RESEARCH CENTER FOR RURAL DEVELOPMENT
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INTERNATIONAL POLLUTANTS ELIMINATION NETWORK

Report

ALTERNATIVES FOR REDUCING HIGHLY HAZARDOUS PESTICIDES IN RICE PRODUCTION: CASE OF THE AN GIANG PROVINCE, VIETNAM

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LIST OF ABBREVIATIONS

1M5R:	1 Must, 5 Reductions
3R3G:	3 Reductions, 3 Gains
ADDA:	Agricultural Development Denmark Asia
CIDCE:	International Center for Comparative Environmental Law
CT:	Directive of the Vietnamese Government
FAO:	The Food and Agriculture Organization
FFS:	Farmers' Field School
GAP:	Good Agricultural Practices
HYV:	High-yielding rice varieties
IFOAM:	International Federation of Organic Agriculture Movements
IPM:	Integrated Pest Management
MARD (BNNPTNT):	Ministry of Agriculture and Rural Development
MOST (BKHCN):	Ministry of Science and Technology
ND:	Decree of the Vietnamese Government
NQ:	Vietnamese national resolution
PIC:	Prior Informed Consent
POP:	Persistent Organic Pollutant
DPP:	Department of Plant Protection
QD:	Decision of the Vietnamese Government
QH:	Congress of Vietnam
TCVN:	Vietnam National Standard
ToT:	Training of trainers
TT:	Circular of the Vietnamese Government
TTg:	The Prime Minister of Vietnam
UNEP:	United Nations Environment Programme
VMD:	Vietnamese Mekong Delta
VOAA:	Vietnam Organic Agriculture Association
WB:	The World Bank
WHO:	The World Health Organization

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1. INTRODUCTION

The wet rice civilization has been formed and developed by the Vietnamese people over the past thousand years. It has not only fed the people, but also created a traditional culture throughout the country. In the past, rice cultivation in Vietnam was associated with traditional farming practices, significantly influenced by the soil, natural and climatic conditions, and water management by the ancient Viet people. Today, rice remains the dominant crop of Vietnam's agricultural sector, contributing substantially to both the national food security and that of the world. The farming practices of Vietnamese rice farmers have been changing over time to adapt to the social, economic, climatic, and natural conditions for thousands of years (Tran Van Dat, 2010).

High-yielding rice varieties (HYVs) have been introduced in many countries, including Vietnam, since the "Green Revolution" in the 1960s. Over time, traditional farming methods were gradually replaced by modern farming techniques in promoting the development of rice intensification in many Southeast Asian countries, and Vietnam in particular. HYVs showed many advantages as they could develop in a short period of time so that farmers could grow several crops per year. These modern rice varieties are also efficient in absorbing chemical fertilizers, which is convenient for mechanization in a large-scale commodity production as it gives a higher yield than traditional rice varieties. The irrigation infrastructure has been invested in to expand the HYV production areas, to form many specialized farming areas for easily applying agricultural chemicals, helping to continuously increase the rice production of Vietnam.

According to the General Statistics Office of Vietnam (GSO), the total rice productivity of Vietnam is about 43.5 million tons per year, an increase of nearly 74% compared to the year of 1995 (25.0 million tons/year). The current rice-cultivated area is 7.5 million ha, an increase of about 10.4% compared to 1995, and the average rice yield was nearly 6.0 tons per ha per crop, increasing nearly double compared to the rice yield in 1995 (3.2 tons/ha/crop). It is a fact that this significant increase in rice yield and productivity of Vietnam has stemmed from the development of HYVs which gradually have replaced the traditional rice varieties, along with a substantially intensified use of agrochemicals. The remaining cultivated area of traditional rice in 2020 was only 1.6 million ha, a significant decrease of nearly 38% compared to that of 1995 at 2.8 million ha (GSO, 2020). According to a report by the World Bank (2017), the average amount of pesticides used by rice farmers in the Vietnamese Mekong Delta (VMD) increased over the period from 1981-2010. The study showed that rice farmers applied on average 0.3 kg of active ingredients (ai)/ha/year (1981-1986), 0.4-0.5 kg ai/ha/year (1986-1990), 0.67-1.0 kg (ai/ha/year (1991-2000), and 2.54 kg ai/ha/year (2001-2017). Particularly, the average amount of active ingredients used in intensive-yield rice fields in An Giang, the largest rice production province of Vietnam, reaches 7.02 kg ai/ha/year instead of using 5.26 kg ai/ha/year which would have been the case if rice farmers adopted the “1 must, 5 reductions” model, which has been introduced by rice scientists as an alternative practicing model.

Since the early years of the development of HYVs, the Vietnamese government has considered the high adverse impacts of modern rice production on human health, ecosystems and environment resulting from rice farmers overusing agrochemicals in the fields. Several national extension programs and development projects have been carried out in many provinces to mitigate

these impacts. However, many challenges have emerged as these extension programs hardly cover and keep up with the prevalence and abuse of agrochemicals by rice farmers. The outcome of Decision No. 09-CT of the Council of Ministers (January 17, 1989) assigned to the Ministry of Agriculture and Rural Development (MARD) for management, has been no longer subsidizing for agrochemical losses. This policy was seen as a critical turning point in the privatization of the agricultural chemical trade, in which the government only participates through controlling the list of pesticides permitted to import and use (Le Thanh Phong and Tran Anh Thong, 2019). Consequently, many private importing and distributing agrochemical companies have been established throughout the country. Vietnam had nearly 28,750 pesticide retailers and wholesalers in 2013 (Vusta, 2013), and this number increased to 30,000 in 2018 (Vibiz.vn, 2018). Farmers could now easily purchase agrochemicals to use on their crops. For several decades, the expansion of cultivating areas and increasing the yield and productivity of rice could be perceived as a result of the political will to ensure national food security in Vietnam, causing farmers to apply more and more agrochemicals to maintain productivity. Over time, this has become a popular farming practice and rice farmers must rely heavily on agrochemicals in their rice production. In comparison with traditional rice varieties, HYVs give rice farmers a larger profit and improve the socioeconomic status of the country, yet this modern rice production method has created new adverse impacts on the environment. It has also influenced and changed the farming practices of Vietnamese rice farmers and the way they treat nature.

In recent years, the national economy has improved, so most Vietnamese consumers tend to put more attention on protecting human health and the environment and the middle- and high-income population demand safe and clean foods, especially organic agricultural products. In response, the government has recently issued many policies requiring agricultural producers and handlers to change their perceptions, attitudes and behaviors when it comes to using toxic pesticides in the fields.

Following our previous HHPs Country Situation report entitled *"Highly hazardous pesticides in Vietnam: a situational analysis",* this report continues to review Vietnam's national policy frameworks for reducing highly hazardous pesticides in rice production and investigate the actual performances in implementing and managing alternative farming practices so as to move away from intensively using chemical pesticides and replace them with biopesticides at both national and local levels. This paper seeks to: (1) identify national policy frameworks and relevant stakeholders participating in the substitution of chemical pesticides with biopesticides in rice production; (2) understand the implementation of new alternative models that are safe for human health and environmentally friendly to replace toxic pesticides in rice production; (3) provide some specific practicing models as examples of replacing pesticides with biopesticides as new initiatives in rice production in the An Giang province of the Vietnamese Mekong Delta.

2. KEY ANALYSIS

2.1. The national policy frameworks on managing pesticides

2.1.1. General management of pesticides

The issue of agrochemicals and especially that of pesticides, is a professional area that has been strictly controlled by the Vietnamese government, from import, production, and distribution to the application in the fields. Laws related to the management of pesticides and biopesticides include: the Law on Plant Protection and Quarantine No. 41/2013/QH13, the Law on Chemicals No. 06/2007/QH12, the Law on Quality of Products and Goods No. 06/2007/QH12, and the Law on Standards and Technical Regulations No. 68/2006/QH11. The management and approval of internal processes for handling administrative procedures in the field of plant protection are assigned by the Vietnamese government to the Ministry of Agriculture and Rural Development (MARD). The MARD concretizes the Laws and the operation of pesticide management through sub-law documents such as Circulars and Decisions within its jurisdiction. Circular No. 21/2015/TT-BNNPTNT issued on June 8, 2015, on "Management of pesticides" regulates the procedures from new product registration, testing, production, and distribution to sales of pesticide products. Circular 12/2018/TT-BNNPTNT issued on October 5, 2018, on "Promulgating national technical regulations on pesticide quality" (which replaces Circular No. 38/2010/TT-MARD, 2010) regulates and manages the quality of pesticides through legal instruments. Annually, the MARD has issued Circulars on "Promulgating the list of pesticides allowed for use, and those banned, in Vietnam", (called "List of Pesticides" in short). Recently, Circular No. 10/2020/TT-BNNPTNT on "Promulgating the List of Pesticides" has also been issued, on September 9, 2020.

In addition to the legal management exemplified above, all plant protection substances imported, produced, and distributed in Vietnam need to comply with the provisions of a number of international conventions, regulations, and laws including: (1) The International Code of Conduct on Pesticide Management highlighted by the Food and Agriculture Organization (FAO), (2) The environmental rule of law promulgated by the UN Environment Program (UNEP), (3) Occupational Safety and Health Regulations issued by the World Health Organization (WHO), (4) the Rotterdam Convention, (5) the Stockholm Convention, (6) the Basel Convention, and (7) the Montreal Protocol.

According to Circular 12/2018/TT-BNNPTNT, dated October 5, 2018, issued by the MARD on "Promulgating national technical regulations on the quality of pesticides", the state inspection agency on the quality of imported pesticides must be the Department of Plant Protection, or the appropriate assessment body authorized by the Department of Plant Protection, to conduct inspections under the scope specified in the authorization decision **(Article 3).** The legal framework for agrochemicals management in Vietnam is summarized in **Table 1**.

Table 1. Legal framework for import, production, distribution, and use of agrochemicals in Vietnam

Organization	Document type	Contents
1. International		
UN	Convention	- Stockholm Convention on Persistent Organic Pollutants (POPs) (2001)
		- Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (PIC) (1998)
		- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989)
FAO	Code of Conduct	- International Code of Conduct on Pesticide Management (2014)
FAO & WHO	Guidelines	- Manual on technical guidelines and standards applicable to pesticides for use in agriculture (First Edition, 2016)
2. Vietnam		
2.1. National level		
National Assembly	Law	- Law on plant protection and quarantine (2013)
- Committee of the National Assembly	Ordinance	- Ordinance on Plant Protection and Quarantine (2001)
Government	Decree	- Decree on regulations for plant protection, regulations for plant quarantine and regulations for the management of pesticides (2002)
- MARD - Plant protection inspector - Other relevant Ministries	Circular	- Circular on promulgating the List of Pesticides allowed for use, and those banned from use in Vietnam.
	Circular	- Circular on pesticide management (Ex: TT21/2015/TT-BNNPTNT)
	Decision	- Internal process for dealing with administrative procedures in the field of plant protection within the scope of the management functions of the MARD
	Decision	- Decisions to allow or prohibit a plant protection substance
- Department of Plant Protection and other relevant departments - Plant protection inspector	Decision	- Decisions on state inspection of pesticide management such as the import, production, distribution, and use of pesticides, including bio-agrochemicals. - Decisions on quality standards and quality control related to pesticides.

Organization	Document type	Contents
	Guidelines	- Official documents guiding the implementation of pesticide management
2.2. Local level		
- Provincial Department of Agricultural and Rural Development - Provincial plant protection inspector - Relevant Departments	- Decision - Plan	- Decisions on administrative sanctions, regulating illegal matters in the field of plant protection - Plans for implementing national and provincial programs in the field of plant protection - Comply with the provisions of the current law
- Provincial Sub-department of Plant Protection - District Plant Protection Station	- Plans - Guidelines - Suggestions	- Comply with the provisions of the current law - Direct implementation, monitoring, and handling

2.1.2. National policies on producing and importing biopesticides

Biopesticides are authorized under the Ministry of Agriculture and Rural Development, of which the Department of Plant Protection is the unit that directly manages the industry in terms of production, import, and distribution for use in Vietnam. All pesticides are governed by a set of laws and regulations as shown in **Table 1.** According to the regulations of the MARD, any pesticide products submitted for official registration, trade mark, or mixture in Vietnam must be tested for their biological large-scale effects (National Standard 12561, 2018).

According to the Department of Plant Protection (DPP) (2020), pesticide management agencies and relevant stakeholders should assess the production, registration, trading, and use of pesticides in general, and biopesticides in particular, both globally and nationally. It is expected that by the year 2025, the number of registered biopesticides in Vietnam will grow to 30% and the number of biopesticides being applied in the fields will increase to 20%. The cultivated land area being applied with biopesticides is anticipated to expand from 3% to 5% annually. About 15% of companies is expected to be able to apply innovative technologies for biopesticides production compared to current levels. Concrete solutions to support the advancement of the biopesticides production are:

- To raise awareness and influence change in food producers' behavior on the role and benefits of using biopesticides and limiting the use of agrochemicals in the fields.

- To improve the quality and effectiveness of national agricultural extension programs on good agricultural practices (GAP), safe agricultural production, and the use of alternative biotechnologies to replace pesticides to ensure food safety and protect the environment.

- To strengthen the governmental management of clean, safe, and organic agricultural products.

- To prioritize and allocate research funding for the development and production of biopesticides for agricultural production in Vietnam.

- To improve technical facilities and infrastructures for research, trial production of probiotics, capacity building, and international cooperation in science and technology in the field of research and application of biopesticides. Active ingredients of biological origin such as Anacardic acids, Laminarin, Verticillium chlamydosporium, Quilaja sponarria (Soap-bark tree), Capsacin, Talin (made from thaumatin), among others, are being considered for early inclusion in the "List of pesticides permitted for use in Vietnam".

- To encourage companies to cooperate with educational institutes, universities and research centers to conduct research to develop biopesticides in Vietnam.

- To create legal favorable conditions for the registration of biopesticides.

2.1.3. National implementation on managing pesticides

a. Elimination of Highly Hazardous Pesticides

In order to gradually eliminate pesticides, in the period from 2017 to 2019, the Ministry of Agriculture and Rural Development (MARD) made 5 decisions to prohibit 13 kinds of pesticides with 414 mixed active ingredients and 782 trade names (**Table 2**). The MARD has also issued various decisions to support biological pesticide production companies at the local level, which are presented in **Figure 1**.

Table 2. List of active ingredients and number of trade names of toxic pesticides that were restricted from import and use in 2017-2020

Year	No.	Active ingredient	Number of active ingredients	Trade names	Decision
2017	1	Carbendazim	68	109	03/QD-BNN-BVTV (03/01/2017)
	2	Benomyl	6	16	03/QD-BNN-BVTV (03/01/2017)
	3	Thiophanate Methyl	48	48	03/QD-BNN-BVTV (03/01/2017)
	4	2.4 D	4	36	278/QD-BNN-BVTV (08/02/2017)
	5	Paraquat	2	46	278/QD-BNN-BVTV (08/02/2017)
	6	Trichlorfon	5	10	4154/QD-BNN-BVTV (16/10/2017)
2018	7	Acephate	3	15	3435/QD-BNN-BVTV (28/08/2018)
	8	Diazinon	2	16	3435/QD-BNN-BVTV (28/08/2018)
	9	Malathion	2	2	3435/QD-BNN-BVTV (28/08/2018)
	10	Zinc Phosphide	1	2	3435/QD-BNN-BVTV (28/08/2018)
2019	11	Chlorpyrifos Ethyl	173	235	501/QD-BNN-BVTV (12/02/2019)
	12	Fipronil	91	143	501/QD-BNN-BVTV (12/02/2019)
	13	Glyphosate	9	104	501/QD-BNN-BVTV (12/02/2019)
Total		**13**	**414**	**782**	

Source: *MARD, 2017, 2018 and 2019*

b. Import and distribution of biopesticides

Figure 1 shows the increasing number of companies engaging in importing, packaging, and distributing biopesticides from 1996 to 2020. From 1996 to 2000, there were only 10 enterprises engaging in biopesticide businesses. However, the number of registered biopesticides companies increased significantly from 10 to 244 biopesticides enterprises from 2000 to 2015. The number of biopesticides enterprises remained the same during the period of 2015 - 2020. These enterprises were initially importing agrochemicals. Later, they applied for registration, including testing, verification, branding, packaging, and distribution of biopesticide products. These biopesticides production enterprises have a network of distributing agents on different levels, from wholesalers to retailers, in many localities. The Ministry of Agriculture and Rural Development has estimated that there are more than 30,000 agents distributing pesticides throughout the country. When it comes to biopesticides, domestic companies produce only 0.5% of all biopesticide products, so the remaining 99.5% need to be imported. Vietnam imports nearly 100,000 tons of pesticides annually, of which about 15,000 tons (15%) are biopesticides (Son Trang, https://nongnghiep.vn, 2020). Despite the high demand for pesticide use in the fields, the production capacity of Vietnamese companies is no more than 75 tons of biopesticides per year. To increase the number of biopesticides produced to about 20%, in accordance with the national plan, Vietnam needs to improve its national production capacity without delay.

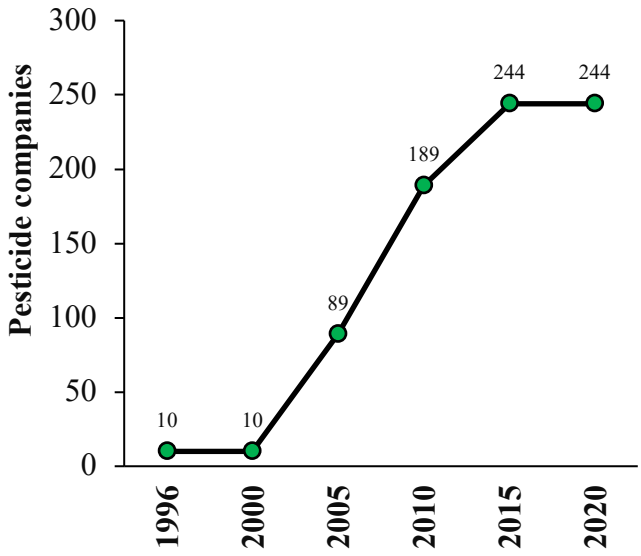


Figure 1. Number of biopesticide companies in Vietnam, 1996-2020

c. Current state of biopesticide use

**** National level:***

The "List of Pesticides allowed for use, and those restricted and prohibited from use in Vietnam" is an important legal document to guide relevant stakeholders such as pesticide manufacturers, distributors and users. By 2010, these documents were well prepared, however, discontinued and rarely updated. Since 2011, the list of pesticide trade names and active incredients has been more regularly updated.

The versions of the "List of Pesticides" in Vietnam issued in 1996, 2000, 2005, 2010, 2015 and 2020 indicate that:

- There were only 14 active ingredients of pesticides granted registration for use in Vietnam in 1996. In the period from 2000 to 2015, the number of active ingredients increased from 296 to 1,758 *(more than 5.9 times compared to 1996)*. In 2020, this number increased to 1,832 active ingredients *(more than 6.2 times compared to 1996 and more than 4.2% compared to 2015),* of

which 104 active ingredients (5.7%) are HHPs. The numbers of active ingredients of both pesticides and biopesticides have been increasing, however, the number related to pesticides tends to rise quicker than that related to biopesticides. Currently, there are 60 active ingredients (**Appendix 1**) being considered as a single biological origin that contribute to the development of different kinds of biopesticides. The number of active ingredients related to biopesticides has increased over the years, from 51 (10.3%) in 2005, to 132 (13.0%) in 2010, 209 (11.9%) in 2015, and 221 (12.1%) in 2020 **(Figure 3**). Vietnam has promulgated many policies to promote clean and safe agricultural production. Hence, the number of biopesticide active ingredients is estimated to increase quickly in the coming years.

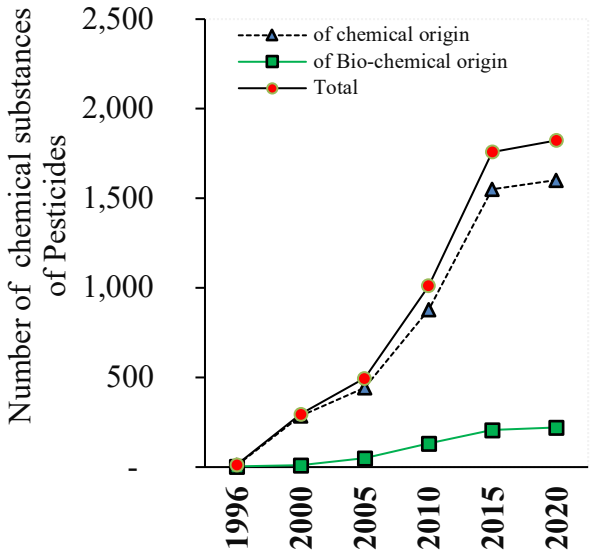


Figure 2. Number of active ingredients of pesticides and biopesticides allowed for use in Vietnam, 2000-2020

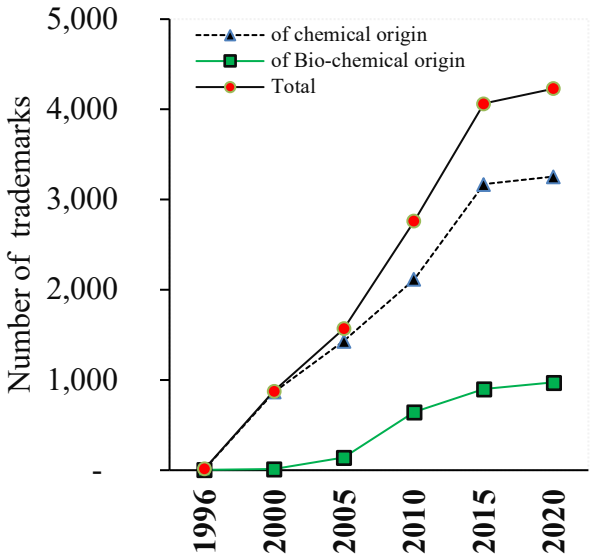


Figure 3. Number of trademarks of pesticides and biopesticides approved for registration in Vietnam, 2000-2020

- Similarly, the amount of trade names registered for pesticides have also increased over the period (**Figure 3**). In 1996, there were only 14 trade names registered, however, after that the number of pesticide trade names has increased quickly, from 876 in the year 2000, to 1,568 (2005), 2,762 (2010), 4,065 (2015), and 4,229 (2020), respectively. In comparison, the amount of trade names related to biopesticides were 10 (1.1%) in 2000, 138 (8.8%) in 2005, 645 (23.4%) in 2010, 897 (22.1%) in 2015), and 974 (23.0%) in 2020. The number of pesticide trade names was on average 2.4 times the number of active ingredients. This means that one single active ingredient could on average be included in 2 or 3 different commercial trademarks.

The graph in **Figure 4** illustrates a comparison between the number of trademarks and active ingredients in pesticide and biopesticide products from 2005-2020. Over time, the ratio between trade names and active ingredients of pesticides demonstrates a tendency to decrease. In contrast, although the active ingredients of biopesticides increased slightly, the number of trademarks for biopesticides increased sharply from 2010 to 2020. This development has reduced the ratio of trademarks of pesticides/biopesticides, from 10.4 in 2005 to 3.3 in 2020, and the

number of active ingredients of pesticides/biopesticide has decreased from 8.7 in 2005 to 7.2 in 2020.

An analysis of the data generated from the "List of Pesticides" in 1996, 2000, 2005, 2010, 2015, and 2020 (**Figure 2** and **Figure 3**), combined with the ratio figures (**Figure 4**) shows that: (1) The Vietnamese government has encouraged farmers to use biopesticides since the early 2000s; (2) During the period 2000-2015, the number of active ingredients in both pesticides and biopesticides has increased. Statistics from 2020 show that the number of trademarks of biopesticides contribute to 12.1% and the active ingredients of biopesticides contribute to 23% of the total number of pesticides available in Vietnam; (3) From 2015 to 2020, the amount of trade names of pesticides has tended to decrease because some trade names have been removed from the List of pesticides (**Table 2**) and farmers have preferred to use more bio-chemical products (**Figure 4**).

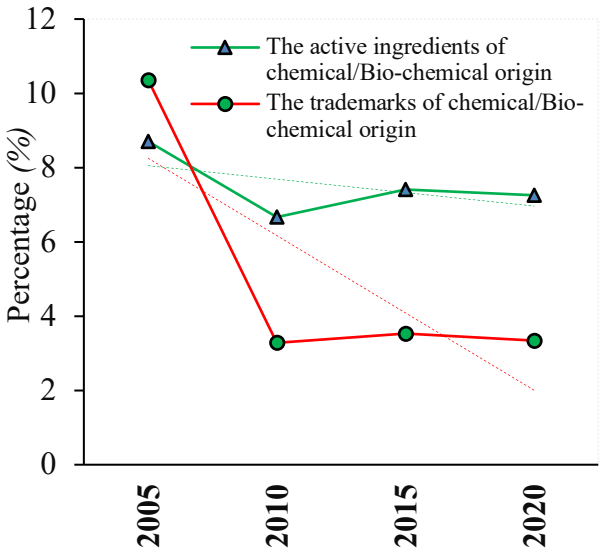
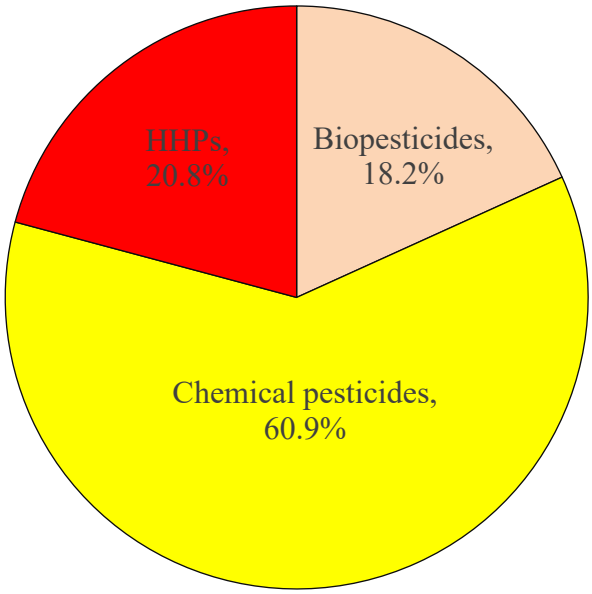


Figure 4. Comparison between the amounts of registered trademarks and active ingredients in pesticides and biopesticide products, 2005-2020

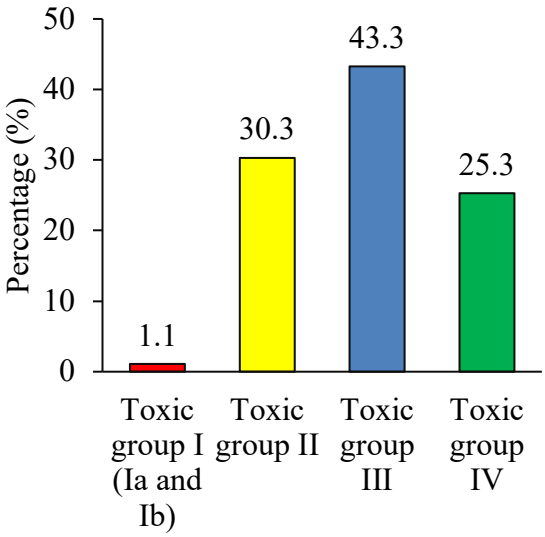
**** Provincial level:***

The An Giang province is the second largest rice production district in Vietnam, with a total cultivated area of about 775,317 ha/year. The cultivated land used for three rice crops per year is nearly 66% of that and for two rice crops per year is 34%. The total rice production is about 4 million tons per year (An Giang Statistical Office, 2019). Local farmers have intensified their rice production using dyke systems for several years. The cultivated land has been exhausted because farmers tend to apply more and more agrochemicals for the intensive rice production. In addition, the soil fertility has significantly decreased as many parts of the delta have no longer received sediments from annual floods due to embarkments and high-dyke constructions. Under these adverse impacts of environmental pollution, land degradation, and water scarcity in the Vietnamese Mekong Delta, together with the negative impacts of the climate change and upstream hydropower dam constructions, the local government of the An Giang province has carried out many agricultural development programs, especially focusing on rice production, to improve the environment and help farmers to adapt. These programs will be presented in section 2.4 *Some typical good farming practices and alternative models to reduce pesticide use in rice production in the An Giang province*.



Source: Survey, 2019

Figure 5. Percentages of pesticides and biopesticides used in the An Giang province



Source: Survey, 2019

Figure 6. Groups of pesticides being used by the farmers in the An Giang province

A study by the An Giang University on using byproducts of rice to generate energy (Pitea project - An Giang) shows that each year the An Giang province consumes 6,153 tons of pesticides, of which 45.2% are herbicides, 14.9% insecticides, and 39.9% fungicides. An analysis from a survey of 150 rice farmers in 6 districts of the An Giang province showed that there were 192 brands of pesticides being applied by farmers for three crops in 2019-2020. The study shows that rice farmers used 60.9% of pesticides with chemical substances, 20.8% of HHPs,[1] and 18.2% of biopesticides (**Figure 5**). An analysis from a household survey performed in 2020 also indicates that rice farmers applied chemical pesticides in the rice fields from toxic group I (Ia and Ib)[2] (1.1%), toxic group II[3] (30.3%, including HHPs), toxic group III[4] (43.3%), and toxic group IV[5] (25.3 %) (**Figure 6**). The color symbols on pesticide containers grading their toxicity levels are shown in **Figure 7**.

[1] *Based on PAN International List of Highly Hazardous Pesticides 2019.*
[2] *Ia: extremely hazardous, Ib: highly hazardous with the code PMS red 199C in Annex 3 - Hazard colour bands of FAO and WHO classification*
[3] *II: moderately hazardous with the code PMS yellow C in Annex 3 - Hazard colour bands of FAO and WHO classification*
[4] *III: slightly hazardous with the code PMS blue 293 C in Annex 3 - Hazard colour bands of FAO and WHO classification*
[5] *IV: very slightly hazardous with the code PMS green 347 C in Annex 3 - Hazard colour bands of FAO and WHO classification*
Link: https://apps.who.int/iris/bitstream/handle/10665/195650/9789241509688_eng.pdf;jsessionid=4B42C0E0F70AC313A36B135DA1160BDE?sequence=1

Figure 7. The hazard colour bands on pesticide labelling in Vietnam

2.2. National policy framework promoting the development of agroecological-based farming systems to reduce toxic pesticides

2.2.1. National policy framework of Integrated Pest Management

The Ministry of Agriculture and Rural Development has implemented many policies and solutions to improve farming techniques, in which various pest management models for rice production have been tested and applied in the fields to improve production efficiency and in doing so to improve the income of rice farmers in Vietnam and the VMD. The first technical solution of cultivating rice with a biological approach is the integrated pest management (IPM), followed by the "3 reductions, 3 gains" (3R3G),[6] which was seen as a successful technical innovation in 2005 (Decision No. 1579 QD/BNN-KHCN, June 30, 2005). The 3R3G program has had a remarkable effect. This solution has been replicated and applied in many farming households and communities. Recently, the cultivation technique "1 must, 5 reductions" (1M5R)[7] has continued to be introduced by the International Rice Research Institute (IRRI) and is also considered a technical advancement in rice production.

Integrated Pest Management (IPM) is an integrated farming model introduced by the World Food and Agriculture Organization (FAO) in 1992. IPM is a pest management system based on the observation of the environment, specific ecological conditions, and the fluctuation of the pest species, and then using appropriate technical means and measures to control the pest population below the threshold of economic harm (Agriculture Vietnam, 2010).

The Department of Plant Protection (DPP) under the Ministry of Agriculture and Rural Development (MARD) is the direct implementation unit. IPM programs of FAO in Vietnam, the IPM component of DANIDA - Vietnam Agriculture Sector Program (ASPS), and the Asian Biodiversity Conservation and Development Program (BUCAP) directly support the Department

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[6] *The three reductions: the amounts of seeds, fertilizers, and insecticides; The three gains: better yields, quality and economic efficiency.*

[7] *"One must" recommends that farmers must use "certified seeds"; "Five Reductions": reducing seed amounts, fertilizers, pesticides, water use, and post harvest losses.*

of Plant Protection to implement the IPM program. In 1994, MARD established the national IPM Program Steering Committee with representatives from 9 relevant ministries and social organizations: MARD, Ministry of Planning and Investment, Ministry of Natural Resources and Environment, Ministry of Health, Ministry of Finance, Ministry of Education and Training, the Vietnam Farmers Union, Vietnam Women's Union, and the Central Ho Chi Minh Communist Youth Union (DPP, 2006).

The overall goal of the IPM Program is to help improve farmers' decision-making abilities, through enhancing their knowledge and skills to ensure effective production on the basis of protecting human health and the environment. The specific objective of the IMP program is to improve the capacity and awareness of agricultural staff and farmers to understand the relationship between fertilizers, pests and the development of crops, which will make farmers able to use the appropriate number of seeds, reduce excess nitrogen use and the use of pesticides, and create good conditions for plants to grow, which as a consequence can help to increase productivity, product quality, and economic efficiency.

The four basic principles of the IPM program are: a) Healthy plants (applying appropriate farming practices such as: good seeds, resilient crop variety, correct sowing time and suitable crop density, balanced fertilizer application, and timely care to achieve healthy rice, resistant to pests and diseases and unfavorable conditions); b) Protection of natural enemies (understanding how to protect natural enemies that eat pests in the fields); c) Regularly visiting the field to grasp the field situation and take timely measures; d) Make farmers become experts (on the basis of knowledge and proficiency, so that farmers become key actors to help the community).

The IPM program has been widely deployed by the MARD in Vietnam and the VMD. Specifically, this program has supported Training of Trainers (ToT) and trained farmers through in-field classes by the Farmers Field School (FFS). With the trainee-centered approach, using the fields as the training ground, providing specific instructions right on the field, this has helped farmers to easily grasp the educational content. In addition, the IPM training courses actively implement simple and easy-to-do experiments for farmers to practice by themselves, self-check the results, and apply them to actual production conditions to achieve good results. It also helps farmers to understand the role and benefits of natural enemies, and the harmful effects of the abuse of pesticides and chemical fertilizers on the ecosystem, human health and the quality of agricultural products.

On June 2, 2015, the MARD issued Decision No. 2027/QDBNN-BVTV approving a project to promote the IPM program for the period 2015-2020. With the support of the World Bank (WB), in 2016, the MARD in Vietnam used 3.04 million USD (about 62,907 billion Vietnamese Dong) from the WB loan to implement the IPM program in rice production in seven provinces of the VMD – An Giang, Hau Giang, Kien Giang, Can Tho, Soc Trang, Bac Lieu and Ca Mau. The program's goal was to reduce the amounts of pesticides used in the field by 50%, and fertilizers by 10%, in association with building sustainable farming and protecting the environment.

On November 24, 2020, the MARD continued to issue Directive No. 8141/CT-BNN-BVTV and directed the People's Committees of all provinces to continue implementing the IPM program on main crops with a high potential for export. This Directive included building strategies and action

plans of a new approach for integrated health management of crops, developing training programs and instructions for trainers. This is being coordinated by the Department of Plant Protection which cooperates with the National Agricultural Extension Center to organize training courses for IPM trainer staff of provincial government organizations such as the Department of Agriculture and Rural Development, and the Sub-Department of Plant Protection. The Department of Plant Protection also assists these local organizations to organize training classes for IPM trainers at the district and municipal levels by using local budgets. Moreover, the Department of Plant Protection cooperates with the FAO, research institutes, universities and colleges, as well as training institutions to continue reviewing, evaluating and updating the IPM program to be suitable to the actual conditions and adaptive to the climate changes.

2.2.2. National policy framework on organic agriculture

In the mid-1990s, a number of non-governmental organizations (NGOs) came to research and invest in organic agricultural projects in Vietnam. Firstly, an organic tea planting project was implemented in the Tuc Tranh municipality of the Phu Luong district (Thai Nguyen province), with the support of CIDCE, the International Center for Comparative Environmental Law. Later, a project focusing on safe vegetables, rice, oranges, grapefruit, tea, and fish etc., funded by Agricultural Development Denmark Asia (ADDA), was carried out in Hanoi from 1998 to 2004. By 2004, the Vietnam Farmers' Union (VFU) cooperated with ADDA to successfully implement organic agriculture models for many groups of farmers in the northern mountainous provinces (Lao Cai, Tuyen Quang, Ha Noi, Hoa Binh, Bac Ninh, Bac Giang, and Hai Phong). Since then, local officials and farmers have accquired good knowledge and experience in organic agricultural production, and have recognized the trend of developing organic agricultural production methods (Bui Thi Cam Tu et al., 2019).

A study of national legal documents has shown that there were 9 legal documents and action programs related to organic agricultural production issued by the Vietnamese government from 2006 to 2020. These documents are presented in **Table 3**, which shows that the first legal document about the criteria and standards of organic agricultural production was issued in 2006 (10TCN 602:2006).

Table 3. Government decisions related to organic agriculture in Vietnam, 2006-2020.

No	Year	Organization approval	Kind of document	Contains
1.	2006	MARD & MOST	Decision	Decision No. 4094 QD/BNN-KHCN (29/12/2006). Decision on publishing Vietnam national standards 10TCN 602 – 2006 - organic – standard of organic agriculture and processing.
2.	2010	Government	Decision	Decision No. 72/2010/QD-TTg (15/11/2010). Decision on regulations for developing, managing, and running national trade.
3.	2012	Government	Decision	Decision No. 01/2012/QD-TTg (09/01/2012). Decision on some policies supporting the application

No	Year	Organization approval	Kind of document	Contains
				of good agricultural practices to agriculture, forestry and aquaculture.
4.	2012	MOHA	Decision	Decision No. 1303/QD-BNV (06/12/2012). Decision on the approval of the Regulations of the Vietnam Organic Agriculture Association (VOAA).
5.	2015	MOST	Vietnam National Standard	TCVN11041:2015, General requirement for production, processing, and labeling of products from organic agriculture.
6.	2017	MOST	Decision	Decision No. 3883/QD-BKHCN (29/12/2017). Decision on publishing Vietnamese national standards (TCVN 11041-1:2017), consisting of: - Part 1: General requirements for the production, processing and labeling of organic agricultural products; TCVN 11041-2:2017 - Part 2: Cultivator agriculture; TCVN 11041-3:2017 - Part 3: Organic livestock - Part 4 - Requirements for organic product processing, evaluation, and providing certification.
7.	2018	MOST	Decision	Decision No. 3965/QD-BKHCN (26/12/2018). Decisions on publishing Vietnamese national standards (TCVN 11041-5:2018 Organic agriculture), consisting of: - Part 5: Rice, organic; TCVN 11041-6:2018 - Part 6: Tea, organic; TCVN 11041-7:2018 - Part 7: Milk, organic; TCVN 11041-8:2018 - Part 8: Shrimp, organic; No equivalent code
8.	2018	Goverment	Decree	Decree No. 109/2018 / ND-CP (August 29, 2018) on organic agriculture.
9.	2020	Goverment	Decision	Decision No. 885/QD-TTg approving the "Project for development of organic agriculture for the period 2020-2030".

Source: *Vietnam law library online - https://thuvienphapluat.vn/*

In 2012, the Vietnam government allowed the establishment of the Vietnam Organic Agriculture Association (VOAA). In the same year, the goverment also issued Decision No. 01/2012/QD-TTg to support the application of good agricultural practices (VietGAP), including organic agricultural production. This government decision allows the state budget to invest in: (i) using 100% funding for baseline surveys, topographical surveys, soil sample analyses, and air and water sample tests to identify potential production areas for projects on agricultural, forestry and fishery production applying VietGAP; (ii) allocating over 50% of the total investment capital for

construction and improvement of roads, irrigation systems, pumping stations, electricity supply systems, waste treatment systems, water supply systems, and drainage systems of production areas compatible with the VietGAP technical requirements; (iii) supporting the investment and construction management regulations; (iv) training for management officials, technical staff, and extension workers at all levels; (v) supporting vocational training for rural workers applying VietGAP in production and preliminary processing of safe products; (vi) providing one-time support for hiring a certification organization to obtain a certificate of safe products; (vii) supporting the application of new technology in using insect-resistant crop varieties, application of IPM, and integrated crop management (ICM); (viii) support for promoting trade activities in accordance with the Prime Minister's Decision No. 72/2010/QD-TTg dated November 15, 2010, on the promulgation of regulations on the building, management, and implementation of the national trade promotion program.

In 2015, the Ministry of Science and Technology (MOST) issued TCVN11041: 2015, guiding the production, processing, labeling, and marketing of organic foods, applicable to crop and livestock products. In 2017, the Ministry of Science and Technology continued to issue the standard TCVN 11041-1: 2017 to replace the standard TCVN11041: 2015, including four parts: Part 1 - General requirements for the production, processing, and labeling of organic agricultural products, Part 2 - Organic farming, Part 3 - Organic animal raising and Part 4 - Requirements for organic product processing and evaluation, and providing certification. In 2018, following Decision No. 3965/QD-BKHCN (December 26, 2018), the Ministry of Science and Technology introduced nine additional organic standards – (i) TCVN 12473: 2018; (ii) TCVN 12474: 2018; (iii) TCVN 12475: 2018; (iv) TCVN 12476: 2018; (v) TCVN 12477: 2018; (vi) TCVN 12560-1: 2018; (vii) TCVN 12560-2: 2018; (viii) TCVN 12561: 2018; and (ix) TCVN 12562: 2018 (on pesticides and biofertilizers). The Vietnam Standards (TCVN) are built on the basis of reference to international standards on organic agricultural production (CODEX, IFOAM), regional regulations and standards (EU, ASEAN), and standards of the U.S and Japan and other countries such as Thailand, the Philippines, and China, among others.

In 2018, the Vietnamese government issued Decree No. 109/2018/ND-CP (August 29, 2018) on organic agriculture. This Decree adresses production, certification, labeling, logos, traceability, trading, and state inspection of organic agricultural products in cultivation, husbandry, forestry, and aquaculture, as well as favourable policies to encourage the development of organic agricultural production. The Decree enacts policies: (i) To prioritize funding for research/projects related to scientific research on insect-resistant varieties, organic fertilizers, biopesticides, herbal medicine, or agricultural extension; (ii) To offer loans supporting the application of high technology and clean agriculture for production, and business activities for small and medium enterprises, agricultural cooperatives, and producers; (iii) To encourage local businesses to have more investment in agriculture and rural areas to create production chains associated with product distribution and trade; and (iv) vocational training for rural workers.

In 2020, the Prime Minister issued Decision No. 885/QD-TTg approving the "Project for development of organic agriculture for the period 2020-2030". The development of organic agricultural production in the period of 2020-2030 serves to promote agricultural restructuring

towards increasing added value, sustainable development, protecting the environment, developing biodiversity, and developing services and tourism. The specific goals for this project are: (i) Continue to improve institutions, mechanisms, and policies for industrialization development; (ii) Promote scientific research, technology transfer, and international cooperation; (iii) Develop and replicate good models of organic agricultural production; (iv) Communication to raise public awareness.

Overall, organic agricultural production is an inevitable trend in Vietnam that has been paid attention to by state management agencies and the Communist Party of Vietnam, which form the legal framework for helping multi-stakeholders to implement the development programs for organic agricultural production in the present time and the future.

2.3. Alternative agricultural practices as good solutions to reduce highly hazardous pesticides applied in rice production

The high-yielding rice varieties thrived in Vietnam in the 1960s. However, after that they have been shown to have many weaknesses. By the 1990s, the first IPM program had been developed in Vietnam to help farmers know how to manage pests with an integrated approach in the field in order to limit the use of pesticides. In the period from 1996 to 2015, the government prioritized to improve rice varieties to better resist some major pests and diseases. Also during this period, the leaf color chart[8] was introduced, helping farmers to limit the excessive use of chemical fertilizers. In 2000-2010, new techniques stemming from the IPM program such as "3 reductions, 3 gains", "1 must, 5 reductions", "1 must, 6 reductions"[9], ecological technology[10], and the System of Rice Intensification (SRI)[11] were applied in specific cultivated areas. From 2015 onwards, the government tried to maintain the previous effective techniques, yet started to issue new policies for further improvement on production standards related to organic agricultural production, ecological agriculture, environmental protection, protection of biodiversity, and natural production. This is a long process, with development inherited from early deployment techniques, from intensive agrochemical application to new environmentally friendly techniques, to encourage the replacement of toxic chemicals with biopesticides or alternative models that definitely do not need to apply pesticides (**Table 4**).

[8] *The Leaf Color Chart (LCC) is used to determine the N fertilizer needs of rice crops. The LCC has four green strips, with colors ranging from yellowish green to dark green. It determines the greenness of the rice leaf, which is an indication of its nitrogen (N) content.*

[9] Similar to *"1 must, 5 reductions", another reduction called "reducing greenhouse gases" was added.*

[10] *Using flowers to feed natural enemies and using natural enemies to control harmful insects.*

[11] *SRI is a farming methodology aimed at increasing the yield of rice produced in farming. It is a water-low, labor-intensive method that uses younger seedlings singly spaced and typically hand weeded with special tools.*

Table 4. Programs on promoting rice production in Vietnam

No	Period	Organizations	Programs/ Projects	Objectives
1.	1970'-Now	RRI/MDI/CLRRI/IAS	Rice variety innovation	To obtain high-yielding, short-day varieties, and pest resistance
2.	1992-Now	FAO/DPP	IPM Program	To manage natural enemies, and reduce pesticide use
3.	1996-1998	IRRI/CTU/CLRRI	Leaf Color Chart (LCC)	To reduce the use of nitrogen fertilizers in rice production
4.	1996-2015	SEARICE/MDI/DARD (13 provinces in the VMD)	Public participation-based variety selection (PPB)	To improve rice quality at households (1 must) and conserve biodiversity
5.	2003-Now	VN Government and NGOs	System of Rice Intensification (SRI)	Ecosystem rice cultivation method, bringing efficiency and high yield, reducing costs
6.	2005-Now	IRRI/CLRRI/DPP/CTU/CT-DARD	3R3G	Rice production efficiency
7.	2008-Now	MARD/DCP	VietGAP/GlobalGAP	Food safety
8.	2009-Now	IRRI/DPP/CLRRI	1M5R	Efficiency of agricultural production and environment
9.	2009-Now	IRRI/DPP	Ecological engineering system	Ecological balance
10.	2010-Now	EDF/MDI/WB	1P6G	To increase household income and reduce emissions in rice cultivation
11.	2016-Now	UNEP, IRRI and the Loc Troi Group	Sustainable Rice Production (SRP)	Sustainable rice production
12.	2016-Now	VN Government	Transforming agriculture sustainably in Vietnam (VNSAT)	Innovating sustainable farming practices and enhancing value chains for the two sectors of rice and coffee
13.	2016-Now	VN Government	Climate change adaptation and sustainable livelihoods in the VMD (MD-ICRSL/WB09)	Improve climate change resilience for land and water resource management practices
14.	2017-Now	VN Government	Resolution 120	Sustainable development of the VMD in response to climate change
15.	2020-Now	VN Government	Project to develop organic agriculture for the period 2020-2030	Develop organic agriculture with high added value, sustainability, and eco-friendly environment, in association with the recirculating agricultural economy for domestic consumption and export.

Source : *Nguyen Quang Tin (2016), MARD (2016-2020), WB (2016)*

2.3.1. The Integrated Pest Management Program (IPM)

To implement the IPM program on a large scale at local levels, the MARD has assigned the Department of Cultivation at provincial level to encourage rice farmers to use tolerant varieties and balanced fertilization to limit harmful organisms. The program encourages and guides organizations and individuals to research, produce, trade, and use rice varieties that are resistant to pests and diseases. The Ministry of Agriculture and Rural Development also directs human resource training units in the field of crop production, through the Vietnamese Academy of Agricultural Sciences, universities, colleges, and specialized agricultural training institutions. The Department of Plant Protection has included the IPM program in the training courses to ensure that graduates have a firm knowledge of IPM and are capable of guiding farmers to apply IPM in the field.

The People's Committees of the Vietnamese provinces direct the Department of Agriculture and Rural Development to lead and coordinate with relevant departments to develop programs and plans to deploy IPM on main crops, including rice, in localities with large-field production. The local government guides the use of local budgets, integrating IPM into programs and projects implemented in the locality (such as new rural construction programs, agricultural extension projects, etc.), and mobilizing social capital through public-private partnerships (PPPs) to create resources to promote IPM development on a large scale.

After 5 years of implementing the IPM program, the Ministry of Agriculture and Rural Development organized the training of basic ToT - IPM trainers (source trainers) for staff of the Provincial Sub-Departments of Crop Production and Plant Protection, and Regional Plant Protection Centers. It is reported that over 90% of rice-growing communities now have IPM classes, and more than 10% of farming households in the country are trained under the IPM program. The yield from IPM-application areas increased approximately 10%, and the economic efficiency increased from 350,000 to 700,000 VND per ha (DPP, 2006). The Department of Agriculture and Rural Development have at the provincial level organized ToT - IPM practical trainings and short-term trainings on rice production for 3,210 members of staff. 1,253 training courses on IPM for rice farmers have also been organized, with the participation of more than 46,000 farmers, and about 1,200 IPM model projects have been carried out. It is estimated that IPM practical techniques have been adopted on about 2 million ha per year (about 17.4% of the agricultural land of Vietnam). The IPM program has contributed to increasing the use of organic fertilizers to 10-30%, reducing inorganic fertilizers to 10-20%, increasing the use of biopesticides by 10-30%, decreasing the use of chemical pesticides by 15-30%, decreasing the seed quantity used by 15-30%, reducing the amount of irrigation water by 15-20%, and gaining an increase in productivity by 5-15%. The total land area of IPM application has increased by 10-15% in the An Giang province. These IPM training courses contributed to improve the knowledge of rice farmers and the application of IPM by 40-70% in 2019 compared to 5 years before.

Due to its effective implementation, the IPM program has attracted investment and assistance from many international organizations and non-governmental organizations such as the FAO, DANIDA, SEARICE, CIDSE, the World Bank, and AUSAID, among others. By the end of 2006,

there were 15 IPM Programs/Projects being implemented in Vietnam by these organizations through the National IPM Program, or in coordination with the National IPM Program. The main sponsors for IPM Vietnam are Denmark, Norway, Australia, and the Netherlands. There are also many other international unions, organizations and countries directly investing in localities to implement IPM such as: the European Union (EU), Cooperation for Development and Solidarity (CIDSE), CARE, ActionAid Vietnam (AAV), Canadian Center for International Studies and Cooperation (CECI), Children's Foundation UK (SCF-UK), Plan International, NAV, Helve-tas, World Vision, World Bread, Netherlands Development Organization (SNV), JIVC, FADO, ADDA, AusAID FAO Belgium, New Zealand, Oxfam Belgium, Oxfam Hong Kong, NOVIB, Action Aid, and IFAD, among others (Department of Plant Protection, 2006).

The IPM program has actively contributed to help rice farmers protect the production environment and improve the quality of Vietnamese rice. The measures applied in IPM are also the basis for the development of technical advances such as the “3R3G” program, which is the basis for the orientation of using probiotics in pest management.

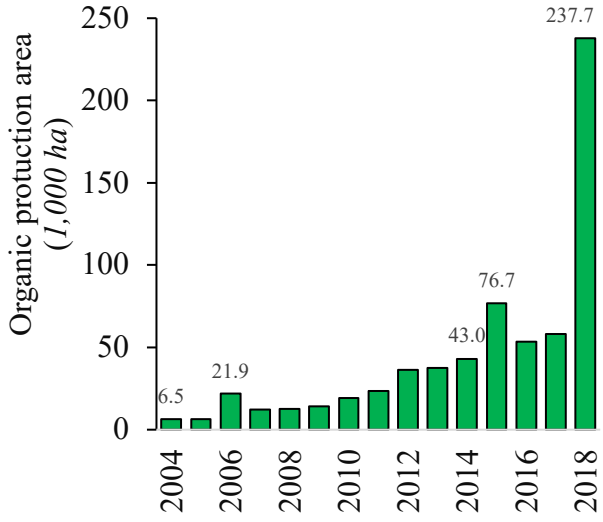
The “3 reductions, 3 gains” program was developed from the integrated rice pest management program (IPM). This method was proposed by three Vietnamese scientists at the international conference on "Management of nutrients and pests for rice-intensive systems", held at the International Rice Research Institute (IRRI) on 20-22 May, 2005 (Pham Van Du, 2008). Immediately after it was introduced, the Ministry of Agrilture and Rural Development recognized it as a new technical measure to increase rice cultivation efficiency. The “3 reductions, 3 gains” program has proven its superiority, and has gradually become a widespread movement, especially in the Vietnamese Mekong Delta. After being deployed, many provinces such as An Giang, Dong Thap, Bac Lieu, Long An, Vinh Long, Hau Giang, Can Tho, Quang Binh, Quang Ngai, Vinh Phuc, and Binh Dinh, have applied this technique very successfully and have replicated this model in many localities. Therefore, the rice area cultivated using the “3 reductions, 3 gains” method has been increasingly expanding (Phuong Nguyen, 2008).

Compared to the traditional rice production model, the yield in the “3 reductions, 3 gains” model increased significantly, from 0.3 to 1.5 tons/ha. The profitability of the rice production model applying the “3 reductions, 3 gains” technique, compared to the traditional production model, has in many different regions of the country increased on average 1-3 million VND/ha (Dang Van Hue, 2008). According to calculations made by agricultural experts, if applying this program on a large scale (1.4 million hectares) in the VMD, rice farmers will save about 850 billion VND/year (Phuong Nguyen, 2008).

Following the model of “3 reductions, 3 gains”, the program of "1 must, 5 reductions" has also been implemented in many places, mainly concentrated to the VMD. As reported by the IRRI (2011), it has been shown that the "1 must, 5 reductions" technique brings many benefits to rice farmers as well, such as reducing production costs through reducing inputs, increasing profits and protecting the environment (Nguyen Hong Tin et al., 2015).

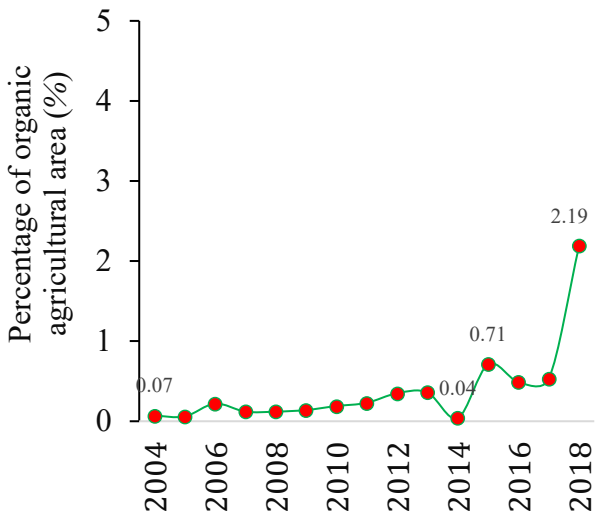
2.3.2. National organic agriculture programs

Organic agriculture has started to develop in Vietnam since the mid-1990s. However, by the end of the 1990s, initiatives related to this new agricultural approach were very modest. In fact, the area of organic agricultural production was mostly limited to just a few single crops such as tea and vegetable oil. These products were mainly exported to Europe. By the end of 2000, organic agriculture had expanded to other crops including tea, vegetables, rice, honey, and aquacultural products. In 2006, the Vietnam government issued a set of organic production standards (TCVN: 10TCN 602: 2006), followed by the establishment of the Vietnam Organic Agriculture Association (VOAA) in 2012. In 2017, Vietnam continued to issue a series of new criteria to standardize the organic agricultural production. **Figure 8** shows that the organic production area increased slowly in the first period from 2004-2014 (from 6,500 – 43,000 ha), however, since 2015 it has been expanding with an increase of 76,700 ha. By the end of 2017, the total area of organic production in Vietnam had increased to 237,700 ha. The total organic agricultural area in 2018 increased to nearly triple of the area in 2017, and accounted for about 56% of the total organic production area in the period from 2004-2017. The graph in **Figure 9** shows that organic agricultural production amounted to less than 0.7 percent of the total agricultural land in Vietnam from 2004-2017 and that this number increased to 2.2% by the end of 2018.



Source: *FiBL survey 2001-2020*

Figure 8. Area of organic agricultural production in Vietnam, 2001-2018



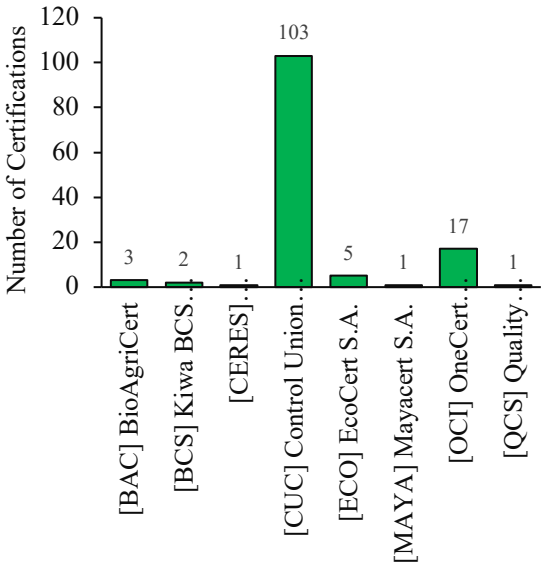
Source: *FiBL survey 2001-2020*

Figure 9. Percentage of organic agricultural area in Vietnam, 2001-2018

According to the MARD (2017), until the end of 2016, there were 26 organic farms or handling facilities established in 15 provinces – Lao Cai, Quang Tri, Hoa Binh, Ben Tre, Quang Ninh, Ca Mau, Lam Dong, Ha Noi, Ha Nam, Quang Binh, Quang Nam, Thai Binh, Thai Nguyen, Ha Giang, and Tra Vinh, with a total area of 4,175 ha. The main crops were coconut with an area of 3,052.3 ha, tea 538.9 ha, rice 489.8 ha, and vegetables 94.08 ha. Ben Tre was considered the biggest organically cultivated area with 3,053.04 hectares, mostly dedicated to organic coconut production. By 2019, Vietnam had 46 out of 63 provinces and cities implementing development

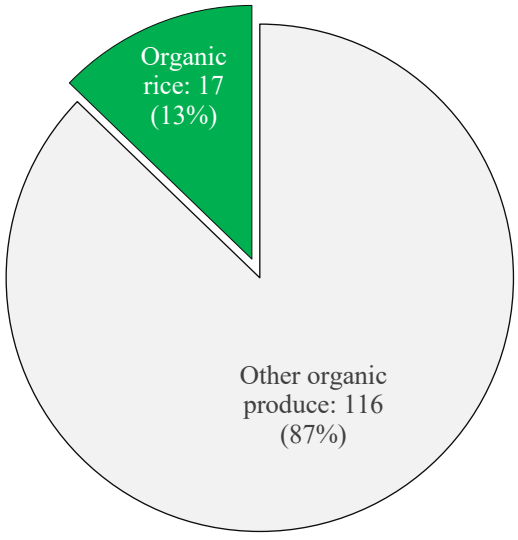
programs on organic production. The number of farmers participating in organic agricultural production was 17,168 people (MARD, 2020). Currently, Vietnam is ranked 32 among 186 countries in the world, ranking 4th in Asian and 2nd in ASEAN countries (after Indonesia), in terms of number of farmers engaging in organic agricultural production (FiBL and IFOAM, 2020).

According to report from the USDA, the United States Department of Agriculture, in 2020 there are a total of 133 organic certificates of agricultural production in Vietnam, given to 127 enterprises and producers in 31 provinces and cities, of which 17 certification labels were provided for organic rice products (**Figure 11** and **Appendix 2**). Currently, there are 8 organizations that provide organic production certificates in Vietnam: (1) [BAC] BioAgriCert, (2) [BCS] Kiwa BCS Oko-Garantie GmbH, (3) [CERES] Certification of Environmental Standards - GmbH, (4) [CUC] Control Union Certifications, (5) [ECO] EcoCert SA, (6) [MAYA] Mayacert SA, (7) [OCI] OneCert International Private Limited, and (8) [QCS] Quality Certification Services (**Figure 10)**. [CUC] Control Union Certifications (Netherlands) is the most popular organic certification organization, providing 103 certificates to producers and handlers, mostly for those engaging in rice production. In addition, in 2015, the standard of PGS (Participatory Guarantee System) Vietnam was officially recognized by IFOAM (**Appendix 4**). Thus, Vietnam now also has one national organization that can issue organic certificates (under the Vietnam Organic Agriculture Association). In the An Giang province, the only certified organic company in rice production is TV Food Co., Ltd., in the Cho Moi district (**Appendix 3**).



Source: *USDA, 2020*

Figure 10. International organic certifying agencies and number of organic certifications given to producers and handlers in Vietnam



Source: USDA, 2020

Figure 11. Percentage of certifications for organic rice compared to other agricultural products in Vietnam

Source: *Website of Vietnam PGS: http://vietnamorganic.vn/pgs*

2.3.3. Organizations supporting and developing ecosystem-based rice production

a. International organizations and iNGOs

- ***FAO-IPM**:* The FAO has supported the integrated pest management (IPM) programs for Vietnam since 1992, including financial aid and technical assistance, Training of Trainers (ToT), Farmers' Field School (FFS) programs, and other activities from the first years of the programs and ongoing (Do Van Hoe, 2005). The FAO has been cooperating with central government and local authorities to carry out IPM programs all over the country. The details of these programs and policies are explained in section 2.2.1, *National policy framework of Integrated Pest Management*.

- ***IUCN**:* The IUCN (International Union for Conservation of Nature) has operated in Vietnam since 1993. IUCN carries out not only wildlife conservation, but also sustainable agriculture and environment protection such as: Piloting flood-based livelihoods in support of a water retention strategy for the upper part of the VMD; and establishing the Kien Luong Karst Species and Landscape Conservation Area. In 2020, IUCN funded a pilot model of the lotus-rice eco-farming system in the An Giang province, and supported another project on ecological deepwater rice cultivation in the Long An province.

- ***The World Bank (WB)**:* Vietnam resumed its relationship with the WB in October 1993 (MOFA, 2012). Since then, the WB has provided substantial funding and many loans for the development of Vietnam. For the period of 2018-2022, the WB focuses on 11 development goals for Vietnam, of which two objectives are related to agricultural production, specifically to: (1) Increasing climate resilience and strengthening disaster risk management, and (2) Strengthening natural resources management and improving water security. For instance, the project WB-09 has been conducted in seven provinces of the VMD and is aimed at manipulating successful flood-based agricultural production to improve the livelihood of farmers and help to retain floodwater in the floodplain areas, increasing farmers' income, reducing the area of intensive rice farming, and promoting sustainable agriculture systems adapting to available nature resources and climate change conditions (World Bank, 2017). In the An Giang province, the WB has provided funding support for four integrated farming models, consisting of: (*i*) Winter-Spring rice crop combined with shrimp culture (no pesticides applied), (*ii*) Winter-Spring rice crop – Lotus cultivation in the flood season together with community-based wild fish catch during the flooding time in the rice fields, (*iii*) Winter-Spring vegetable crop - Spring-Summer vegetable crop - Floating rice cultivation and fishing during the flooding time, and (*iv*) Winter-Spring rice crop - Spring-Summer rice crop - fishing in the flood season.

- ***PAN AP**:* Pesticide Action Network Asia Pacific has been working in Vietnam through cooperation with three local organizations: (*i*) CGFED (Center for Gender, Family & Environment in Development), (*ii*) SRD (Centre for Sustainable Rural Development) and (*iii*) RCRD (Research Center for Rural Development) from 2008 up to now. PAN AP campaigns to reduce or ban toxic pesticides such as paraquat, glyphosate, chlorpyrifos, 2,4-D, and other highly hazardous pesticides (HHPs). PAN AP has supported research on the current status of knowledge, attitude and practice (KAP) towards the use of chlorpyrifos and paraquat in the rice fields and the adverse impacts of these pesticides on human health and environment. PAN AP has also supported the project "Community-based pesticide action monitoring - CPAM". In addition, PAN AP has assisted local research centers to develop eco-friendly alternative farming models to help farmers reduce the amount of agrochemicals used in the field, such as 1M5R, and instead introduce IPM (Integrated

Pest Management) and floating rice cultivation in the VMD, and the System of Rice Intensification (SRI) and organic rice production in the North of Vietnam.

- ***GIZ:*** Deutsche Gesellschaft für Internationale Zusammenarbeit is a consolidation of three German organizations: DED (German Development Service), GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit), and InWEnt (Internationale Weiterbildung und Entwicklung gGmbH) in 2011. In Vietnam, GIZ has focused its activities on sustainable economic development, environment protection, natural resource management, urban and rural health issues. From 2019-2020, the "Mekong Delta Climate Resilience Programme (MCRP)" was implemented in the VMD, with a human and science-technology centered approach. GIZ has also provided funding for developing the integrated floating rice/vegetable farming model in An Giang and other provinces in the Mekong Delta from 2012 to ongoing.

- ***UNDP****:* The United Nations Development Programme has operated in Vietnam since 1978 supporting many developing efforts, mainly on poverty reduction. Recently, UNDP has worked more closely on sustainable development within the context of the fourth industrial revolution (Industry 4.0). One of the outstanding projects funded by UNDP is the rice-shrimp farming model implemented in some targeted provinces in the Mekong Delta, while the floating rice model is used in the Long An province (in 2020).

In addition, there are many more iNGOs and International Organizations cooperating with the Vietnamese government, on both national and local levels, to help Vietnam reduce the amount of highly hazardous pesticides being used, to protect human health and environment and to promote a sustainable agricultural development.

b. Research institutions and universities

According to the MARD (2020), there are several research institutions and universities that have conducted various studies on biopesticides and agricultural commercialization. Some examples are:

- The Center for Biotechnology of HCMC has developed biopesticides from *Paecilomyces lilacinus.*

- The Center for Research and Development of Biochemicals has developed a polyphenolic biopesticide from *Oroxylum indicum, Salix babylonica, Litchi chinesis sonn*, *Sophora japonica* L. Schott), and *Mangifera indica L.*

- Nong Lam University of HCMC has developed a biopesticide from *Trichoderma virens.*

- The Plant Protection Institute has developed a biopesticide from protein hydrolysis, and herbal and beneficial microorganisms (*Trichoderma harzianum, Bacillus subtilis, Metarhizium anisopliae, Azotobacter beijerinckii, Bacillus gisengihumi, and Streptomyces owasiensis.)*

- The Agricultural Genetic Institute has developed biopesticides from *Chaetomium cupreum* and Abamectin.

- The Vietnam Forest Science Institute has developed biopesticides from an extract of cashew nut oil.

- The Applied Materials Science Institute has developed biopesticides from Azadirachtin, chitosan and caffeine.

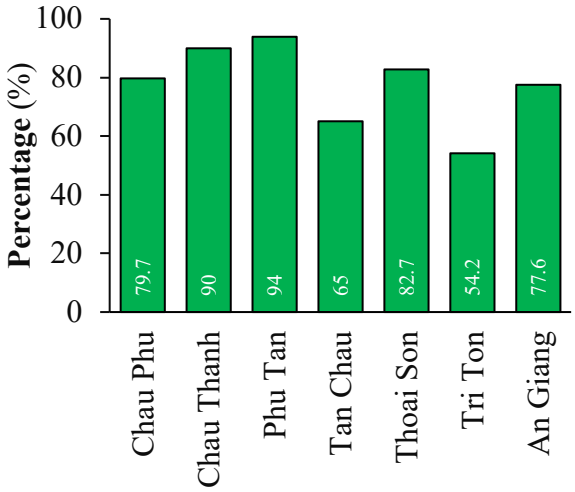
- The Cuu Long Rice Institute has studied biopesticides from *Beauveria bassiana* Vuill, and *Metarhirium anisopliae.*

- The ITC institute has developed biopesticides from polyphenols extracted from *Gleditschia australis*, *Siegesbeckia orientalis*, *Bidens pilosa*, *Parthenium hystherophorus,* and *Litchi chinesis sonn*.

- The Can Tho University also conducted research on biopesticides from *Trichoderma asperellum, Trichoderma atroviride* Karsten, *Trichoderma virens* J.Miller, *Trichoderma hamatum* (Bon.) Bainer, *Trichoderma viride* Pers, *Trichoderma harzianum* Rifai, and *Trichoderma sperellum.*

2.4.Some typical good farming practices and alternative models to reduce pesticide use in rice production in the An Giang province

Applying alternative solutions in rice production is necessary, however, the level of application of these innovations depends on the knowledge, personal behavior and attitude of farmers towards intensifying rice production and protecting the environment. The local government has made efforts to implement more alternative solutions for replacing toxic pesticides with biopesticides. An Giang is a rice-intensive province where farmers could grow three rice crops per year in high-dyke systems. Nevertheless, over time, water, soil, and environment have significantly been degraded. For example, rice farmers tend to apply too large amounts of rice seeds when sowing, resulting in increasing labour costs, and excessive amounts of fertilizers and pesticides being used. The local governmental agricultural extension staff have suggested that farmers should sow from 80-100 kg of seeds/ha only, yet the seed amount used by the rice farmers have reached up to 200 kg/ha. To solve this problem, many alternative techniques have been introduced and applied in rice cultivation in the An Giang province, such as IPM, 3R3G, 1M5R, 1M6R, and biologically integrated farming systems, to just name a few. Some of these alternative models for rice farming have shown a high level of efficiency when being implemented in the fields.



Results from a survey on local technique, 2019-2020

Figure 12. Percentage of farmers applying IPM in some districts of the An Giang province in 2018

2.4.1. The IPM program

The IPM program (Integrated Pest Management) has been applied to rice production in the An Giang province since 1992. Thanks to various trainings carried out in the rice fields, the attitude of rice farmers has been changing as this program has provided them with important knowledge about the ecological system of the rice fields. Farmers usually take this into more consideration

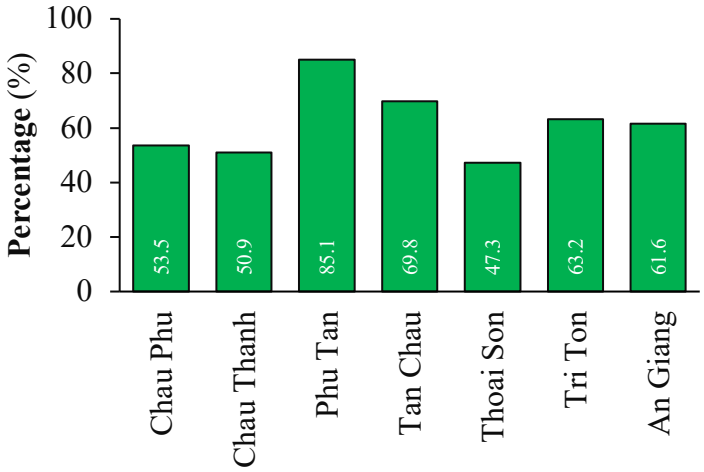
when they are planning to apply pesticides. The aim of the IPM program is to help rice farmers to understand the importance of "balanced ecology" to control harmful insects and to protect the existing natural enemies (An Giang DARD, 2009). The results of a survey from 2020 showed that the percentage of rice farmers in the An Giang province applying IPM models amounts to 77.6%. The Phu Tan and Thoai Son districts are the most popular locations for applying IPM, with percentages ranging from 80 to 100%. The percentages of rice farmers applying the IPM model in the An Giang province are showed in **Error! Reference source not found.**.

2.4.2. The "three reductions, three gains" farming practice

The "three reductions, three gains" model has been applied in An Giang province since 2001. This technique was inherited from several extension programs in agriculture such as the IPM program, and a program on nutrients management in rice of the Cuu Long Rice Institute of Vietnam and the International Rice Research Institute (IRRI) (An Giang DARA, 2009). The farming techniques in this program were accurate, easy to learn and understand, and easy to put into practice on the rice fields. When performing the trials, local technicians usually practiced them with the farmers right on their actual farmland. In the past, rice farmers were often trained, but mostly only on theory and were rarely shown how to apply their knowledge in real-life situations. Now, with the 3R3G model, farmers can understand clearly how the "three reductions, three gains" method works in rice cultivation. The three reductions (**3G)** consist of: *(1)* decreasing the quantity of seeds planted*, (2)* decreasing the quantity of fertilizers used, and *(3)* decreasing the quantity of pesticides applied; and the three gains (**3T)** are: *(1)* an increase in rice yield, *(2)* an improvement of rice quality, and *(3)* an increase of the net profit.

2.4.3. The "one must, five reductions" model

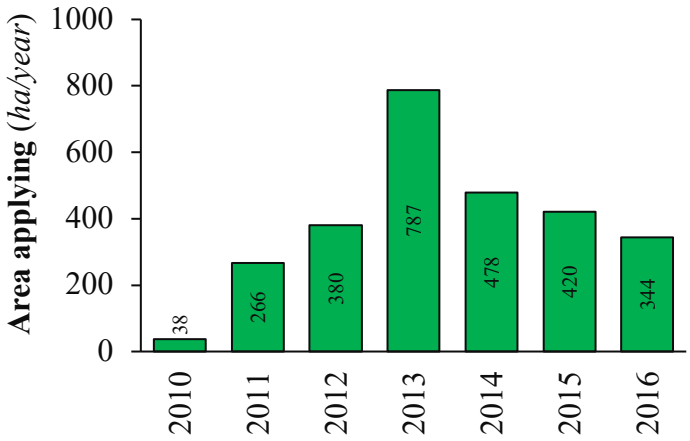
In the forum, "Agricultural Extension in the Technology Era", held on the 24th of October 2008, organized by the National Agriculture and Aquaculture Extension Center and the Vietnam Agriculture Newspaper in An Giang province, several specialists developed the "3R3G" model into "1 must, 5 reductions" (1M5R). This model means: (**1M)** Farmers must use a good and certified rice seed variety, (**5R)** – (1) decreasing the quantity of seeds planted, (2) decreasing the quantity of nitrogen residue, (3) decreasing the quantity of toxic pesticides applied, (4) decreasing the quantity of water used, and (5) minimizing crop loss when harvesting. The Petia project undertaken in the An Giang province showed that rice farmers who applied 1M5R in their rice fields could decrease the quantity of



Results from a survey on local technique, 2019-2020

Figure 13. Percentage of farmers applying the 1M5R method in some districts of the An Giang province, in 2018

agrochemicals used: (1) decreasing the amounts of pesticides by -0.92 kg ai/ha, (of which herbicides -0.27 kg/ha, insecticides -0.35 kg/ha, and fungicides -0.30 kg/ha); (2) decreasing the amounts of fertilizers applied, of which N_2O_5 account for 11 kg/ha, P_2O_5 for 8.4 kg/ha, and N_2O for 0.3 kg/ha (RCRD, 2020). In 2020, the percentage of rice farmers that adopted the 1M5R model in the An Giang province reached a total of 61.6% (**Figure 13**).



Source: *An Giang SDPP, 20114-2016*

Figure 14. The total area applying the eco-technology model in the An Giang province, from 2010 - 2016

2.4.4. Ecological technology in rice production

The ecological technology in rice production model has been called in Vietnamese "Ruộng lúa, bờ hoa" (Rice fields and flower banks) (**Figure 15** and **Figure 16**). This ecological model was developed from the 1M5R model but adding certain kinds of flowers, such as Cosmos flowers (*Cosmos bipinnatus*), sunflowers (*Helianthus annuus*), okra (*Abelmoschus esculentus*), or daisies (*Bidens pilosa*) along the small dykes around the rice fields. These flowers can attract many kinds of parasitic bees and natural enemies living around the fields to attack the insects that harm the crop. Although it brings several benefits to the ecological system, a report from the An Giang SDPD (2014-2016) illustrates that this model has been hard to develop at a large scale due to the different policies implemeted in each locality and because it is time-consuming for the farmers. Although the rice fields look like a flower garden when the eco-technology model is applied, it requires more time from the farmers to grow and take care of the flowers before sowing rice. This model is still being applied in several communities of the An Giang province, however, the statistics have not been updated by the local governmental extension staff since 2017. **Figure 14** illustrates the total area applying the ecological-based rice production model of "Rice fields and flower banks" in the An Giang province.

Figure 15. Rice field applying the eco-technology model in the An Giang province

Figure 16. Cosmos flowers in rice fields applying the eco-technology model

2.5. Some practice models to replace HHPs based on indigenous knowledge

2.5.1. Floating rice – vegetable farming system

The floating rice (deepwater rice) vegetable model is a traditional cropping system in An Giang and the Mekong Delta. Floating rice can adapt to high flooding conditions (**Figure 17**), even at a 3-4 meters high water level. The yield of floating rice is low, around 1.5-2.0 t/ha, however it does provide large quantities of rice straw which could be used for growing vegetables to generate added revenue for rice farmers. Floating rice cultivation rarely needs agrochemicals, so it is not harmful to the environment, and this is the premise for developing the organic agricultural system. The Mekong Delta is divided into three ecology areas: the upper, middle, and lower Mekong river basins (the Mekong Delta Plan – MDP, 2013). The upper area is a floodplain. Before 1975, floating rice was popular in this area, with 500,000 ha cultivated (Vo Tong Xuan, 1975). The An Giang province also had 250,000 ha of floating rice (nearly 50% floating rice area). After 1975, there were more policies introduced to invest in the high-dike system (closed dikes) to develop high-yielding varieties (HYVs), which caused the floating rice to decrease more and more and lose its position as a staple food crop in the Mekong Delta. **Figure 18** shows the fluctuations in floating rice area in the An Giang province and the Mekong delta in 2011-2020. From 2012, the Research Center for Rural Development (RCRD) began to set up several studies to recover and conserve the floating rice-vegetable cropping system, as it is nature-friendly and requires little or no agrochemical use. After seven years' work in this area, the RCRD has carried out more studies on environmental issues, biodiversity, ecology, social-economic impacts, rice breeding and conservation. The floating rice varieties were introduced to rice famers in various provinces in the Mekong Delta and is presently known by many international organizations and universities such as the World Bank, Searca, Sumernet, Mitsui foundation, and the Australian National University, among others. From 2015 to 2017, the floating rice area has gradually decreased because many farmers experienced failed crops due to droughts and rat damage in 2015 and 2016. The total floating rice cultivation area in 2020 was 110 hectares in the Mekong Delta, of which 60 hectares were grown in the An Giang province (**Figure 18**). As a result of the failed crop, local farmers did also not have enough seeds of floating rice to sow for the following crops. The second reason was that the local government and trading companies do not offer enough support to introduce and bring floating rice products onto to the market. The An Giang People's Committee has issued some policies about the establishment of a floating rice conservation area of 200 ha in the Tri Ton district, from 2015, and a plan for expanding the floating rice cultivation to the An Phu district with 500 ha (*WB09 project - Mekong delta integrated climate resilience and sustainable livelihoods*).

Figure 17. A floating rice field in flooding season in the An Giang province

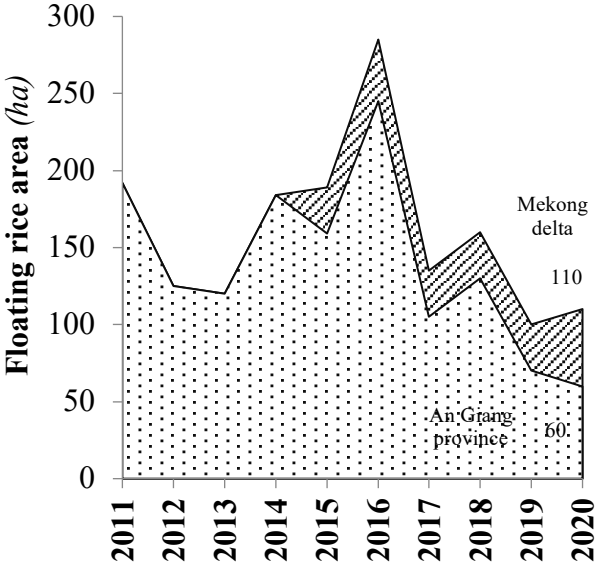


Figure 18. Floating rice cultivation area in the An Giang province and Mekong delta 2011-2020

2.5.2. Integrated rice-lotus farming system

The lotus is a wetland plant grown in some wetlands of the Vietnamese Mekong Delta. Traditionally, lotus was mainly grown for home consumption. Today, the Mekong Delta's inhabitants can use different parts of the lotus such as the roots, seeds, leaves and flowers for producing commercial products, including nutritional foods and handicrafts. Several development projects supported by the IUCN and the World Bank have been undertaken in the An Giang and Dong Thap provinces to help farmers improve their household income by practicing the integrated rice and lotus farming system. After harvesting the rice crop in the dry season, farmers can continue to grow lotus which can grow well in deepwater during the wet season (**Figure 19** and **Figure 20**). Cultivating lotus helps the farmland retain more alluvium soil during the flooding season of about 4 months. The rotation of lotus after rice cultivation during the year leads to a significant improvement in soil fertility that helps farmers to reduce production cost. This farming practice has also resulted in a remarkable restoration of the soil ecosystem and natural fish resources in the Mekong Delta.

Figure 19. Flooding discharge over a rice field in the Tri Ton district of the An Giang province

Figure 20. Lotus growing in a rice field during flooding time (the integrated rice-lotus farming system) in the Tri Ton district, An Giang

2.5.3. Biologically based rice cultivation system

A recent research study undertaken by the Research Center for Rural Development found that farmers in the Chau Phu district of the An Giang province were practicing a rice farming system on about 450 hectares of land which applied no insecticides in the field, although the rice farmers still applied chemical fertilizers and used some fungicides when needed. This farming innovation was called the "biosafety rice system" by local farmers and the governmental agricultural extension staff. There were over 300 rice farmers engaging in this biologically based rice cultivation system which has been maintained by local rice farmers from 1991 up to now. The amount of pesticides applied in this environmentally friendly rice farming system is 4-5 times less than that of intensive rice farming systems (An Giang DARD, 2019). The rice farmers practicing this rice cultivation model have also applied different farming techniques they have learnt from various training sessions such as IPM, 3R3G, 1M5R. Hence, they have obtained knowledge about the life cycle of insects, and about how to balance them in the rice fields' ecosystem. Farmers also know well how to manage water and irrigation systems to control pests in the rice fields. This ecological rice cultivation system has been expanded in many areas of the Chau Phus district, especially when the An Giang province has carried out the WB09 project (funded by the World Bank) which fostered the further development of the existing ecological rice farming systems to more integrated farming systems such as the rice-shrimp farming model, rice-fish farming model, or rice-lotus cultivation model in the An Phu district. It is expected that these farming models will attract the participation of over 700 farmer households, in an farming area of over 500 hectares, by the end of 2021.

2.5.4. Organic rice production

According to the An Giang Department of Agricuture and Rural Development (2019), organic rice production has been promoted in many locations of the An Giang province despite the fact that there is currently only one certified organic agricultural company in An Giang. To be initially certified as an organic agricultural production area, farmers must maintain pesticides-free rice cultivation for at least 3 years before applying for a fully organic production certification granted by an international organic organization. The organic rice production area of the An Giang province includes: 3 hectares of pesticides-free production in the outskirts of Long Xuyen city, nearly 25 hectares of Global GAP standards rice production in the Chau Phu district, 60 hectares of Nang Nhen traditionally rainfed rice of Khmer origin in the mountainous areas of the Tri Ton and Tinh Bien districts, about 100 hectares of deepwater rice cultivation areas without any pesticide and chemical fertilizer use in the Tri Ton district, and nearly 400 hectares of rice farming area without application of fungicides.

Although most farming areas mentioned above have currently not fulfilled all the standards for organic rice production, the efforts made by the local government and rice farmers in the An Giang province has built a good foundation for producing organic rice products in the near future.

2.6. SWOT analysis on alternative agriculture

The research on the development of alternative agricultural models in the An Giang province highlights the strengths, weaknesses, opportunities, and threats (SWOT analysis) which is presented in **Table 5**.

Table 5. SWOT analysis on alternative agriculture in Vietnam

Strengths	Weaknesses
• Vietnam is an agriculture-based country and rice is the staple food. • Vietnam has a favourable nature with land, water, and biodiversity conditions suitable for a clean and safe agricultural production. • The Vietnamese government has recently issued many policies to promote alternative agricultural models, especially organic rice production. • The infrastructure system, especially canals and irrigations for rice production, has been much improved since the *Doi Moi* policy in 1986. • Cultivating more rice varieties with high quality and yield. • Having several alternative models for rice cultivation that reduce the use of chemicals, which are highly efficient and sustainable for local production conditions. • More studies about biopesticides have been conducted by many research institutes and universities, gaining attention and participation of manufacturing companies. • Food producers (farmers, groups of farmers and companies), governmental/non-governmental organizations, and consumers are all investing in developing more and more clean, intelligent and organic agriculture.	• Agriculture production is normally small-scaled (private and household levels). • Producers lack adequate knowledge about integrated pest management, ecology, and the environment. • Costs for production, management and logistics are high, making the prices of alternative products higher than regular products. • For a long time, agriculture has relied on agrochemicals, so the process of establishing alternatives requires a lot of time and social resources to succeed in changing the awareness of both food producers and consumers. • The cooperation between stakeholders including rice farmers, companies, and research institutes, as well as the role of government to link all related partners, is not good enough. • Despite having more policies and funding in place for studies on biopesticides and alternative solutions, Vietnam has produced a very low quantity of biopesticides, only 0.5% of the production requirement. • There is a gap between the policies of the central government and the reality on the ground, depending on the natural conditions, the knowledge of food producers, and the management on all levels of local government.
Opportunities	**Threats**
• The process of changing to agricultural production with alternatives or non-chemical (organic agriculture) systems to support health and environment is strongly being encouraged around the world. • The awareness level for “following natural means” in agriculture (among government, farmers, and other stakeholders) is increasing in Vietnam.	• The level of customers' confidence in alternative agricultural products (that must be certified by a third party) is still limited. • It takes a long time to restore ecosystems and ecosystem services after a long period of damage done by the use of toxic chemicals. • The linkage between producers, businesses, government coordination and consumers is relatively weak.

• Vietnam has signed many trade agreements for agriculture with developed countries, so there is a large potential sales market for products from good agricultural practices. • The demand for clean agricultural products from organic agriculture has continuously increased in Vietnam. • Reducing production costs means a possibility to reduce the price of the products. • Developments in science and technology will support a sustainable development and quick distribution of products from good agricultural practices.	• Climate change and extreme weather conditions such as storms, abnormal floods, drought, and salinity. • Weed problems when using alternative solutions in large areas. • The gap between policy and local enforcement; and the low level of determination of the whole society. • The influence of agrochemical companies and corporations on national and local policies.

3. CONCLUSIONS AND RECOMMENDATIONS

3.1.1. Conclusions

Over the last two decades, Vietnam has witnessed a significant transformation of the rice production sector from a traditional farming approach to modern, intensive, and diversified production, including the nationwide introduction of high-yielding rice varieties. After that, the rice productivity has notably increased, which makes Vietnam currently the second largest rice exporter in the world. However, the intensive rice production has also caused significant amounts of agrochemicals to be used in the fields. As a result, the imported quantity of pesticides has just kept increasing, as Vietnamese rice farmers are more and more depending on agrochemicals to maintain their rice yield and productivity. This intensive agriculturing has created a new production culture for both food producers and consumers. Rice farmers want to keep the rice yield increasing over time by intensively using agrochemicals, while food consumers wish to buy agricultural products at a low price.

The Vietnamese government has recently promulgated various policies and regulations for supporting the development of environment-friendly agricultural production, however what is needed is the determination and higher awareness of the whole society in supporting this alternative movement. The research findings suggest that there is still a big gap between national policies and frameworks, and their actual enforcement and implementation over the last decades. National policies on the general management of biopesticides have been issued since the early 2000s. However, these national regulations seem to have been less, or not at all, enforced and implemented at the local levels until the period of 2016-2019. It is evident that there is a strong political will of the Vietnamese government to prohibit highly hazardous pesticides, and to promote a safer agricultural production with an increasing proportion of biopesticides used in the rice fields. Various policies and regulations have been issued by the Vietnamese government for supporting clean and organic agricultural production.

To make further progress on promoting clean/organic agriculture in Vietnam, and reducing toxic pesticides, some key factors are needed: (1) good knowledge about ecology, biocontrol and organic agriculture to gradually change farmers' behavior from using highly hazardous pesticides to instead using biopesticides in rice production, (2) new knowledge and techniques on IPM, ecology, biopesticides, biofertilizers, new rice varieties, and alternative agricultural models in order to change farming practices when it comes to the use of agrochemicals, (3) campaigns to propose new policies aimed at helping to change the attitudes of consumers and companies about the importance of biopesticides and an ecological-based agricultural production for human health, the environment and agricultural sustainability.

3.1.2. Recommendations

- *National Policy:* The Vietnamese government has promulgated various policies to support the development of alternative ecosystem-based agricultural practices to reduce the amount of toxic chemicals applied in agricultural production. However, we recommend that the government should exert even more efforts to develop a good plan with detailed activities that must be well implemented among food producers on the ground in order to increase their effectiveness. The government should encourage research activities by allocating more research funding to strengthen the capacity of domestic research institutions promoting environmental-friendly rice production. The priority should be concentrated on studying and producing biopesticides, identifying good agricultural farming practices, supporting and developing these initiatives, supporting local enterprises to improve their human resources and production capacities, as well as help to improve the distribution systems of these enterprises introducing safe, clean and organic agricultural products to potential markets, both domestically and internationally.

- *Raising awareness:* Communication through mass media and schools should be strengthened to raise awareness among businesses, farmers, universities, and high-school students about the harmful effects of highly intensive uses of agrochemicals and help them understand the benefits of biopesticides and alternative farming practices for a healthy environment and sustainable agriculture.

- Strengthening the *linkage between,* and among, *producers and consumers:* Modern agricultural production needs to develop on a higher level, however traditional farming practices also need to be promoted to gradually reduce the use of agrochemicals and toxic pesticides in particular and replace the application of agrochemicals with organic and biological products in the fields. It is necessary to guide consumers to distinguish between clean/organic agricultural products and conventional products (with pesticides applied) in the supermarkets so that they can recognize and trust the safe products. The governmental bodies on both national and local levels should assist rice farmers and enterprises to develop good connections between organic agricultural producers and handlers, and consumers and potential markets.

- *Enhancing multi-stakeholder cooperation*: It is necessary to promote the engagement and cooperation between government, farmers, scientists, enterprises and other relevant stakeholders in the policy-making process. On one hand, scientists in research institutes and universities should study alternative solutions in relation to the fields' actual conditions. On the other hand, farmers need to cooperate with local enterprises to produce clean and organic agricultural products to be

compatible to the market demands. Government planners should balance the total area allocated for ecological rice production and intensive rice production, and also balance between rice crops and other crops to reduce the amounts of highly hazardous agrochemicals applied in the field.

- *Adapting to climate change and other extreme weather conditions:* More research needs to be conducted on the development of new rice varieties and agricultural innovations and practices which are able to adapt to extreme weather conditions and balance the biological functions of protecting the environment, getting along well with the new philosophy of the Vietnamese government that "agricultural production must favor mother nature", indicated in the Government Resolution 120/NQ-CP on Sustainable and Climate-Resilient Development of the Vietnamese Mekong Delta.

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APPENDICES

Appendix 1. List of active ingredients of biopesticides permitted in Vietnam

No	Active ingredient (ai)	Types	Group
1.	Abamectin	Insecticide	Toxic
2.	Acrylic acid + Carvacrol	Fungicide	Herbal
3.	Amino acid	Hormone	Others
4.	Anacardic acid	Fungicide	Others
5.	Ascorbic acid + Citric acid + Lactic acid	Fungicide	Others
6.	Azadirachtin	Insecticide	Herbal
7.	*Bacillus* var,	Insecticide	Microorganism
8.	*Beauveria bassiana*	Insecticide	Microorganism
9.	Caffeine + Nicotine + Azadirachtin	Moluscide	Herbal
10.	Chaetomium cupreum	Fungicide	Microorganism
11.	Chitosan	Fungicide	Others
12.	Citrus oil	Fungicide	Herbal
13.	Cnidiadin	Insecticide	Herbal
14.	Cytokinin (Zeatin)	Fungicide	Herbal
15.	Cytosinpeptidemycin	Fungicide	Antibiotic
16.	Plant oil complex	Insecticide	Herbal
17.	Extracted from the *Lychnis viscaria*	Hormone	Others
18.	Emamectin Benzoate	Insecticide	Toxic
19.	Erythromycin	Fungicide	Antibiotic
20.	Esterified vegetable oil	Insecticide	Oil
21.	Esters of botanical oil	Insecticide	Oil
22.	Eugenol & Methyl Eugenol	Fungicide	Herbal
23.	Extract of cashew nut shell oil	Insecticide	Oil
24.	Extract of Neem oil	Insecticide	Oil
25.	Folic acid	Hormone	Others
26.	Fugavic acid	Hormone	Others
27.	Fulvic acid	Hormone	Others
28.	Garlic	Insecticide	Herbal
29.	Gentamicin sulfate	Fungicide	Antibiotic
30.	Gibberellic acid	Hormone	Others
31.	Glufosinate ammonium	Herbicide	Others
32.	Glysine amino acid	Hormone	Others
33.	Humic acid	Hormone	Others
34.	Kasugamycin	Fungicide	Antibiotic
35.	Liuyangmycin	Insecticide	Toxic
36.	Matrine and oxymatrine	Insecticide	Herbal
37.	*Metarhizium anisopliae* (Metsch.)	Insecticide	Microorganism
38.	*Methylanine avermectin*	Insecticide	Toxic
39.	Ningnanmycin	Fungicide	Antibiotic
40.	Oligo-Alginate	Hormone	Others
41.	Oligo-Glucan	Hormone	Others
42.	Oligo-Sacarit	Hormone	Others
43.	Oligo-Saccharins	Hormone	Others
44.	Oxolinic acid	Fungicide	Others
45.	Oxytetracycline	Fungicide	Antibiotic
46.	Petroleum Spray Oil	Insecticide	Oil
47.	Polyoxin complex	Fungicide	Antibiotic
48.	Polyphenol complex	Insecticide	Herbal
49.	Protein hydrolysis	Pheromone	Others
50.	*Pseudomonas floureacens*	Fungicide	Microorganism
51.	Pyrethrins	Insecticide	Herbal

No	Active ingredient (ai)	Types	Group
52.	Rotenone	Insecticide	Herbal
53.	Salicylic Acid	Fungicide	Herbal
54.	Saponin	Moluscide	Herbal
55.	Spinosad	Insecticide	Toxic
56.	Streptomycin sulfate	Fungicide	Antibiotic
57.	Tetramycin	Fungicide	Antibiotic
58.	*Trichoderma spp*	Fungicide	Microorganism
59.	Validamycin A	Fungicide	Antibiotic
60.	Zhongshengmycin	Fungicide	Antibiotic
	Total	**60**	

***Source**: MARD, 2020*

Appendix 2. List of organic rice companies in Vietnam

No	Companies	Certifier	Provinces /Cities	Country
1	ASIA CHEMICAL CORPORATION	CUC	Ho Chi Minh	Viet Nam
2	BLUE OCEAN IMPORT EXPORT CO., LTD	CUC	Ho Chi Minh	Viet Nam
3	CO MAY COMPANY LIMITED	CUC	Dong Thap	Viet Nam
4	DANI FOODS VIETNAM CO., LTD	CUC	Ho Chi Minh	Viet Nam
5	GEN GREEN ORGANIC FARM COMPANY LIMITED	CUC	Dong Nai	Viet Nam
6	HO QUANG TRI PRIVATE ENTERPRISE	CUC	Soc Trang	Viet Nam
7	HOA NANG AGRICULTURAL COMPANY LIMITED	CUC	Ho Chi Minh	Viet Nam
8	NHAT THONG AGRICULTURE COMPANY LTD	CUC	Ho Chi Minh	Viet Nam
9	NHAT THONG AGRICULTURE COMPANY LTD - DAK LAK BRANCH	CUC	Daklak	Viet Nam
10	PHUONG ANH BINH DUONG MANUFACTURE COMPANY LIMITED	CUC	Binh Duong	Viet Nam
11	TAY NINH TAPIOCA JSC	CUC	Tay Ninh	Viet Nam
12	TRA VINH FOOD COMPANY	CUC	Tra Vinh	Viet Nam
13	TV FOOD COMPANY LIMITED	CUC	An Giang	Viet Nam
14	VEDAN (VIETNAM) ENTERPRISE CORP.	CUC	Dong Nai	Viet Nam
15	VIEN PHU TRADING & PRODUCTION ONE MEMBER COMPANY LIMITED	CUC	Ca Mau	Viet Nam
16	VIET - SUISSE ORGANIC AGRICULTURE COMPANY LIMITED (VSOA CO., LTD)	CUC	Ho Chi Minh	Viet Nam
17	VINAMIT JOINT STOCK COMPANY	CUC	Binh Duong	Viet Nam
	Total: 17 companies			

***Note:** [CUC] Control Union Certifications* ***Source:** USDA, 2020*

Appendix 3. Distribution map of organic agriculture in Vietnam

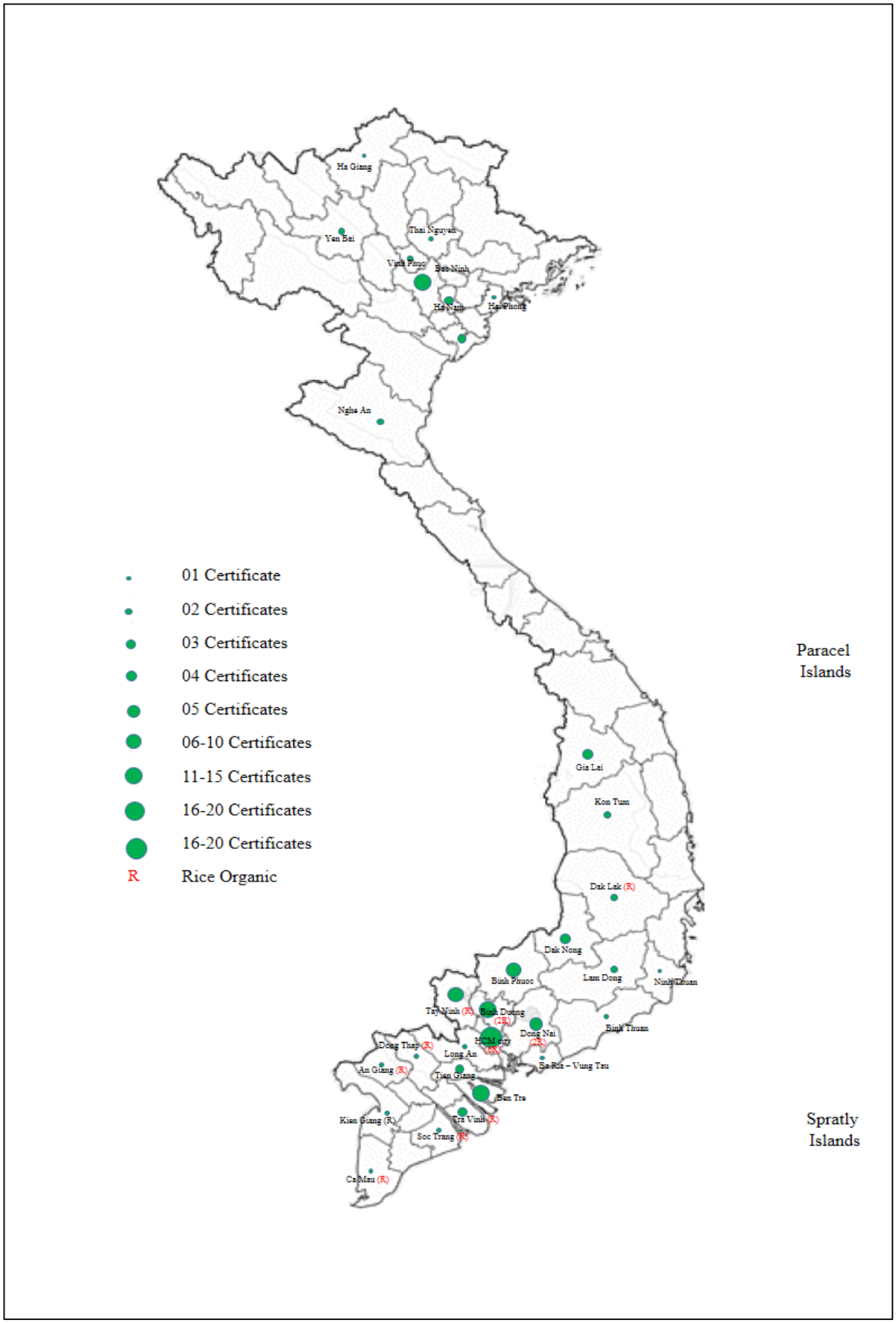

Photo from the Internet, data from USDA (2020), mapping by Le Thanh Phong, 2021

Appendix 4. Certificate of Vietnam PGS standard from IFOAM

ORGANIC
IFOAM FAMILY of STANDARDS
That's Organic - Worldwide.

CERTIFICATE OF ADMISSION INTO THE IFOAM FAMILY OF STANDARDS

This certificate confirms that the

Vietnam Organic Agriculture Association

listed in the IFOAM Family of Standards as

- Vietnam PGS Standards, Vietnam -

has successfully passed the equivalence assessment against the Common Objectives and Requirements of Organic Standards (COROS), also known as IFOAM Standards Requirements, and is herewith admitted into the Family of Standards.

Markus Arbenz
Executive Director

Joelle Katto-Andrighetto
Value Chain Manager

This certificate is valid until December 31, 2015.
Notwithstanding its validity, this certificate becomes void should the above standard not be listed in the official Family Frame, available on www.ifoam.org.

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Source: *Website of Vietnam PGS http://vietnamorganic.vn/pgs*