A Comparative Study Between Organic Agriculture for Vegetables and Fruits Production in Lao PDR and the MRL Approach Used by Other Countries in the Mekong Region

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Abstract

Food safety and the reduction of chemical use in agriculture, in particular, are common issues that reflect consumer concerns in many developing countries. This paper summarizes the history of the development of Organic Agriculture (OA) in Lao PDR, followed by the outline of the Japan International Cooperation Agency (JICA) Clean Agriculture Development Project (CADP) which supports organic vegetables and fruits production under the clean agriculture policy promoted by the Lao government. Next, the relevant policies of its neighboring countries in the Mekong region (Thailand, Vietnam, and Cambodia) are also summarized. The policies in these countries focus mainly on reducing chemical residues based on the Maximum Residue Limits (MRL) rather than promoting OA, which has recently been included in their national policies in response to social demands for chemical reduction in agriculture. Finally, the paper compares the approach of Lao PDR and other countries in the Mekong region. As a result, the Lao approach can contribute to improving both food safety and income generation of farmers. In contrast, the MRL-based approach has some limitations due to its insufficient operations under the regulatory systems in these countries. This suggests that the Lao approach should be taken into consideration by other developing economies where small-scale farmers are the majority.

Keywords: Lao PDR, organic agriculture, food safety, chemical reduction, Maximum Residue Limits (MRL)

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Introduction

The reduction of chemical use in agriculture is a common issue in both developed and developing countries, reflecting consumer concerns over agrochemical residues that affect food safety. In the Mekong region, there is a large body of literature on chemical residue in fresh agricultural products and its impact on public health (Food and Agriculture Organization of the United Nations, 2020; The Thailand Life, 2018; Thai-PAN, 2016; Wanwimolruk et al., 2016; Tawatsin et al., 2015; Ha et al., 2019; Rassapong, 2016; Rassapong et al., 2018). Lao PDR has developed its Clean Agriculture (CA) policy to promote the reduction of agrochemical use. This unique policy recognizes the traditionally lower agrochemical inputs used in the country compared to those surrounding Lao PDR, which can be a competitive advantage for the supply of safe and environment-friendly agricultural products to the ASEAN region and beyond.

The research first presents the outline of the promotion of Organic Agriculture (OA) in Lao PDR, including i) the history of OA in Lao PDR, ii) the activities of the Japan International Cooperation Agency (JICA) Clean Agriculture Development Project (CADP), and iii) the challenges and limitations of the policy of Lao PDR. Next, Thailand, Vietnam, and Cambodia are selected, and the research analyzes their policy, whose approach is, in general, the reduction of chemical residues based on the Maximum Residue Limits (MRL), as well as their application of national policy for promoting OA in response to social demand for chemical reduction in agriculture. Finally, the paper compares the policy of Lao PDR with the selected countries, showing comparative advantages in strengthening the promotion of OA applied in developing countries.

Research Method

Organic agriculture of vegetables and fruits production under the Lao policy is analyzed using the literature review and survey data of JICA Clean Agriculture Development Project (2019a, 2019b). Next, the relevant policies of Thailand, Vietnam, and Cambodia are described by literature review. Meanwhile, the policy for chemical reduction by Lao PDR are described, based on the information from the Division of Standard and Certification, Department of Agriculture, Ministry of Agriculture and Forestry, Lao PDR (DOA/MAF) (2023), with some literature. Finally, the comparison is made between the policy by Lao PDR and the selected countries based on the description of the previous sections.

There are some data shortages in the discussion section, such as the economy of OA compared to conventional agriculture. The examination of this topic is supplemented by collecting literature containing survey data in both developing and developed countries. Collecting literature is conducted by literature survey at the National Diet Library in Japan and via the Internet, including Google Scholar, using keywords and references of key papers.

Background Information

Organic Agriculture (OA) in Laos

The History of Developing Organic Agriculture (OA) Policy in Laos

OA in Lao PDR started in the late 1990s with non-government organizations (NGOs) and private sector enterprises, which mainly focused on incorporating sustainable farming technologies and practices into training activities without considering market linkages (Panyakul, 2012). With the support of the Promotion of Organic Farming and Marketing in Lao PDR (PROFIL)[1] Project in 2005, the Department of Agriculture, Ministry of Agriculture and Forestry Lao PDR (DOA/MAF) developed its OA standard based on the principles of the International Federation of Organic Agriculture Movement (IFOAM) and the organic standard of the Organic Agriculture Certification Thailand (ACT), followed by the approval of the Lao Certification Body (LCB) in 2008. With continued PROFIL support, DOA/MAF introduced guidelines for the promotion of OA in 2009, including for Internal Control Systems (ICS), inspectors and certification, human resource development, and institutional capacity building, as well as the establishment of the first OA farmers group in Vientiane Capital (Panyakul, 2012, Department of Agriculture, Ministry of Agriculture and Forestry, Lao PDR, 2016). The PROFIL initiative has been followed up by several development partners, including JICA[2] which has supported OA with the cooperation of DOA/MAF since 2013.

In concurrence with this development of the OA policy in Laos, the government has advocated a CA policy. It was one of the key objectives of the agriculture development strategy for 2006-2010. Then, it has continued to be a basic agriculture policy of Lao PDR. OA is one of four production systems recognized in CA, as shown in Table 1.

Table 1 Comparison of Four Production Systems of Clean Agriculture (CA)

	OA	GAP	Pesticide Free Agriculture	Conservation Agriculture
Chemical fertilizer	No	Yes	Yes	No
Chemical insecticide	No	Yes	No	No
Chemical fungicide	No	Yes	No	No
Chemical herbicide	No	Yes	No	No
Chemical hormone	No	Yes	Yes	No
GMO variety	No	No information	No information	No
Slash and burn	No	No	No	Yes
Standard and certification system in Lao PDR	Yes	Yes	No	No

Note: These four production systems are described in Ministry of Agriculture and Forestry (2015). GAP stands for Good Agricultural Practices. GMO stands for Genetically Modified Organism.
Source: Training material of Clean Agriculture Standard Center (CASC/DOA/MAF). The original document seems to come from that agreed upon at the National Assembly in about 2005 (Clean Agriculture Standard Center, 2018)

[1] Promotion of Organic Farming and Marketing in Lao PDR (PROFIL), supported by the Swiss NGO Helvetas, 2004-2011.

[2] It also includes Helvetas, the local NGO SAEDA (Sustainable Agriculture and Environment Development Association), the Food and Agriculture Organization (FAO), and the Asian Development Bank (ADB).

In 2016, DOA/MAF published its Strategic Plan for National Organic Agriculture Development 2025, Vision Towards 2030, with the support of the Lao Organic Agriculture Promotion Project (LOAPP). It was also supported by JICA from 2013 to 2016. This plan led to the improvement of the organic markets in Vientiane Capital and expanded OA to other Lao provinces (Department of Agriculture, Ministry of Agriculture and Forestry, Lao PDR, 2016).

Outline of the JICA/CADP Project

CADP started in November 2017 as a five-year project funded by JICA following the completion of LOAPP. The project activities focused on the OA market for vegetables and fruits in four pilot provinces, namely Vientiane Capital, and three northern provinces of the country: Luang Prabang, Xayaboury, and Xieng Khouang (see Figure 1).

Figure 1 Map of Pilot Provinces in Clean Agriculture Development Project (CADP)

Table 2 provides basic data on the population and characteristics of OA markets in Vientiane and the three pilot provinces. The situation of OA for vegetables and fruits in each pilot province is explained as follows.

a) Vientiane Capital

Vientiane is the capital city of Laos, with a population of over 900,000 people. Due to the previous project support outlined above, the OA farmers' groups have been developed, and they have operated six OA markets within the city where they can sell their vegetables and fruits directly to consumers. They regularly open a few times a week, with the largest (at the International Trades Exhibition and Convention Center (ITECC)) having around 500 customers a day. This reflects consumer distrust of vegetables and fruits sold at the general market, some of which are imported and have been shown to

have excessive chemical residues in some instances[3]. One of the biggest groups in Vientiane Capital is that in Thaxang village. They started organic agriculture in 2010 with eight families covering about one hectare, but membership increased year by year to over 100 families in 2019.

Table 2 Basic Data of Organic Agriculture (OA) Market in Pilot Provinces

Province or District	Population (1,000 persons)	OA market for vegetables and fruits			
		Number of Markets	Number of farmers	Production (ton/year)	Yearly sales ('000 USD)
Vientiane Capital	928[a]	6	350	804[c]	1,094[c]
Luang Prabang City	92[b]	2	26	82	64
Xayaboury District	80[b]	0	39	n.a.	n.a.
Pek District, Xieng Kouang Province	78[b]	2	101	46	36

Note: Yearly sales are calculated from LAK as 1 USD equals 10,000 LAK. C in the note means authors estimated from the data of the baseline survey by CADP concerning Vientiane Capital because the baseline survey only targets the ITECC OA market but not the other five OA markets. The authors calculate the production volume and yearly sales of OA vegetables and fruits in Vientiane Capital, taking account of the market share of ITECC market in six OA markets in Vientiane Capital. The other data are collected by CADP. The data for the number of OA markets and farmers is in October 2020. Production and yearly sales are calculated from a baseline survey conducted by CADP in 2018-2019.

Source: [a]Ministry of Agriculture and Forestry, Department of Planning and Finance (2020), [b] Lao National Statistics Center, Ministry of Planning and Investment (2016), and [c]Estimated from CADP data.

b) Luang Prabang

Luang Prabang was designated a World Heritage Site by UNESCO in 1995. Because of its high number of tourists, there is a potential for demand for organic vegetables and fruits from service industries such as hotels and restaurants. When CADP begins, it reorganizes group management from a previously unsustainable group and enables it to open an OA market in the city center.

c) Xayaboury

Xayaboury province is in the northwest region of Laos at the border of Thailand. Plains alongside the Mekong River are advantageous for agriculture due to flat land and fertile soils. Organic vegetable production by OA groups has started with CADP.

d) Xieng Khouang

Xieng Khouang province is located in a mountainous area of northeast Laos close to the Vietnam border. Its relatively higher altitude (800 to 1,200m above sea level) means the

[3] Provincial Agriculture and Forestry Office (PAFO) Vientiane Capital started to monitor some general markets in the city subject to two regulations, namely "Agreement of VC-Governor on Promotion and Quality Control on Crop Production and Products in VC No: 0689/GVC, dated 13 July 2018" and "Agreement of VC-Governor on Pesticide Use and Management No: 0688/GVC, dated 13 July 2018". However, the result has not been published.

potential for cool-climate vegetable production (Ministry of Agriculture and Forestry, 2015). Organic farming has already been established by previous donors[4], with an OA vegetable group comprising mainly women farmers selling their products at OA markets in the city center.

Overall, CADP determines that there are several issues to be overcome for the further development of OA in Laos, such as limited sales outlets and opportunities for OA products and an insufficient number of reliable OA products that meet the increased customer needs for food safety and without the illegal use of agrochemical inputs. With this background, CADP's expected outcome is the supply of CA products (including OA products) based on market needs, as promoted in pilot provinces. Under this purpose, CADP conducts training activities for the OA farmers group and counterpart organizations belonging to MAF.

i) Training for OA farmers' group
To strengthen the ability of OA farmers/farmers groups to sell their products corresponding to market needs, CADP conducted the following activities. In Vientiane, capital activities prioritize marketing more than production and focus on "match-making" to enable the group to find alternative sales outlets other than the OA market, such as retailers (including supermarkets and convenience stores), restaurants, and home delivery.

In the three pilot provinces (Luang Prabang, Xieng Khouang, and Xayaboury) where Lao organic certification is not obtained or has expired, CADP conducts a series of training activities to the OA farmers/farmers group to obtain Lao organic certification during the first half of the project. The standard training curriculum for OA certification, for example, is shown in Table 3. It must be accompanied by other training for basic skills and techniques of OA, such as soil management, Integrated Pest Management (IPM), and seed collection and production. In addition, these OA farmers have visited an OA market and a village in Vientiane Capital to understand their operations and advance their skills in OA production.

ii) Capacity building for counterpart organizations
The counterpart organizations of CADP are the Clean Agriculture Standard Center (CASC) under DOA/MAF in the central government and the provincial and district agriculture and forestry offices (PAFO/DAFO) at local government levels. Government staff is assigned as project counterparts planned and participates in OA training and learns together with farmers.

[4] SAEDA, FAO, and Helvetas.

Table 3 Standard Curriculum of Training for OA Certification

Step	Title of training	Contents
1	Training of OA standards and principles (twice)	● Learning Lao organic standards and its principles ● The first training for PAFO/DAFO staff and leaders of farmers, and the second one for all farmers
2	Training for group management	● Formulation of OA farmers' group ● Guidance on the organizational structure of the group ● Selection of members of group committee and ICS inspectors
3	ICS training (three times)	● Learning the roles and duties of group committee and ICS inspector ● Producing OA group regulations ● Supervision of application documents on OA certification: farm history, production calendar, and record of production ● As an exercise, visitation to farms of selected farmers and check the records of production by ICS inspectors ● Drawing maps (group mapping and individual farmland)
4	Submission of application document	Submission of application documents through PAFO to DOA

Note: This table summarizes what was compiled by CASC/DOA/MAF on 29 October 2019 under the activity of CADP. PAFO and DAFO stand for Provincial Agriculture and Forestry Office and District Agriculture and Forest Office, respectively. ICS stands for Internal Control System. Its explanation is referred to in the section of "Challenges and Limitations of OA in Laos".

Challenges and Limitations of OA in Laos

In the case of Laos, some challenges remain to be considered to strengthen its system and meet social needs when promoting OA. The first challenge is to build public awareness of the value of OA products. As OA normally requires labor-intensive practices, such as soil management, weed control, and pest management, farmers expect more profit than those practicing conventional farming with chemicals, and consumers are not used to paying higher prices. Farmers will be unable to continue without premium prices. According to data collected by CADP, the difference in price of vegetables between the OA market and the conventional market in the rainy season is 50 % higher on average and 230% higher in the highest instance (Chinese mustard). Mass media also plays an important function in promoting public awareness. For Lao consumers, this includes watching Thai television programs promoting OA (Vagneron & Xong, 2015).

A second challenge is the trust building between producers and consumers. Establishing standards and certifying OA products are valuable tools to build trust between these parties (see Figure 2).

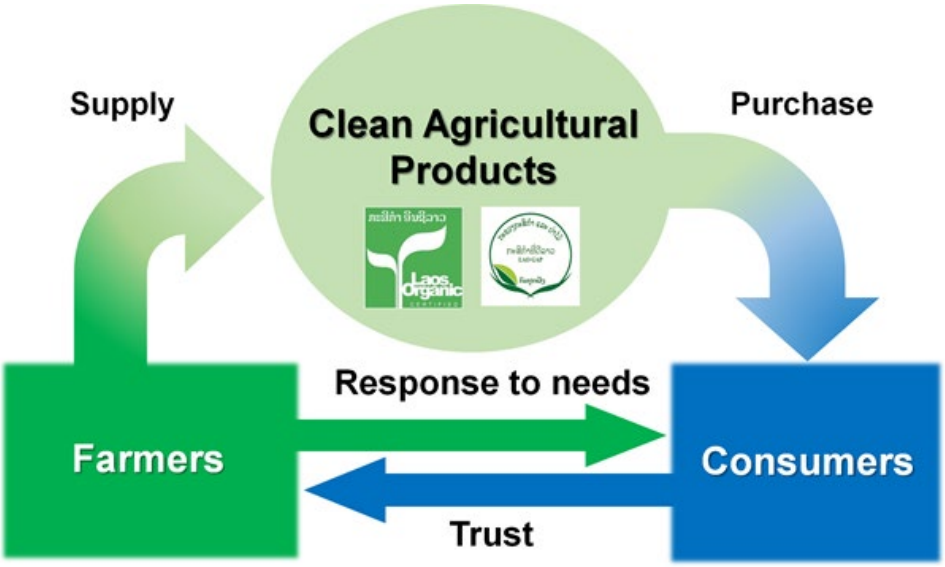

Figure 2 Trust Building between Producers and Consumers
through Clean Agriculture (CA) Products

However, sometimes, it is not easy to ensure that OA products conform to the DOA/MAF standard since this standard does not define end products but is a production and processing standard. Some malicious producers and traders have mixed organic products with those produced by conventional practices. In order to prevent such incidents, adequate farm management must be ensured under a consolidated certification system. In the case of the OA farmers group in Vientiane Capital, an ICS is applied, and conformity to the OA standard is inspected internally within the group in addition to an external inspection mechanism conducted by local government staff. Continuous efforts are needed by both farmers and the certification body if trust is to be maintained.

A third problem arises in the complicated procedures to receive certification, which is required annually. Without project support, farmer groups must bear the documentation and certification fees.

In conclusion, these challenges are the reason that the uptake of organic farming remains low in Laos. The volume of OA vegetables and fruits accounts for only 0.7% of total sales in Vientiane Capital, according to data collected by CADP. "0.7%" is calculated by authors based on the data on vegetables and fruits production in Vientiane Capital in 2019 as follows: OA production/Conventional production = 804 (ton/year)/ 121,736 (ton/year) = 0.7%. The 804 comes from Table 2 in the article and 121,736 comes from Agricultural Statistics 2019. Then, 121,736 is summed up of vegetable production (104,119) plus fruit production (17,617).

The Situation for OA of the Countries in the Mekong Region

Overview of the Statistics of OA in the Selected Countries in the Mekong Region

Table 4 shows the overall statistics of OA production for Thailand, Vietnam, and Cambodia compared to Lao PDR. The share of organic areas is less than 1% in all countries in terms of vegetable organic area and total organic area. The scale of OA in each country in terms of area and the number of producers seems to be reflected by the size of the economy (i.e., population, GDP, and the size of agricultural land) in general. However, the scale of OA in Thailand is much bigger than in Vietnam, taking into account the size of the economy. This is because the commencement of OA in Vietnam is later than in other countries like Thailand and Lao PDR. However, the social demands for OA are common, namely the transition to intensive agriculture using more chemicals from traditional agriculture.

Table 4 The Comparison of OA and Relevant Statistics in 2019 among the Four Countries

	Thailand	Vietnam	Cambodia	Lao PDR
Organic Area (ha)	188,451	61,901	25,757	8,952
Share (%) of total agricultural land	0.9	0.5	0.5	0.4
Producer	118,985	17,174	6,350	2,165
Vegetable organic area (ha)	2,693	2,057	10	47
Share (%) of total vegetable land	0.6	0.2	0.0	0.0
Population (thousands)	67,990	96,484	16,289	7,123
GDP (million US$)	543,958	261,587	27,102	18,844
Agricultural area (000 ha)	22,110	12,388	5,566	2,394

Source: OA data from Willer et al. (2021), and Population and GDP from The ASEAN Secretariat (2020) and (2021).

Thailand

An important characteristic of the development of OA in Thailand is that NGOs play a very important role at the initial stage, rather than governmental agencies. These NGOs have a long history of promoting organic production and marketing since 1980 (Win, 2017; Chitov, 2020). In 1995, the Organic Agriculture Certification Thailand (ACT) was established with the cooperation and initiative of sustainable agriculture among Alternative Agriculture Network (AAN), NGOs, academia, consumer networks, media representatives, and eco-friendly businesses (Chitov, 2020). ACT drafted the first Thai organic crop standards, followed by the commencement of organic farm inspection and certification in 1997 (Win, 2017).

Following these initiatives made by private sectors, the Thai government, namely the Thailand Institute of Technological and Scientific Research (TISTR), Export Promotion Department of the Ministry of Commerce, and Department of Agriculture, Ministry of Agriculture Cooperatives (DOA/MOAC) drafted its organic crop standards in 1999.

Afterward, the Thai government published several national policies for promoting organic agriculture for two main reasons: the promotion of agricultural exports and chemical-free agriculture. In relation to the latter reason, it is a response to the awareness of the pesticide residue problem. Many farmers and supporting agencies have made a step toward pesticide-safe agriculture in the conversion of conventional agriculture from traditional agriculture (Chitov, 2020).

The major crops in Thai OA are rice, vegetables, and fruits. Organic vegetables and fruits are sold mainly in domestic markets. In contrast, organic rice goes to the domestic market in small quantities compared to the large amount of rice exported by Thailand. There was little government support for OA production and farmers before 2017, and the private sector was the main player in the development of Thai OA (Win, 2017).

Thailand has two types of organic farming: the integrated organic farming system and the mono-crop organic farming system. In the former system, many varieties of plants are grown in one unit of area to reduce production costs and attain self-sufficiency. This type of organic farming is operated in a manner of environmentally friendly production with its products sold to the local community. In contrast, the mono-crop organic farming system gains revenues from its great amount of production and sales of the products to meet international standards. The latter production type is also considered environmentally safe (Win, 2017).

Recently, MOAC has prepared the 20-year Agriculture and Cooperative Strategy (2017-2036), which contains reforms dealing with environmental sustainability as well as economic stability, human capital, economic opportunities, and so on. To achieve inclusive and sustainable economic growth, the government also launches a new strategy called "Thailand 4.0" which contains the promotion of sustainable agriculture as an important mechanism in accordance with SDGs. In this background, the government has developed the National Organic Agriculture Development Plan (2017-2021) (Laohaudomchok et al., 2021). The plan envisions Thailand as the leader in the region in terms of production, consumption, trade, and services in organic agriculture at the international level. There are four strategic themes as follows: (1) Promote research, knowledge dissemination, and innovation in OA, (2) Develop OA production and services, (3) Develop market and services as well as certification system for OA products, and (4) Drive OA extensively (Pongsrihadulchai, 2019).

Vietnam

OA production in Vietnam expanded by 4.5 times to 240,000 ha in 2020 from 53,350 ha in 2016, responding to social concerns about the side effects of conventional farming on human health and the natural environment. However, its production is still limited (Ngan & Ngoc, 2022). The main OA commodities are rice, shrimp, coconut, coffee, cocoa, milk, tea, vegetables, fruits, cinnamon, and anise (Nguyen, 2020; Nguyen, 2021). Since the expansion of OA has only begun in the past 6-7 years, national regulation is also under development and has yet to be active. For example, Vietnam National Organic Standard 2017 was not applied in practice because it was not accredited by other international and regional standards

(Nguyen, 2020). This is the reason that International Certification, such as those standards from the USDA, JAS, EU, and Australia, are dominant (Nguyen, 2020; Nguyen, 2021). Furthermore, many farmers develop small-scale organic farms at the individual level without organic certification and inspection. Some organic farmer groups belong to the Participatory Guarantee System (PGS) initiated by IFOAM (Nguyen, 2020).

As a reflection of recent government trends, the Organic Agricultural Development Project for 2020-2030 was approved in June 2020. It aimed to gradually create a strong domestic organic agricultural industry and grow land for organic agricultural production to 1.5-2% of total agricultural land by 2025 (Nguyen, 2021).

Cambodia

The Cambodian Organic Agriculture Association (COrAA) was established in 2006 through an international development initiative. In 2019, 34 operators were certified under the United States National Organic Program (US NOP). Rice is the main commodity for OA, with cassava and cashew nuts in the pilot stage. In April 2020, the government introduced an OA policy to boost the production and exports of OA (Willer et al., 2021).

The Situation of Agrochemical Use and the Reduction Policies in the Four Countries

Thailand

There is a long history of efforts to improve food safety in fresh vegetables in Thailand. Buurma and Saranark (2006) described the Thai Fresh project as an export project starting in 1999 when Golden Exotics Holland and KLM Cargo established a distribution and packing center near Bangkok airport. Before and during the project, fresh products were purchased from wholesalers and brokers. However, such traditional sales were no longer workable for those shipments to the EU and Japan, where the quality and safety requirements continued to increase. With this in mind, the project aimed at the development of an integrated quality chain for the export of exotic vegetables. The challenge of this development had to be considered both at the retail and producer levels. The former was to establish a distribution and packing center at Bangkok airport, while the latter was to establish a regional post-harvest center in Ratchaburi province, the production site of the project, translating the quality and safety requirements at the retail level into GAP at the producer level. It suggested that pesticide residues were the most important food safety concern in the vegetable supply chain. It also suggested that farmers should be trained in good agricultural practices with regard to pesticide application.

In 2004, the Thai Government advocated 'from-farm-to-table' to ensure a food safety monitoring and control system throughout the food chain. Under this policy, several regulations and standards were established by government and private initiatives (see Table 5). However, the problem of pesticide management was "the lack of a consolidated, uniform system designated specifically for pesticide management" under the Hazardous Substance

Act established in 1992 with subsequent amendments. This deficit weakened the enforcement of existing regulations, resulting in the misuse/overuse of pesticides after the point of sale, leaving their use largely uncontrolled (Panuwet et al., 2012).

In Thailand, GAP plays an important role in food safety. Three GAP programs are employed in the country: Q-GAP, Thai GAP, and GLOBALG.A.P. Q-GAP is the national GAP for domestic products, while Thai GAP and GLOBALG.A.P. are used mainly for exports. Retailers and consumers recognized the importance of GAP for food safety. However, the national Q-GAP program meets with low credibility due to the government's involvement, which does not entirely rely on the private sector.

Table 5 Summary of Regulations and Standards on Food Safety of Fresh Products in Thailand

Name	Agency (organization)	Year established	Scope	Targeting area or market
1 Mandatory regulations (selected only main acts)				
Agricultural Standards Act B.E. 2551	Government: ACFS (MOAC)	2008	Input, including the management of agricultural chemicals and fertilizer. Post-harvest and distribution Processing, packaging, and consuming.	National regulation
Food Act B.E.2522	Government: FDA(MOPH)	1979	Post-harvest and distribution Processing, packaging, and consuming	National regulation
2 Voluntary standards				
Thai Agricultural Commodity and Food Standard	Government: ACFS, DOA (MOAC)	No information	Production and harvest	National Standard
Q-GAP (National GAP of Thailand)	Government: ACFS, DOA (MOAC)	2004	Eight key points of the standard: (1) Water source; (2) cultivation site; (3) use of agricultural hazardous substances; (4) product storage and on-site transportation; (5) data records; (6) production of disease and pest-free products; (7) management of quality agricultural production; and (8) harvesting and post-harvest handling.	Recognized in domestic and regional markets
Thai GAP	Private sector: Board of Trade of Thailand	2007	Equivalence with GLOBALG.A.P.	Known only among trade partners of Thai companies (e.g., European partners)
GLOBALG.A.P.	Private sector: Food Plus in Germany	1997 (Note)	All activities on-farm, post-harvest, and handling products	Recognized in international markets

Note: The table is summarized from the information of Wongprawmas et al. (2015). The years were when the former scheme, EUREPGAP, was established. It was renamed GLOBALG.A.P. in 2007. ACFS= National Bureau of Agricultural Commodity and Food Standards; MOAC= Ministry of Agriculture and Cooperatives; FDA= Food and Drug Administration; MOPH= Ministry of Public Health; and DOA= Department of Agriculture

There is some literature reporting on excess levels of pesticide residues with fresh agricultural products in Thailand (see Table 6). Thai researcher's group has investigated its surrounding provinces. The results show that in Chinese kale, mangosteen, Pak choi, and morning glory, which Thai people regularly consume, pesticide residue detection exceeds the MRL. However, no samples exceed the MRL in the case of watermelon and durian. After this research, the Thai Pesticide Alert Network (Thai-PAN) publishes the results of pesticide residues in six fruits and ten vegetables from samples collected from modern supermarkets and wholesale fresh markets in Bangkok and surrounding provinces. The result shows that all commodities included pesticide residues in samples exceeding the MRL, with 89 out of 158 samples (56%) over the MRL (Thai-PAN, 2016). According to these reports, it should be noted that the incidence of pesticide contamination is found to be similar between samples bought from local markets and supermarkets (Wanwimolruk et al., 2016). In addition, even samples of fruits and vegetables labeled with GAP collected from major supermarkets have problems (Thai-PAN, 2016).

Tawatsin et al. (2015) examined pesticide use and its effects on farmers in Thailand concerning workers' health. Thailand was ranked third out of 15 Asian countries and fourth in terms of pesticide use per unit area and annual pesticide use, respectively. Acute poisoning of farmers was also high, ranking first in Asia, followed by Indonesia, Malaysia, and Sri Lanka. These figures reflected the situation that the total amount of imported pesticides increased from 2007 to 2013, namely from 110,000 tons to 172,000 tons. Reported cases of toxic effects of substances during 2007-2013 were found predominantly in the central region of Thailand (15,262 to 22,035 cases per year, 31 to 36% in all areas) followed by the northeast region (27 to 31%), north (18 to 20%), and south (18 to 19%). The authors indicated "a high potential risk of pesticide exposure among farmers because Thai farmers were not aware of pesticide hazards, while about half of them applied higher than recommended concentrations, wore no personal protective equipment, and did not observe recommended intervals between spraying and harvest" (Tawatsin et al., 2015). They also recommended that "to reduce the intensive use of pesticide, it is an urgent need to promote organic farming practices".

Laohaudomchok et al. (2021) reported the current situation concerning the health risks of pesticide use in Thailand based on the results of the Southeast Asia GEOHealth Network Meeting of February 2019. It concluded that widespread and poorly regulated use of pesticides presented a potential risk to the health of the general population as well as that of farmers and called for the necessity of research to evaluate the long-term health effects of pesticide exposure since there were still significant gaps in research and policy.

Table 6 Summary of Literature on Pesticide Residue of Vegetables and Fruits in Thailand

Authors	Commodities	Area for sampling	Key points
Wanwimolruk et al. (2015a)	Watermelon Durian	Markets including supermarkets located in eight provinces including and surrounding Bangkok	• Twenty-eight pesticides were tested. They were widely used in agriculture in Thailand. • Out of 105 samples in total, no samples were detected with pesticide residue over the MRL, with the exception of one sample (Durian). • Out of 75 samples for watermelon, pesticide was detected in 68 (90.7%). • Out of 30 for durian, the pesticide was detected in 27 (90%), including 1 sample over the MRL.
Wanwimolruk et al. (2015b)	Chinese kale	12 local markets located in Nakhon Pathom Province near Bangkok	• Twenty-eight pesticides and two metabolites of carbofuran were tested. They were widely used in agriculture in Thailand. • Out of 117 samples, 34 (29%) were detected pesticide over the MRL.
Phopin et al. (2017)	Mangosteen	38 markets (local and supermarket) located in 11 provinces, including and surrounding Bangkok	• Twenty-eight pesticides and two metabolites of carbofuran were tested. They were commonly used in agriculture in Thailand. • The pesticide was detected in all samples (n=111). • For 97% of samples, pesticide exceeded the MRL. • The data showed edible pulp containing much less pesticide residue. • Washing fruits before eating was an effective way to reduce pesticide residue.
Wanwimolruk et al. (2016)	Chinese kale, Pak choi, Morning glory	Local markets and supermarkets located in 7 provinces, including and surrounding Bangkok	• Twenty-eight pesticides and two metabolites of carbofuran were tested. They were widely used in agriculture in Thailand. • In almost all samples (n=137 for Chinese kale, n=125 for Pak choi, and n=135 for morning glory), pesticide was detected. • It has a remarkably high rate of exceedance of the MRL (35 to 71%) • The rate of exceedance of the MRL was similar between the vegetables from local markets and supermarkets.
Thai-PAN (2016)	16 fruit/vegetables	Three modern supermarkets (Big C, Makro, and Tesco) and three wholesale fresh markets in Thailand (Bangkok, Nakorn Pathom province, and Ratchaburi province)	• Out of 158 samples, 56% had residues above the MRL. • In 29 samples out of 158, pesticides classified into type 4 or 3 (Note) were detected. Type 4: hazardous materials which were no longer allowed to be used in Thailand. Type 3: hazardous materials which had not been authorized for use by the Department of Agriculture.

Vietnam

Since 1986, Vietnam has opened to the outside world under the Doi Moi policy, focusing on economic reform. Agriculture has been restructured: crop diversification, more cash crop production (including vegetables), more international trade of agricultural inputs and products, and increasing application of agricultural inputs (Hoi et al., 2009). Between 1991 and 2007, pesticide use in Vietnam increased from 15,000 to 76,000 tons. The expenditure on pesticide imports even increased 9.8 times between 1991 and 2006. Consequently, consumers were increasingly concerned and faced food risks associated with chemical residues (Hoi et al., 2009).

Within this social context, on 26 July 2003, the Vietnamese government issued the "Ordinance of Food Safety and Hygiene (SRV 2003)", in which food business operators were legally responsible for the safety and hygiene of foods they produced and traded in the Article 4 (Hoi et al., 2009). Before implementing this policy, the Vietnam Ministry of Agriculture and Rural Development (MARD) launched the "Safe Vegetable" program in 1998. Its main objective was to plan and monitor areas for safe vegetables based on specific regulations targeting minimum residue levels of chemical pesticides, fertilizer, heavy metals, and nitrate (Ngo et al., 2019). In conjunction with the program, a series of safety standards were developed, namely *Rau An Toan* (RAT), meaning "safe vegetables" in Vietnamese, organic, and VietGAP (see Table 7).

Table 7 Development of Standards for Safety Vegetable Production in Vietnam

	RAT (Safe vegetables)	Organic	VietGAP
Year developed	1998	2006	2008
Development partner	No information	ADDA	Syngenta foundation
Type of standards	Public/voluntary standard	Private/voluntary standard	Public/voluntary standard

Note: ADDA= Agricultural Development Denmark Asia.

Source: Pham (2017)

In spite of this history and development of food safety policies and regulations, including the government effort to manage the safety of pesticides, much literature mentions the limitations of these efforts in terms of efficacy. Referencing data on the increase in pesticide use in Vietnam between 1991 and 2007, Hoi et al. (2009) indicated that the safe vegetable production and distribution system had not yet been able to take a significant share of the vegetable market despite the effort and investment by state authority over ten years. They suggested that the reason behind this was distrust of private arrangements in food governance from market actors, especially from consumers, due to the problems in transparency and the involvement of market actors. Their study was followed up by Hoi et al. (2016).

Ngo et al. (2019) also pointed out the limitations of the "safe vegetable" program policy, in which 80% of safe vegetables were distributed to traditional markets without price premiums. They also mentioned that the food traceability system in Vietnam was at a very early stage compared with developed countries. From the consumers' point of view, Ha et al. (2019) conducted a face-to-face survey with consumers in Hanoi. They concluded that consumers experienced a high level of anxiety about food safety and suggested the importance of better risk communication to eliminate consumer fear in both rural and urban regions.

Finally, there are very little published data on chemical residues for Vietnam in English literature, especially in comparison with Thailand, except for the World Bank (2006) and Ngo et al. (2019). The latter introduces the data reported by national TV programs, where the proportion of vegetables exceeding MRL is over 10% nationwide, according to data from MARD.

Lao PDR

In 2017, a Decree by the Prime Minister on Pesticide Management was promulgated to improve the protection of the environment and human health, calling for inter-ministerial collaboration to strengthen pesticide management (Food and Agriculture Organization of the United Nations, 2018; Laohaudomchok et al., 2021). Before establishing the Prime Minister's decree, a national inspection scheme for pesticide distribution existed but was not actionable (Food and Agriculture Organization of the United Nations, 2018). Unfortunately, there is little information available after the establishment of the Prime Minister's decree. However, according to the situation analysis report on pesticide monitoring program of ASEAN countries compiled by the Food and Agriculture Organization of the United Nations (2021), Lao PDR is classified at the "basic" level in terms of pesticide residue monitoring capacities by their self-evaluation (see Table 8).

The country established LaoGAP in 2008, adopted from ASEANGAP. It is contained in four production systems (see Table 1) and has been promoted under CA policy by the Lao government. In 2011, MAF issued Standards for Good Agriculture Practices for the Safety of Crop Produce (Decree No. 0115/MAF, 27 January 2011). In 2022, it was renewed as the MAF Minister's Decree No. 3004/MAF containing the principles, rules, regulations and measures regarding the management, monitoring, inspection, and utilization of techniques in compliance with LaoGAP to ensure high quality and safe production for consumers, as well as the LaoGAP Standards. Lao GAP is a voluntary national program containing four modules, namely the safety of crop produce, the environment, workers, and production quality, in alignment with ASEANGAP.

According to the Division of Standard and Certification of MAF, the production in line with LaoGAP was 399 ha, 55 farms with 262 farmers located in Vientiane Capital, Vientiane Province, and Champasack Province in 2020. The commodities were fruits and vegetables, such as melon and lettuce. Then, they were sold to big supermarkets such as Pakson Mall in Vientiane Capital, though the quantity was very small.

Table 8 Comparison of the Four Countries in the Mekong Region Concerning the Level of Pesticide Residue Monitoring Capacities

	Thailand	Vietnam	Lao PDR	Cambodia
Level of pesticide residue monitoring capacities (*)	Intermediate	Intermediate	Basic	Basic
Government agency responsible for pesticide registration authority	Yes DOA/MOAC	Yes PPD/MARD	Yes DOA/ MAF	Yes MAFF
The government agency responsible for setting up MRL	Yes ACFS/MOAC	Yes MH	Yes DOA/MAF (**)	Yes/No MAFF (**)
Government agency responsible for public health/food safety	Yes Thai FDA/ MPH	Yes MH	Yes FDD/MOH	Yes/No MOH, MAFF, MOC, MISTI
Government agency responsible for pesticide control use	Yes DOA/MOAC	Yes PPD/MARD	No DOA/MAF	Yes/No DOA
The government agency responsible for the management of pesticide residue monitoring	Yes Multi-agency	Yes PPD/MARD	Yes FDD/MOH DOA/MAF	Yes/No DOA
Pesticide-related activities the country wishes to undertake but is currently unable to do	-Effective risk-based monitoring programs -Traceability in the food chain	Residue monitoring on export	-Importing fruits/ vegetables -Exporting crops	Monitoring residue program in fresh fruits and vegetables

Note: ACFS: National Bureau of Agricultural Commodity and Food Standards, DOA: Department of Agriculture, FDD: Food and Drug Department, MAF: Ministry of Agriculture and Forestry, MAFF: Ministry of Agriculture, Forestry and Fisheries, MARD: Ministry of Agriculture and Rural Development, MH: Ministry of Health, MISTI: Ministry of Industry, Science, Technology and Innovation, MOAC: Ministry of Agriculture and Cooperatives, MOC: Ministry of Commerce, MOH: Ministry of Health, MPH: Ministry of Public Health, and PPD: Plant Protection Department.

(*) The definition of the three categories for response to the FAO questionnaire concerning self-evaluation of residue monitoring capacities. Basic capacity: None-to-fair capacity, which can be described as a development stage, commencement, limited monitoring, or sporadic monitoring. Intermediate capacity: at least some data have been produced and are easily accessible. Regular monitoring activity of at least one pesticide/commodity exists, but data are not enough to achieve the desired results. Advanced capacity: regular monitoring of key pesticides/commodities is taking place, and capacity is already developed and sustainable.

(**) These countries set their MRL from Codex MRL instead of their own MRL.

Source: Food and Agriculture Organization of the United Nations (2021)

Cambodia

There is very little literature on Cambodian food safety in comparison to Thailand and Vietnam. In Cambodia, the Food Safety Law was established in 1997, followed by the Law on Cambodia Standards in 2011 and the Law on Management of Quality and Safety Products and Services in 2018.

At the federal level, food safety is governed by six ministries: The Ministry of Health, Ministry of Agriculture, Forestry and Fisheries, Ministry of Tourism, Ministry of Commerce, Ministry of Industry and Handicraft, and Ministry of Economy and Finance. To date, national

food safety initiatives have focused largely on the chemical contamination of food products, including production-related chemicals like pesticides (Ebner et al., 2020). The same report by the Food and Agriculture Organization of the United Nations (2021), as mentioned for Lao PDR, indicates that Cambodia is classified at the "basic" level in terms of pesticide residue monitoring capacities by their self-evaluation (see Table 8).

As the other countries in the Mekong Region, the Cambodian government set out its national GAP in 2010. It reflected that quality and safety of agricultural products was critical requirement for producing countries in the context of global and regional trade (Department of Plant Protection Sanitary and Phytosanitary, General Directorate of Agriculture (GDA), Ministry of Agriculture, Forestry, and Fisheries, 2020).

Survey data on chemical residues in food is also very limited. Schreinemachers et al. (2020) conducted a survey on those farmers producing leaf mustard and yard-long beans and indicated that 73% of sampled farmers overused pesticides above the optimum level. Wang et al. (2011) collected data on Organochlorine Pesticides (OCPs) from the three regions of Cambodia. They implied that there was a cancer risk for residents of these regions, presenting the result of much higher exposure to OCPs than developed countries, including Europe.

Discussion

In developing countries, especially those in Southeast Asia, the use of agricultural chemicals has increased after the Green Revolution, which pushed productivity and crop yield drastically (Hoi et al., 2009; Schreinemachers et al., 2015; Tawatsin et al., 2015; Hoi et al., 2016; Schreinemachers et al., 2020). As a result, social concerns about the excessive use of agricultural chemicals have appeared both at the consumption level as well as at the production level, namely the issue of farmers' health while working. In response to this trend, the policy direction of these countries has moved to promote environmental conservation and sustainable development rather than just focusing on increasing productivity using abundant chemicals. At the same time as this paradigm changes, demand on the production side also changes. It becomes more diversified and shifts to more vegetables and fruits than stable foods such as rice.

In the context of these trends, the governments of countries in the Mekong region established policies for chemical reduction in agriculture. For example, the Thai government advocated 'from-farm-to-table' in 2004, aiming to ensure a food safety monitoring and control system throughout the food chain. Vietnamese government launched the 'safety vegetable' program in 1998. Their approach is to monitor and control the chemical residues of agricultural products with reference to the MRL by the FAO/WHO *Codex Alimentarius* Commission. However, the efficacy of these regulations has been very limited because of the insufficient enforcement of the regulations without a sufficient monitoring system, especially for the domestic market. Food and Agriculture Organization of the United Nations (2021) pointed out that a comprehensive pesticide risk management framework was key for the success of a national monitoring program. However, it was not attained at a sufficient level in

ASEAN member countries, even in Thailand and Vietnam, whose self-evaluation for pesticide residue monitoring capacity was "intermediate".

GAP is employed to control and monitor food safety, but a lack of confidence in food safety still exists in the domestic market (Wongprawmas et al., 2015). The involvement of the public sector and cooperatives is the reason for the low level of dissemination of VietGAP to farmers (Pham, 2017). Under these circumstances, chemical residues in agricultural products remain a social issue in these countries, and less confidence in agricultural products from consumers has continued through the various extent from country to country (Hoi et al., 2009; Panuwet et al., 2012; Hoi et al., 2016; Thai-PAN, 2016; Ebner et al., 2020).

The promotion of OA is another solution to prevent the use of chemicals in agriculture. However, it has only been recently that the governments of Thailand and Vietnam adopt this as their national policies. The development of OA in Thailand was commenced as a private initiative previously. However, now the government has also supported it by including it in the national policy while promoting OA in Vietnam has just begun.

In contrast, the government of Lao PDR advocated the Clean Agriculture Policy as an agricultural development strategy for 2006-2010, aiming at the reduction of excessive use of chemicals by means of conceivable measures, such as OA, GAP, and pesticide-free agriculture, integrating it into national policy. Among these measures, OA has been developed, especially in vegetable and fruit production, under the national policy with the support of international cooperation.

One successful model of Lao PDR is the organic market in Vientiane Capital, where vegetable and fruit production and the number of participant farmers are increasing year after year. An important point of success has been the adoption of non-chemical use agriculture by small-scale farmers. Examples of its success include i) higher premiums compared to conventional agricultural products and ii) direct sales by farmers to consumers at the market, which enables farmers to receive the profit from the sales revenue to avoid mismanagement of organic certified products. If distributors have managed OA products between farmers and consumers, larger quantities can be dealt with. However, the margins will be deducted from distributors while increasing the risk of mixtures with non-organic products through the supply chains.

Though there are no data on the income of OA farmers with comparable data of conventional farmers in Laos, the literature review on those examples in developed and developing countries concludes that organic farming is more profitable than conventional farming in general due to the degree of reduction of variable cost for agricultural chemicals and price premium exceeding the reduction of yield and labor cost (Crowder & Reganold, 2015; Shennan et al., 2017; Conrado, 2018).

In summary, there are two approaches to promoting policies responding to consumers' demand for chemical reduction: 1) monitoring of the MRL by government agencies to provide confidence to consumers, and 2) promotion of OA, which ensures the absence of chemicals in products if the certification system is functional. The former approach is used by Thailand

and Vietnam, as shown in the research, while the Lao approach is the latter. Ideally, these two approaches should be effectively implemented simultaneously to provide consumers' confidence and achieve food safety for them. The MRL approach may have the advantage of directly identifying the problem, that is, products with excess amounts of chemical residue. However, it cannot work effectively in developing countries with systemic problems affecting its operation and enforcement. In addition, food industries in less developed economies, such as Laos, do not regulate their product purchasing, which will assure consumers that farm products are safe (Wanwimolruk et al., 2016; The Thailand Life, 2018).

On the other hand, the promotion of OA is more advantageous to smallholders, like most Lao farmers, without bargaining power when dealing with traders. This advantage should be enhanced by direct selling to consumers at OA markets operated by organic farmer groups with higher returns to farmers, as well as cost savings on certification fees and other operations by the formation of groups. Although the operation of OA has limitations again in terms of insufficient monitoring of OA certification, especially in developing countries, promoting OA will bring better revenue to farmers and safer food to consumers.

Conclusion

The literature contains numerous studies on activities in Mekong region countries for promoting initiatives to reduce chemicals in agricultural products. However, most of these studies indicate that chemical input in agricultural practice focuses on the MRL, even though effectiveness is limited due to insufficiency in the operational and regulatory systems.

In this regard, there are two main findings of this study. Firstly, chemical reduction in agriculture is a common concern in the countries in the Mekong region, reflected by farmers' health at the production level as well as food safety at the consumption level. It is affected by the transition from traditional agriculture to conventional agriculture in the region. Secondly, previously, the government in the Mekong region countries such as Thailand and Vietnam mainly focused on the MRL approach for reducing chemical use at the production level. In contrast, the Lao government promoted OA under its CA policy.

The Lao approach is unique from the point that it contributes to the improvement of food safety for consumers and income generation of farmers while at the same time promoting organic agriculture. The MRL approach is definitely essential to promote the reduction of chemical use in food safety. Then, OA still accounts for a small percentage of total agricultural production, especially in developing countries. However, the Lao initiative, whose policy goal is to help spread OA practices worldwide, deserves consideration by other developing countries where small-scale farmers are the majority.

Considering future research on the study, some solutions against challenges to promote OA, especially in developing countries, should be studied. If the Lao case is a reference, the method for promoting OA, especially at the initial stage, will be one research theme, while institutional and human resource aspects to ensure the credibility of the OA certification system can be other themes.

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