticreport/page/sector/en/02.aspx

Office of Agricultural Economics, Ministry of Agriculture and Cooperatives. (2024). OAE12 joins the big seminar for the year 2023. February 7. https://oaezone.oae.go.th/view/20/new_detail//EN-US

Office of Natural Resources and Environmental Policy and Planning. (2024). *Impacts of agricultural chemical use*. June 10. https://www.onep.go.th/impacts/of/agricultural/chemicale/use/

Pierre, J., Appel, B. (2011). When the World's population took off: The Springboard of the Neolithic Demographic transition. *Science, 333*(6042): 560–561. DOI:10.1126/science.1208880

Poapongsakorn, N., Chokesomritpol, P. (2017). Agriculture 4.0: Obstacles and how to break through. *Thailand Development Research Institute (TDRI)*. September 15. https://tdri.or.th/en/2017/06/agriculture-4-0-obstacles-break-2/

Pollard, E., Rosenberg, C., Tigor, R. (2015). *Worlds together: Worlds apart*. 1:23. (Concise ed.). New York: W.W. Norton & Company. ISBN 978-0-393-25093-0.

SCB Economic Intelligence Center. (2017). Thai organic foods have healthy growth potential. *Bangkok Post*. February,6. https://www.bangkokpost.com/business/general/1193633/thai-organic-foods-have-healthy-growth-potential

Smithsonian Magazine. (2023). Agricultural inventions. *National Geography.* October 4. https://www.history.com/topics/pre-history/neolithic-revolution/agricultural-inventions/

Sompong, T. (2022). How farmers in Thailand are adapting to climate impacts. *Next Blue*. June 7. https://www.next.blue/how-farmers-in-thailand-are-adapting-to-climate-impacts/

Thailand Development Research Institute. (2022). Thai agriculture needs a shake-up. November 22. https://tdri.or.th/en/2022/11/thai-agriculture-needs-a-shake-up/

The International Trade Administration. (2024). Agriculture: Thailand - Country Commercial Guide. *U.S. Department of Commerce*. January 8. https://www.trade.gov/country-commercial-guides/thailand-agriculture

The Nation Thailand. (2024). The country reports a trade surplus of over THB900 million. *Business & Economy.* December 12. https://www.nationthailand.com/business/economy/40044090

The National Science and Technology Development Agency (NSTDA). (2024). Eco-friendly control agents elevating Thai agriculture to new heights of safety and sustainability. February 2.

https://www.nstda.or.th/en/news/news-year-2024/eco-friendly-control-agents-elevating-thai-agriculture-to-new-heights-of-safety-and-sustainability.html

The Office of the National Economic and Social Development Council (NESDC). (2024). Thai Economic Performance in Q3 of 2024 and the Outlook for 2024 – 2025.

The World Bank. (2016). Agriculture, value added (% of GDP). *The World Bank Thailand*. Retrieved 26 November 2016

Tirado, R., Englande, A. J., Promakasikorn, L., Novotny, V. (2008). Use of agrochemicals in Thailand and its consequences for the environment. *Greenpeace Research Laboratories Technical Note 03/2008*. https://www.greenpeace.to/publications/GPSEA_agrochemical-use-in-thailand.pdf

Tudi, M., Ruan, H. D., Wang, L., Lyu, J., Sadler, R., Connell, D., Chu, C., Phung, D. T. (2021). Agriculture development, pesticide application, and its impact on the environment. International *Journal of Environment Research and Public Health, 18*(3):1112. DOI: 10.3390/ijerph18031112

United Nations Environment Programme. (2024). *Promoting a sustainable agriculture and food sector in Thailand.* ISBN: 978-92-807-4179-7. Job number: DEP/2667/NA. https://www.greenpolicyplatform.org/sites/default/files/downloads/resource/TEEB_AgriFood_Thailand.pdf

van Cutsem, P. R. J. (2024). What are the major 'made-in-Thailand' products? *Quora.* https://www.quora.com/What-are-the-major-made-in-Thailand-products

Walderich, A. (2024). Agriculture in Thailand - statistics & facts. *Statista*. April 23. https://www.statista.com/topics/5730/agriculture-in-thailand/

Wiggins, S. (2018). Thailand's progress in agriculture: Transition and sustained productivity growth. *One Day International*. June 13. https://odi.org/en/publications/thailands-progress-in-agriculture-transition-and-sustained-productivity-growth/

World Health Organization. (2024). *Food safety*. October 4. https://www.who.int/news-room/fact-sheets/detail/food-safety

Yokying, P., Promkhambut, A. (2024). Drought, Flood, And Rice Security In Central Thailand – Analysis. *East-West Center*. July 20. https://www.eurasiareview.com/20072024-drought-flood-and-rice-security-in-central-thailand-analysis/