STOCK TAKING REPORT ON

THE USE OF AGROCHEMICALS IN THE ASEAN REGION

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Stocktaking Report on the Use of Agrochemicals in the ASEAN Region

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TABLE OF CONTENTS

THE STOCK TAKING REPORT ON THE USE OF AGROCHEMICALS IN THE ASEAN REGION

GLOSSARY AND ABBREVIATIONS

AFSN	ASEAN Food Safety Network
AMR	Antimicrobial Resistance
AMS	ASEAN Member States
ASEAN	Association of Southeast Asian Nations
BCA	Biological Control Agents
CAGR	Compound Annual Growth Rate
CGIAR	Consultative Group for International Agricultural Research
CIMMUT	International Maize and Wheat Improvement Center
DOA	Department of Agriculture
EFB	Empty Fruit Bunch (of palm)
EU	European Union
EWG-MRLs	Expert Working Group on Harmonization of Maximum Residue Limits
FAMA	Federal Agricultural Marketing Authority
FAO	Food and Agriculture Organization of the United Nations
FAW	Fall Armyworn
FELDA	Federal Land Development Authority
FOA	Farmers' Organization Authority Malaysia
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GHS	Globally Harmonized System
HHPs	Highly Hazardous Pesticides
IFAD	International Fund for Agricultural Development
JMPR	Joint Meeting on Pesticide Residues
MADA	Muda Agricultural Development Authority
MAFI	Ministry of Agriculture & Food Industries
MARDI	Malaysia Agricultural Research & Development Institute
MITI	Ministry of International Trade and Industry (Malaysia)
MPIC	Ministry of Plantation Industries & Commodities
MPOB	Malaysia Palm Oil Board
MRLs	Maximum Residue Limits
NAFAS	National Farmers' Association / Pertubuhan Peladang Kebangsaan
NIOSH	National Institute for Occupational Safety and Health
NPK	Nitrogen, Phosphorus, Potassium
OECD	Organization for Economic Co-operation and Development
OPF	Oil Palm Fronds
OPT	Oil Palm Trunks
OSHA	Occupational Safety and Health Administration

PPSD	Plant Protection Sub-Division Viet Nam
RRI	Rubber Research Institute
SAICM	Strategic Approach to International Chemicals Management
SDGs	Sustainable Development Goals
STDF	Standards and Trade Development Facility
UN	United Nations
UNEP	UN Environment Programme
USAID	United States Agency for International Development
WHO	World Health Organization

EXECUTIVE SUMMARY

The United Nations' 17 Sustainable Development Goals (SDGs) aim to develop and to achieve decent lives for all as a healthy planet by 2030 (the 2030 Agenda for Sustainable Development United Nations, 2015). By 2020, only 3 of the 21 SGDs targets had been met, with the current forecast being that by 2030, the majority of the goals will be missed by 2030. (Hitting the Targets, populationmatters.org). The UN SGDs were, and are an urgent call for action by all the countries, developed and developing to a global partnership.

Sustainable Development has been described with 6 main principles:

1. Increasing productivity in food systems
2. Protecting and enhancing natural resources
3. Improving livelihoods
4. Enhancing resilience
5. Good governance
6. Improving biodiversity

The areas of focus for sustainable farming include:

- The problems of how to increase food production productivity and reproducibility to ensure food security whilst protecting environmental and biodiversity concerns.
- Creating economic returns for all groups involved.
- Ensuring the health and safety for both the farming community and the food produce.
- Providing more equitable economic solutions to all the communities involved.

It is imperative that all food production, for the future of the world, is carried out with a vision of a common clean safe production system, which itself produces clean safe food for populations in both developing and developed countries. Food produced within ASEAN should be produced with the same standard as food produced in the EU or any developed country in the world.

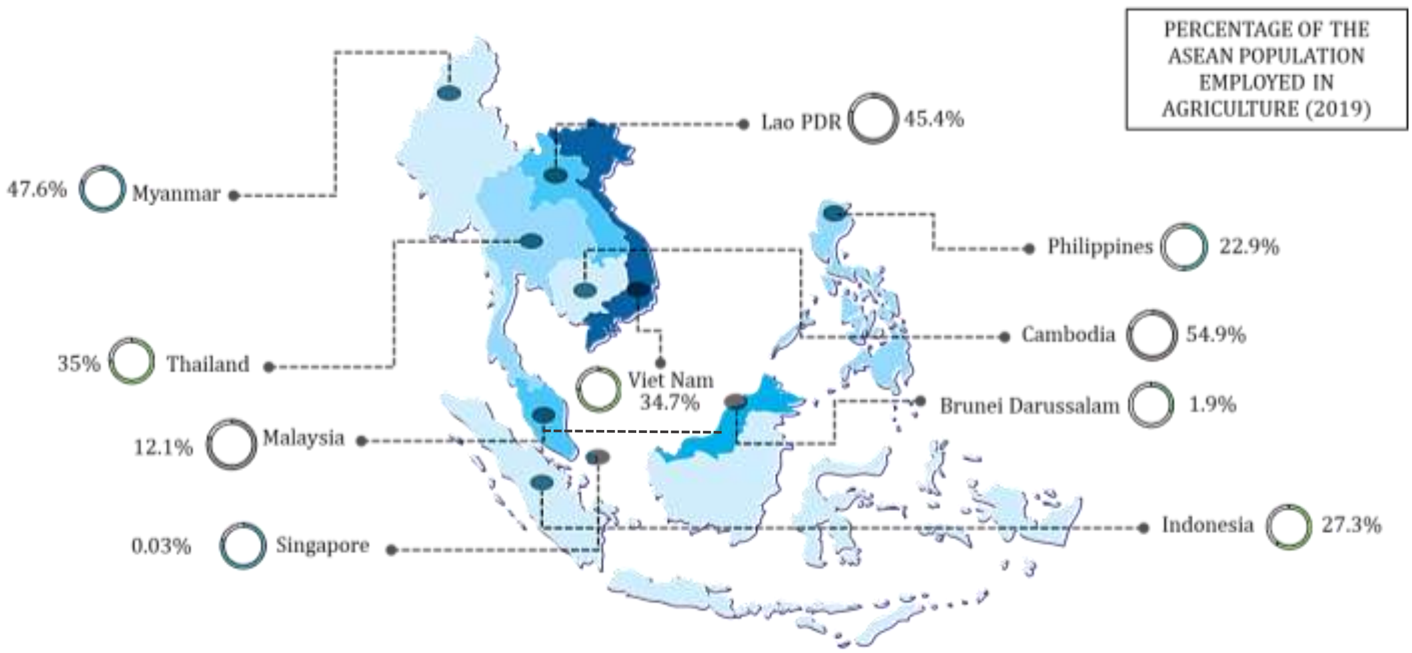
The use or overuse of chemical inputs (fertilizers, antimicrobials and pesticides) creates negative effects throughout the ecosystem, and creates numerous long-lasting effects on the environment, and by extension, the economy and the society throughout the world.

1. INTRODUCTION

It has been said that agriculture is a way of life in ASEAN. With a population expected to grow by 120 million from 2020 to 2050, there is an unprecedented demand to grow more food. This has to take place without causing any further environmental degradation while the effects of climate change have had profound effects on many of the food production systems.

In an article by the FAO entitled "Supporting Responsible Investments in Agriculture & Food Systems (RAI)" dated 3rd April 2020, the FAO estimated that USD 5.2 billion per year was needed to support both agriculture and rural development in the ASEAN region to achieve the first two SDGs on poverty and hunger (Achieving Zero Hunger. The Critical Role of Investments in Social Protection and Agriculture - FAO, IFAD & WFP2015).

Diagram 1: Agriculture Employment Percentage in ASEAN



Authors Composition (Information Source: ASEAN Key Figures (2020))

1.1. BACKGROUND OF THE PROJECT

In order to drive the needed sustainable, circular agriculture development in agriculture in ASEAN, and in order to meet the actual potential of the agriculture sector while ensuring the health and economic security of the large farming communities within ASEAN, there is a need to take stock of the present methodology and the systems to place them within the concept of sustainable and circular agriculture development. This involves the need for greater safety in the methodology and systems for not only the food products produced but also the farming communities involved and the welfare of the surrounding environment.

- Increasing agricultural production or agricultural intensification has led to the increased usage of a whole range of agrochemicals within ASEAN. These comprise, among others, pesticides (weedicides, herbicides, fungicides, rodenticides etc.), antimicrobials, medication for aquaculture and animal husbandry species, synthetic fertilisers and feed additives. ASEAN has increased its usage of agrochemicals, as the perceived link between agricultural productivity and the increased use of agrochemicals is a strong one.

- The planned development and employment of Sustainable Circular Agriculture within ASEAN will have to be based on an understanding and a balance to the relationship between the usage of these inputs and the sustainability of the farming programs within ASEAN.

- The employment of pesticides was estimated at around 3.5 million tonnes globally in 2020. Although pesticides are beneficial from the crop production point of view, extensive use of pesticides can pose serious consequences because of their biomagnification, persistent nature and the development of resistance to the pesticides. Pesticides can directly or indirectly pollute air, soil, and water and thus the overall ecosystem. In addition, the persistent usage of large amounts of pesticides in agriculture is now affecting the public health sectors in the increased resistance of Aedes mosquitoes (Aedes *aegypti* and Aedes *albopictus*) within ASEAN carriers of the dengue virus. First reports of field-evolved resistance to agrochemicals in dengue mosquitoes (Aedes *albopictus)* were from Pakistan (Hafizazhar, et al., 2011) with an up-to-date report (2021) on insecticide resistance in Aedes mosquitoes within ASEAN. This is mentioned later in this report (Gan, et al., 2021).

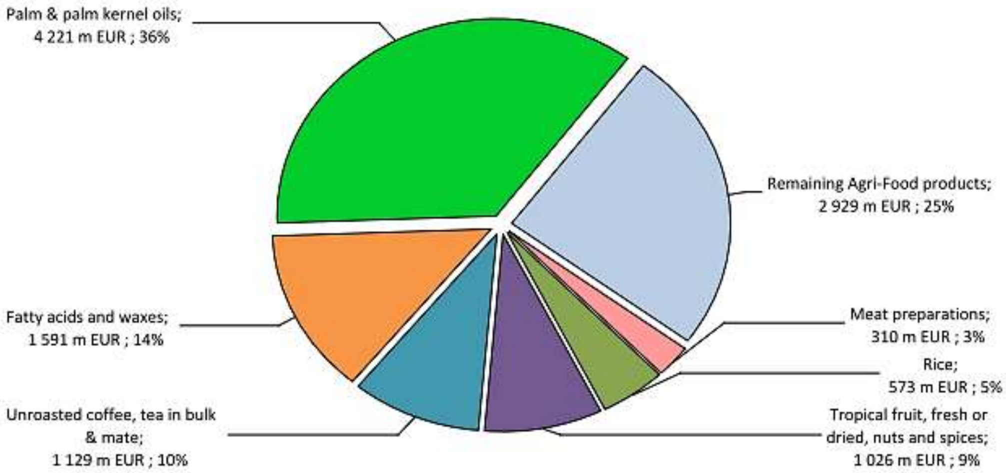
Table 1: Agriculture Area in S. E. Asia

Country	Population (million)	GDP (US$ Billion)	Real GDP growth (%)	Agricultural land (000 ha)	Agriculture as % of GDP (%)
Indonesia	267.7	1,126	5.00	45,420.10	12.8
Thailand	69.4	520	2.40	20,882.08	8.1
Myanmar	53.7	77	6.50	16,544.94	24.6
Philippines	106.7	356	5.90	14,801.00	9.3
Viet Nam	95.5	255	7.00	14,007.38	14.7
Malaysia	31.5	370	4.30	7,461.90	7.5
Cambodia	16.7	24	7.00	3,804.80	22
Lao PDR	7.1	20	4.70	1,516.86	16.2
East Timor	1.3	3	3.10	182.98	17.5
Brunei Darussalam	0.4	13	3.90	14.00	1
Singapore	5.8	382	0.70	1.11	0
	655.8	**3146**		**124,637.15**	

Source: Agribusiness Global, 2020

1.2 THE NEED TO MAINTAIN QUALITY OF ASEAN GOODS TO EXPORT MARKETS

Diagram 2: Top EU Agri-Food imports from ASEAN (Association of Southeast Asian Nations) in 2020



Source: Agri-Food Trade Statistical Fact Sheet EU-ASEAN, 2021

The development of sustainable, circular agriculture systems in ASEAN is a key step forward identified within ASEAN to ensure the continuous productivity and cost-effectiveness of agriculture within ASEAN while adhering to environmental and social welfare concerns. A key component of this Sustainable Circular Agriculture strategy is the overall ecological health of the natural system and the health and wellbeing of the farming communities within ASEAN.

Table 2: Status of ratification of international chemicals conventions and implementation of GHS

Country	Rotterdam convention	Stockholm convention	Minamata convention	GHS implementation[1]
Brunei	-	-	-	No
Cambodia	Party	Party	-	No
Indonesia	Party	Party	Party	Fully
Lao PDR	Party	Party	Party	No
Malaysia	Party	Party	-	Partly
Myanmar	-	Party	-	No
Philippines	Party	Party	-	Partly
Singapore	Party	Party	Party	Fully
Thailand	Party	Party	Party	Partly
Vietnam	Party	Party	Party	Fully

Symbols: (-) Represent that the country is not a party to the convention at the time of the report while responses to the question on the Global Harmonized System (GHS) on the Classification and Labelling of Chemicals indicate whether it has adopted the GHS for classification and labelling of chemicals.
Source: Regional Programme: "Towards a Non-Toxic Southeast Asia" Phase II (2019)

1.3 GOOD AGRICULTURAL PRACTICES (GAP)

GAP aims at applying available knowledge to addressing environmental, economic, and social sustainability dimensions for on-farm production and post-production processes, resulting in safe and quality food and non-food agricultural products (BAFPS, 2020).

1.3.1 Consumer Demand as a Driver of GAP Promotion

Consumers now set the quality requirements on how food products are retailed. Rather than price, the deciding factor for consumers is whether poor farmers in developing countries can deliver produce into these markets with the best prices that have these quality requirements (Chan, K. Manual on Good Agricultural Practices (GAP), 2016).

Under this modern system, consumers have a right to safe food. The new aspect of this conceptual approach to agriculture is the moral and legal obligation for every farmer to produce hygienic food that is assured to be safe and clean. Consumer demands in the market system mean that farmers must now produce crops in compliance with GAP standards (Chan, K. Manual on Good Agricultural Practices (GAP), 2016).

1.3.2 The Development of GAP in the Horticultural Production System

GAP includes farm codes of conduct, manuals, guidelines, standards, and regulations that have been developed by growers' associations, food processors, retailers, governments, and NGOs. The aim of these codes of conduct is to assure that the food produced is at the quality level demanded by consumers and safe for human consumption. The guidelines are based on science, and should conform to local and national standards. GAP also addresses environmental sustainability issues, as well as the economic and social sustainability of the stakeholders. GAP standards are adopted by practitioners on a voluntary basis (Chan, K. Manual on Good Agricultural Practices (GAP), 2016).

1.3.3 Assurance of Safe Food Production

The modern food trade system gives consumers greater influence in determining what food is grown, when it is grown, and how it is grown. Consumers demand that the produce delivered to them meets recognized quality and safety standards. Food that is safe for consumption is defined in terms of food hygiene, cleanliness in production and preparation, and an absence of physical, biological, and chemical contamination. However, due to increasingly complex modern food chain systems coupled with the development of experienced food producers and processors working alongside less developed food producers, many consumers now have doubts about the safety and hygiene of their food. This public concern is driven by food regulation authorities and also by the business entities that are held responsible for food safety by consumers (Chan, K. Manual on Good Agricultural Practices (GAP), 2016).

1.3.4 Sustainable Agricultural Production

GAP allows chemical inputs in farms. However, the applications of these chemicals must ensure handling and residual safety, that the farm ecology is not irreversibly damaged, and that the negative impacts of farm practices are minimized and do not affect the environment outside the farm. These farm management practices promote ecological sustainability and enable farms to produce efficiently in a sustainable manner that leads to profitable returns. Sustainable agriculture is a farming system that provides safe, nutritious, and affordable food to meet the needs of the world population in a way that conserves the environment and natural resources. It seeks to optimize skills and technologies to achieve long-term productivity and profitability for stakeholders of the agriculture enterprise in order to ensure that future generations can also experience the same prosperity that we enjoy today (Chan, K. Manual on Good Agricultural Practices (GAP), 2016).

Additional specific ecological concerns include soil productivity (erosion, depletion of top soil, desertification), water conservation (depletion, groundwater usage, contamination), pest and disease resistance to chemical pesticides, the greenhouse effect, and climate change (Chan, K. Manual on Good Agricultural Practices (GAP), 2016).

1.3.5 Impacts on Human Health and Social and Economic Concerns

In the majority of the developing countries in the Asia-Pacific region, farm laborers are illiterate and among the lowest paid members of the work force. Because of this, they are not likely to recognize chemical hazards or understand the seriousness of food contamination risks. Dissemination of knowledge, training, and the provision of remunerative incentives and sustainable wages for laborers are imperative to ensure the effectiveness of good farm practices (Chan, K. Manual on Good Agricultural Practices (GAP), 2016).

Modern consumers are influenced by their moral convictions when they make their purchases. Their agenda now includes socioeconomic concerns on the production of their food purchases, including the price of food at the farm gate, the incomes of small and rural farmers, and the health and welfare of the farmers and their children. These concerns are now critical criteria in the food production process (Chan, K. Manual on Good Agricultural Practices (GAP), 2016).

1.3.6 The Purpose and Scope of ASEAN GAP

ASEAN GAP is a standard for good agricultural practice during the production, harvesting and postharvest handling of fresh fruit and vegetables in the ASEAN region. The practices in ASEAN GAP are aimed at preventing or minimizing the risk of hazards occurring. The hazards covered by ASEAN GAP include food safety, environmental impacts, worker health, safety and welfare, and produce quality (ASEAN GAP, 2016).

Global trade in fresh fruit and vegetables is increasing as trade becomes freer. Changes in consumer lifestyle in the ASEAN Region and throughout the world are driving the demand for assurance that fruit and vegetables are safe to eat and of the right quality, and are produced and handled in a manner that does not cause harm to the environment and the health, safety and welfare of workers (ASEAN GAP, 2016).

The impact of these trends is increasing requirements from retailers for compliance with GAP programs and the introduction by governments of legal requirements for food safety, environmental protection, and workers health, safety and welfare (ASEAN GAP, 2016).

The member countries of ASEAN have common farming practices, infrastructures and weather patterns. The implementation of GAP programs currently within the ASEAN region varies, with some countries having government-certified systems and others beginning the journey with awareness programs for farmers.

The purpose of ASEAN GAP is to enhance the harmonization of GAP programs within the ASEAN region. This will facilitate trade between ASEAN countries and to global markets, improve viability for farmers, and help sustain a safe food supply and the environment (ASEAN GAP, 2016).

ASEAN GAP covers the production, harvesting and postharvest handling of fresh fruit and vegetables on farm and post-harvest handling in locations where produce is packed for sale. ASEAN GAP may be used for all types of production systems but it is not a standard for certification of organic products or GMO-free products (ASEAN GAP, 2016).

1.3.7 The Importance of ASEAN Good Aquaculture Practices (GAqP)

Aquaculture in the Southeast Asian countries is not only important because of its contribution to food security and nutrition, countries in Southeast Asia also depend heavily on the aquaculture sub-sector, as a critical contributor to national and regional social and economic development with contributions to the rural economy, and foreign exchange. Seven (7) countries in the ASEAN region including Indonesia, Malaysia, Myanmar, the Philippines, Thailand, Viet Nam, and Cambodia are ranked among the top twenty-five countries in terms of aquaculture volume (ASEAN GAqP Policy Brief, 2014).

Asia has been the main aquaculture producer for the last two decades and produces the 92% of the total world aquaculture products. Southeast Asia produced 22.5 million tonnes of aquaculture products in the mid-2010s, which accounts the 22% of the total world production. Estimation of the production for 2020 in Southeast Asia is of around 30 million tonnes, based on the previous data, together with the global annual growth rate of the sector (~5.8%) (Soriano, 2020).

Indonesia is the main aquaculture producer in Southeast Asia, contributing to 50% of the region's production, followed by Viet Nam, the Philippines, and Thailand. Likewise, Indonesia is the regional leader in the culture in brackish water and mariculture, especially in shrimp production. Regarding culture in fresh water, Viet Nam is the main aquaculture producer, followed by Indonesia. The most common freshwater species in the region include tilapia, carp and catfish. (Soriano, 2020).

If aquaculture in Southeast Asia is to continue its growth, standards must be set in place to address issues important to consumers including food safety, animal health, environmental sustainability, and worker-related issues. All of these must be addressed to sustain the growth of the aquaculture industry in the ASEAN region. As the ASEAN integration and ASEAN economic community develops, it becomes important that standards must be recognized mutually between the ASEAN Member States (AMS). This mutual recognition can be facilitated if there are harmonized standards in place to address Good Aquaculture Practices in the aquaculture industry across all ten member states. Not only will this facilitate intra-ASEAN trade but it will go a long way to satisfy export requirements and facilitate exports as the ASEAN community develops (ASEAN GAqP Policy Brief, 2014).

2. AGROCHEMICALS

2.1.1 PESTICIDES (Insecticides, Herbicides, Fungicides, Rodenticides, Acaricides & Nematicides)

Pesticide use in Southeast Asia has increased steadily, driven by the growth of large-scale commercial farming, as well as a desire to maximize food production in rural subsistence farming. Pesticides are used extensively in agriculture around the world and in ASEAN to improve crop yields by controlling insects, fungi, mollusks, and rodents (Akta, et al., 2009).

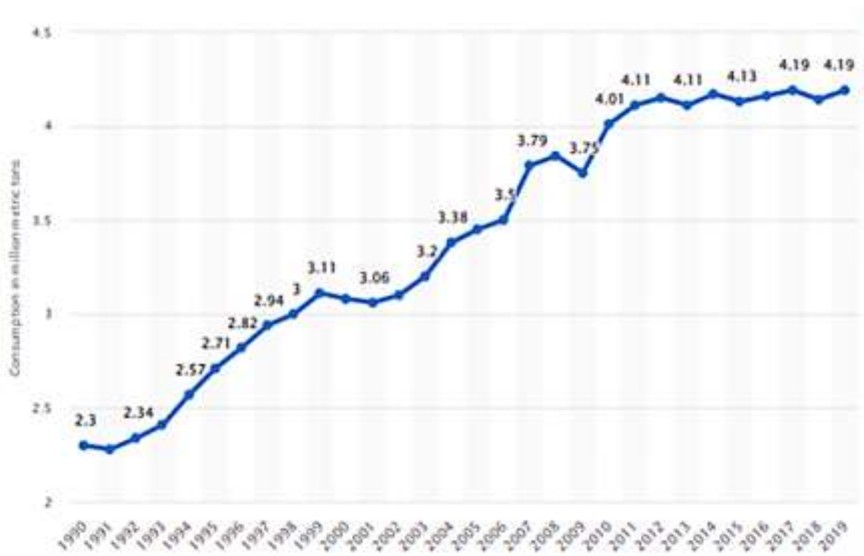


Diagram 3: Agricultural Consumption of Pesticides Worldwide :1990-2019 (in million metric tonnes)
Lucia Fernandez, Sept 27th, 2021

Their use has increased tremendously within the region, spurred by a drive to increase food productivity. Grains, vegetables, and fruit are the main products in AMS. Chemical pest control has been popular from the dawn of the Green Revolution to protect fruit and vegetable crops, and there may be resistance to changing what are seen as long-established practices (Panuweet, et al., 2012).

There is a powerful driving economic incentive for farmers to increase production of food in order to increase incomes. However, the long-term effects of chemical pesticides use have been shown to have harmful effects on the surrounding ecological system while there is mounting evidence of damage by pesticides to human health (Ratanachina, et al., 2020; Patel, et al., 2019; Kumar, et al., 2019). Pesticides can contaminate rivers, lakes, and oceans, and in turn a polluted natural environment means a polluted food chain. Documented human health risks of pesticide exposure includes: acute neurologic poisoning, chronic neurodevelopmental impairment, cancer, reproductive dysfunction, and possibly dysfunction of the immune and endocrine systems (Nicopolou-Stamati, et al., 2016). Pesticide residues on agricultural products can be transferred directly to humans, with deleterious health effects (Thapinta, et al., 2000). In addition, soil contamination and water contamination with pesticides / fumigants may also have negative health effects on soil and water (Ecobichon, et al., 2001). Apart from effects on health through pesticide-contaminated food, pesticide applicators and their families are the ones who are most exposed to pesticides. Absorption occurs through the skin, lungs, and mucous membranes. Farm workers, including sprayers and mixers, are a high-risk group whose health may be seriously compromised (Curl, et al., 2020). The ASEAN drive for food productivity and security has led to a dramatic increase in pesticides use. Support for small farmers remains a challenging development issue in ASEAN. It has been estimated that the volume of pesticides used in Southeast Asian countries increased by approximately 400 percent in the first decade of the new millennium (Panuweet, et al., 2012). Thailand is reported to be the highest user of imported pesticides by volume in the region (Mohammad, et al., 2017), while Viet Nam has the highest application rate of 16.5kg/hectare (Schreinemachers, et al., 2015). However, pesticide use in Cambodia and Lao PDR is increasing rapidly too (Schreinemachers, et al., 2015).

Most pesticides are synthetically-produced organic and inorganic chemical compounds, although biological agents are also coming into wider use (Samada, et al., 2020). The most commonly imported pesticides are organophosphates (OPPs) and carbamates (Pakvilai, et al., 2015). OPPs and carbamates kill insects by blocking acetylcholinesterase (AChE), an enzyme that catalyzes hydrolysis of a neurotransmitter acetylcholine, resulting in overstimulation of the neuromuscular system and the parasympathetic nervous system. Exposure to OPPs by inhalation or ingestion with or without food is toxic to the human body. It can be detected by a reduced AChE concentration in capillary blood. Acute OPP poisoning symptoms include: increased salivation, diarrhea, vomiting, muscle tremors, gastrointestinal upset, and confusion (Eddleston, et al., 2000). The onset of symptoms can start within minutes or hours and last for days to weeks. In the long term, lower-dose exposure to OPPs has been reported to cause polyneuropathy and cardiovascular diseases (Hung, et al., 2015). Carbamates can also pose health and environmental hazard, including through groundwater contamination and food (Baron, et al., 1994; Taylor, et al., 2017). The health impact of pesticide use has been a topic of heated debate for many years in Asian countries, both at national and local government levels. There is a need to prevent adverse health effects as part of a wider pesticides management strategy in agriculture including farmer pesticide applicator health, and we should establish a framework for cooperation within ASEAN. To carry this out at present, AMS have only their differing national strategies, and it would be valuable to compare approaches and develop a more uniform approach that takes the best ideas from each country.

Pesticide residue monitoring is only a part of the overall pesticide risk management framework. However, most pesticides are toxic to human beings, especially for those who work with them or come into contact with them. In sustainable agriculture, the health of the community is an important parameter to be assessed and factored in. The determination of the MRLs by the Codex Alimentarius gives an indication of the levels of the pesticide residues on the food product at the end of the cycle and by extrapolation, these have been used as an indication of the usage of these pesticides in the field. However, these do not truly give an accurate indication of the usage of the pesticides in the field. A much better indicator of pesticide exposure to farmers, and pesticide applicators is the tests on exposure to the pesticides which have been drafted by bodies under the Departments of Health and Safety, or NIOSH (National Institute for Occupational Safety and Health) and OSHA (Occupational Safety and Health Administration). This test for exposure to pesticide poisoning, which is a routine requirement for public health employees should perhaps be encouraged to be carried out as a routine test for pesticide applicators in both public health and agriculture. It is necessary to develop a strategy which will enable monitoring of the health of agricultural workers involved in the application of pesticides throughout AMS together with the monitoring of MRLs.

Research confirms that the use of agricultural pesticides in Southeast Asia has skyrocketed during the last 20 years. Pesticides have become so easily available that a pesticide retailer can nowadays be found in nearly every village in Thailand and Viet Nam. These two countries have recorded growth in pesticide use of 7-10% annually over more than 10 years. Levels of pesticide use are much lower in Cambodia and Laos but these countries appear to be catching up quickly. (Pesticide troubles in SE Asia – World Vegetable Center, 2019)

2.1.1 Pesticide Usage within ASEAN

The World population is estimated to reach 8.5 billion by the year 2030 (UN, 2015) and the ASEAN population is estimated to reach 717 million by 2030 (MITI; Ministry of International Trade and Industry, Malaysia). Agriculture remains a significant contributor to employment within most ASEAN member states. ASEAN is also one of the most productive agricultural regions in the world (Table 1).

(i) Results of Surveys on the use of pesticides in ASEAN

From a study of a representative sample of one thousand (1000) vegetable farmers in Cambodia, Lao PDR and Viet Nam (World Vegetable Center, 7th October 2019), results showed that 100% of the sampled farmers in Viet Nam, 73% in Cambodia and 59% in Lao PDR overused pesticides. In addition, pesticide expenditure in excess of the economic optimum was 96% for Viet Nam, 92% for Cambodia, and 42% for Lao PDR. Another finding was that pesticide overuse was much more prevalent when men were in charge of the pest management decisions rather than women and that farmers seeking advice from pesticide salesmen helped to generate and maintain the idea that food productivity can only be achieved with the applications of more pesticides. Results showed that a majority of the sampled farmers in Viet Nam, Cambodia, and in Lao PDR tended to overuse pesticides. In addition, pesticide expenditure was in excess of the economic optimum in all three countries. These studies showed that farmers in Southeast Asia are spraying pesticides excessively, inefficiently and could actually increase profitability by spraying less. In fact, the same study showed that the probability of a farmer overusing chemical pesticides is greatly reduced (by 68%) if farmers use biopesticides. In general, promotion of overall GAPs was an effective strategy to reduce the use of pesticides.

The work done by the World Vegetable Centre mentioned focuses on Vietnam, Cambodia and Lao PDR particularly. Other studies show (Table 3 and Table 4) show that tests done by the European Food Safety Authority (EFSA) on food imports into the European Union (The 2019 European Union report on Pesticides in food (EFSA, 2021) showed that five of the countries with the highest number of food samples exceeding the Pesticide Maximum Residue Limits (MRLs) in food imported into the EU out of the top nine are members of ASEAN. The percentage of the samples exceeding the European MRLs was registered as between 15.7% to 51.4%.

Table 3: Percentage of Food Samples Originating from AMS that Exceeded the MRLs

Country	% of the Samples > MRLs
Lao PDR	51.4%
Malaysia	27.3%
Viet Nam	21.2%
Thailand	17.3%
Cambodia	15.7%

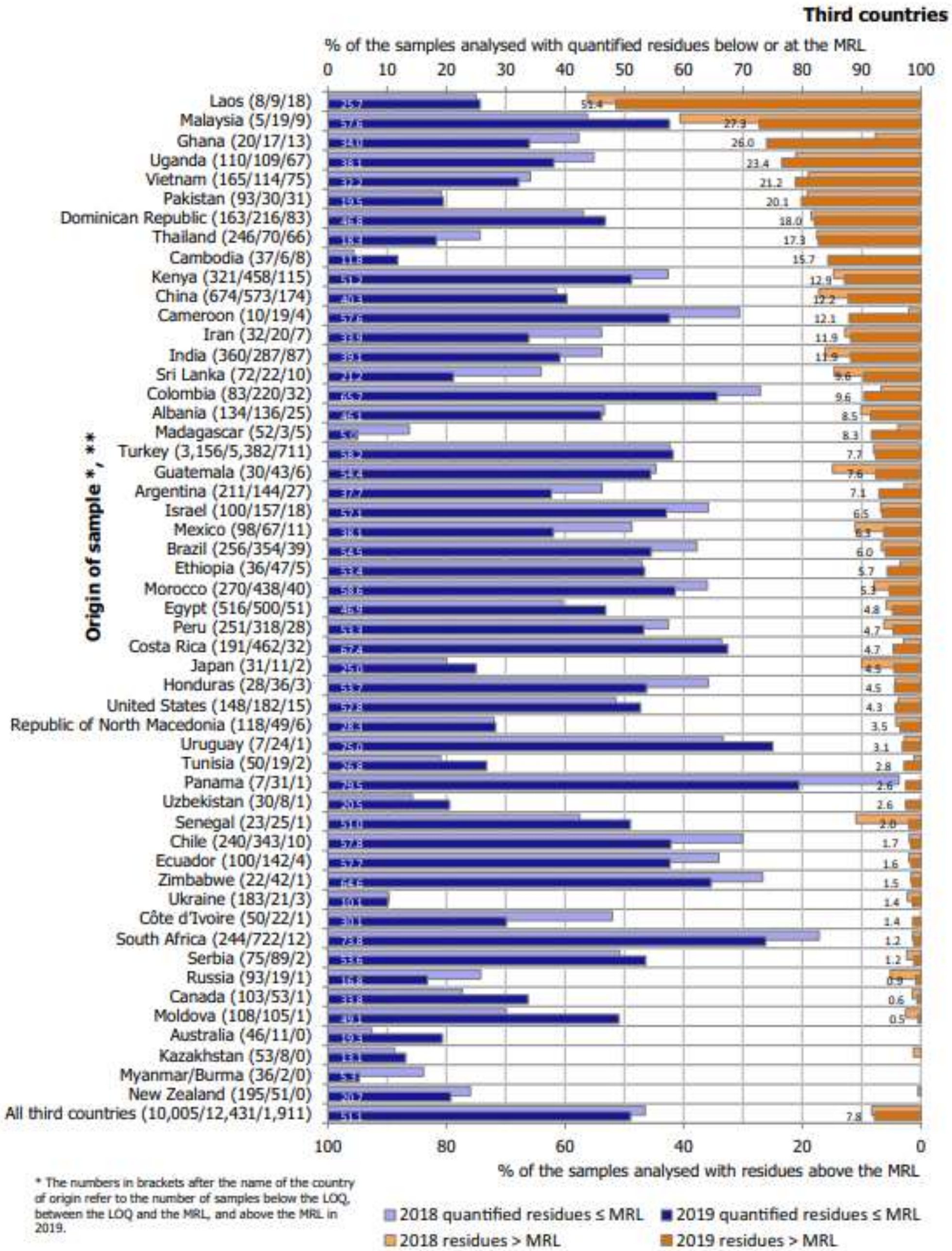
Source: The 2019 European Union Report on Pesticides in Food (2021 – European Food Safety Authority (EFSA)

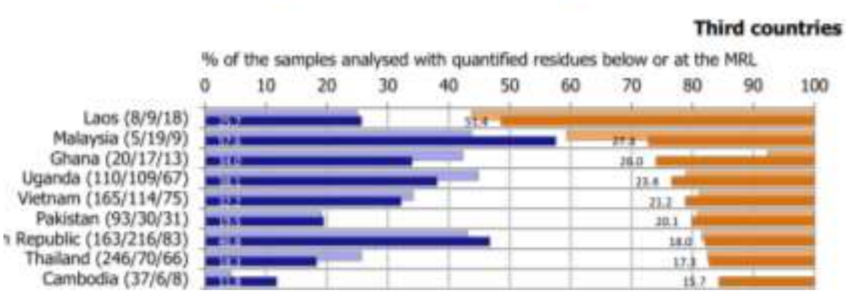
The Maximum Residue Limits for pesticides are defined as “the highest level of a pesticide residue that is legally tolerated in or on food or feed when pesticides are applied”. In this regard, farmers in 5 ASEAN Member States may be over applying pesticides onto crops which are being exported to the EU as evidenced in the report by the European Union.

In an article entitled “The trap of pesticide use” by Prof. Yunita T. Winarto, presented at a workshop on “The behavior of Pesticide purchasing and use” (2021) Prof. Yunita describes how pesticides are being overused with pesticide cocktails in Indonesia. In addition, in a recent article (2022) on “Farmers’ knowledge and practice regarding good agricultural practice (GAP) on safe pesticide usage in Indonesia” by Istriningsih et al, the author states that “The level of pesticide use in Indonesia has been increasing over the last few decades”. Joko et al, 2020; Mariyono et al, 2018

“The consequences of the ‘Green Revolution’ persist in Indonesia and are most evident in the continuing high use of pesticides. After 1986, Indonesia made dramatic reductions in its use of pesticides for rice by adopting methods of integrated pest management, but these reductions were significantly reversed after 2002, producing a ‘tsunami’ in a costly and deleterious promotion of a wide range of pesticides. By destroying natural predators, this deleterious increase enabled the brown planthopper, a major pest on rice, to become endemic, causing substantial crop losses”. (“The Tsunami of pesticide use for rice production on Java and its consequences”, Adlinanur Prihandiani, et al, 2021)

Table 4: MRL Exceedance and Quantification Rates by Country of Origin (Third Countries)





Source: European Food Safety Authority. EFSA Journal, 2021

(ii) Past Case Studies

According to a study conducted by Pepijn, et al. (2019), high and rising levels of pesticide use in developing and developed countries pose an enormous challenge to the health of consumers, farmers and the environment. Pesticide exposure is linked to various chronic and short-term health hazards including cancer. The health of farm workers in developing countries is particularly at risk due to high levels of occupational exposure (Wanwimolruk, et al., 2016)

The extent of the problem is large in Southeast Asia with Thailand, Philippines, Malaysia, and Viet Nam being the largest users and particularly in vegetable production systems (Pepijn, et al., 2019). A study conducted in Thailand showed that the health and environmental costs of pesticide use is about five times higher per hectare of vegetables compared to rice production (Praneetvatakul, et al., 2013). Another study by Grovermann, et al., 2013, on vegetable production in Thailand estimated that 84% of the quantity of pesticides applied was in excess of the economic optimum.

To stimulate agricultural growth, governments have supported the use of pesticides by creating conditions for widespread availability and affordable prices (Dangupta, et al., 2005, Praneetvatakul, et al., 2013, Van Hoi, et al., 2013).

(iii) Observations

The rapid rate of the increase in pesticide use caused by the need for an increase in food production has created an enormous challenge in managing the accompanying increased risks to farming communities and detrimental effects on the environment. This has resulted in widespread pesticide misuse and the accompanying adverse effects such as that recorded in Thailand (Boonyatumanond, et al., 1997; Thapinta and Hudak, 2000; Stuetz, et al., 2001., Asawasinsopon, et al., 2006; Kunstadter, et al., 2006; Panuwet, et al., 2008; Grovermann, et al., 2013; Riwthong, et al., 2015). Similarly, this pesticide misuse has also been recorded in Viet Nam (Berg, 2001; Dasgupta, et al., 2005; Hoi, et al., 2009; Hoai, et al., 2011; Lamers, et al., 2011). It would be prudent for ASEAN Member States to check the misuse of pesticides in order to protect ASEAN agricultural exports.

Similarly, in a survey presented to UNEP, SAICM (2nd to 4th April 2019), a working group of the International Conference on Chemicals Management, the survey of a total of 2025 small-scale farmers and agricultural workers which was carried out in seven (7) countries: Bangladesh, India, Pakistan including four (4) ASEAN countries; Indonesia, Malaysia, Philippines, Viet Nam, the following was found:

- 7 out of 10 farmers were suffering from symptoms of acute pesticide poisoning.
- 50 highly hazardous pesticides were in use.
- Users often lacked information on the pesticides they used.
- The majority did not use PPE when handling pesticides.

These and other scientific studies suggest a need for further work on this area by AMS.

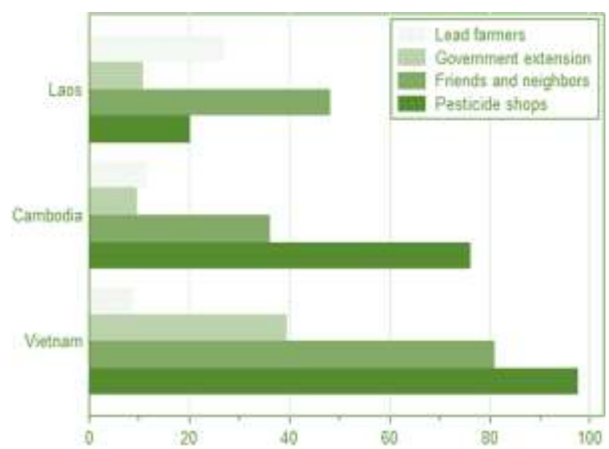
(iv) Challenges

Main challenges which should lead to the development of the betterment of pesticide governance. Included in these are:

- The rush to achieve food security and increase food productivity in the region which has been linked to an unnecessary increase in the use of agrochemicals. This has resulted in a large market for agrochemicals within ASEAN as shown with the import of pesticides from various countries **(Appendix A: Table 5 and Table 6)**. **Table 7** represents pesticides banned or severely restricted in EU as a consequence of the application.

(v) Main sources of pest management advice to vegetable farmers in various AMS

Diagram 4: Sources of advice on pest management in Lao PDR, Cambodia and Viet Nam, in % of vegetables farmers (Schreinemachers, et al., 2017).



In a report on farmers attitudes on pesticides in the report on "Farmers Knowledge, Attitudes and Practices on Synthetic pesticide use in Thailand, Cambodia, Viet Nam and Laos", Dr. Srinivasan Ramasamy of the World Vegetable Center, presenting work done by Dr. Pepija Schreinemachers on work in the region funded by GIZ and BMZ, in an ASEAN FAW (Fall Armyworm) meeting on September 2021, the following conclusions were expanded:

- Countries in Southeast Asia are experiencing rapid growth in pesticide quantities.
- Incorrect use of pesticides leads to environmental and health risks to consumers and farm workers.
- Comprehensive interventions – from the farm to the policy level are needed to address these risks.

As can be deduced from the graph, the main sources of advice for the vegetable farmers on pest management in the regions tested were the pesticide shops as well as the farmers' friends and neighbors. These observations are also noted by independent reports in Indonesia (Dr. Yunita T. Winato, "The Behavior of Pesticide Purchasing and Use" – (ASEAN FAW action plan workshop – Sept 2021)

Some conclusions by the authors on this subject are that:

- Farmers are aware of the health risks of pesticides but perceive pesticides as indispensable.
- Better knowledge about beneficial insects and pests, and the use of biopesticides helps to reduce synthetic pesticide use.
- Interventions are needed to increase the availability of biopesticides while reducing access to synthetic pesticides (through limiting retail points, increasing prices for the riskiest products, and better training of retailers).
- A similar conclusion on the sources of advice on pest management in given in Dr. Joseph Goebs' paper on "Experience in Developing Pesticide Education and Training Programmes: Zambia and Myanmar – 2021"
- Better training of pesticide sales personnel and better interaction and training of farmers on the subject together with the availability of alternate less-toxic alternatives.
- The use of pesticide "cocktails" of up to seven (7) different pesticide products were reported by Fox and Winato in 2016 and Adlinatar in 2021.

Pesticide cocktails: How pesticide mixtures may be harming human health and the environment.

The mixing of various pesticides in order to create a stronger pesticide response by farmers is now a common occurrence in most parts of the world, including in the countries of Southeast Asia. There is a growing body of evidence showing that pesticides can become more harmful when combined, even when each individual chemical appears at levels at or below its "no-observed-effect-concentration". This phenomenon is known as the "cocktail effect" (Soil Association / Pesticide Action Network, Oct 2019).

Dr. Yunita Winarto of the Universitas Indonesia and the Academy of Indonesian sciences reported on the use of pesticide cocktail use in West Java, Indonesia of 100 farmers using a total of 243 different mixed combinations of between 2-7 products, with only eleven farmers using one product. (The Trap of Pesticide use and the Struggle to Get Out of the Trap, Dr. Yunita Winarto, presented at the ASEAN Fall Armyworm Action Plan Conference, 7th Sept 2021). Similarly, Adlinanur P., et al. documented the effect of pesticide cocktail use in Java in the paper on "The Tsunami of Pesticide Use for Rice Production on Java and its Consequences" (20th July 2021).

(vi) Pesticide Use in Rice Cultivation

Professor K.L. Heong pointed out in his paper "Biological Control: Enhancing Farmers Ecological Literacy through Communication Support Strategies" that:

- Farmers have little or no productivity gains from insecticide use and that rice farmers are much better off not using any pesticides.
- In addition, he pointed out that Way and Heong in 1994 had concluded that in tropical rice, insecticides are not needed.

Furthermore, the FAO workbook "Save and Grow", a policymaker guide to sustainable intensification of smallholder crop production of 2012 stated that "most tropical rice crops under intensification require no insecticide use".

The use of pesticides in the production of rice (8th June 2021, Effective Farmer Communication)

A recent summary of the application of pesticides in the production of rice by Professor K. L. Heong Distinguished Qiushi Professor at Zhejiang University, and the former principal scientist at the IRRI (International Rice Research Institute) in the Philippines summarized the use of pesticides in rice as follows:

- Rice farmers have little or no productivity gains from the use of insecticides in rice production.
- Usage of pesticides by rice farmers is done incorrectly (wrong timing, wrong targets, wrong chemicals, wrong concentrations, and poorly-maintained sprayers).
- Rice farmers are much better off not using any insecticides.
- Similarly, Way and Heong (1994) concluded that in tropical rice, insecticides are not needed.
- Rice Integrated Pest Management programs were established to teach farmers and help them rationalize, change their practices, and reduce or stop insecticide use completely.
- "Most tropical rice crops require no insecticide use under intensification. Yields have increased from 3 tonnes/ha to 6 tonnes/ha through the use of improved varieties, fertiliser, and irrigation." (Save and Grow, a policy-makers guide to the sustainable intensification of smallholder crop production, 2011).

2.1.2 ASEAN HARMONIZED MRLS: ASEAN & OTHER COUNTRIES

(i) Overview of ASEAN MRLs

Employing the use of Codex standards is crucial to achieving consensus for food safety standards harmonization within the Southeast Asian region, according to a food safety expert from the United Nations Food and Agriculture Organization (UNFAO). "The harmonization of food safety standards in the ASEAN region has been an ongoing effort many years now but despite multiple working groups working on this from different angles, the progress has been reported this far and the onset of the Covid-19 pandemic appears to have slowed things down even further." (Sridhar Dharmapun, UNFAO Senior Food Safety and Nutrition Officer)

A summary of the FAO – ASEAN meeting on the 25th August 2020 is summarized below:

The Food and Agriculture Organization of the United Nations (FAO) recognize the need for a comprehensive framework for pesticide residue risk management through science-based risk assessment, management, and communication. FAO and Codex Alimentarius members also recognize that a sound pesticide residue risk management framework does not rely only on residue monitoring but importantly includes pesticide registration, chemical control-of-use, trace back investigation, and a chemical review process. Moreover, there is an increasing focus on harmonization of the pesticide management framework including the setting of maximum residue limits. Noting the broad spectrum of pesticide residue risk management frameworks present in the ASEAN countries saw the FAO recognizing the need to develop a guidance document to assist countries in establishing such a framework through appropriate residue monitoring initiatives, trace back review, farm level education and pesticide use review.

The Food and Agriculture Organization of the United Nations (FAO) conducted a regional workshop entitled "Capacity Building on Risk Categorization for Ranking Risk of the ASEAN Food Hazards for Developing the Risk-Based Monitoring Protocol for Food Safety" from 23-25 April 2019. In parallel, the ASEAN Secretariat members responsible for the Health Cluster 4 "Ensuring Food Safety" (AHC4) collaborated with FAO and planned to develop a series of criteria for food safety risk categorization. FAO and AHC4 agreed that the best approach is to develop an ASEAN-wide guide to develop/improve pesticide residue monitoring and surveillance programs.

The project consists of the following steps:

1. Consultative online meeting with countries as well as AHC4 members to discuss the current status, and the progress.
2. Administration of the situation assessment questionnaire.
3. Analysis of the questionnaire results.
4. Discussion between FAO and AHC4 to discuss the direction of the work.
5. Confirmation of the objectives and direction of the work with the countries.
6. Development of the guide to develop/improve pesticide residue monitoring and surveillance programs for ASEAN countries.

A residue monitoring program needs:

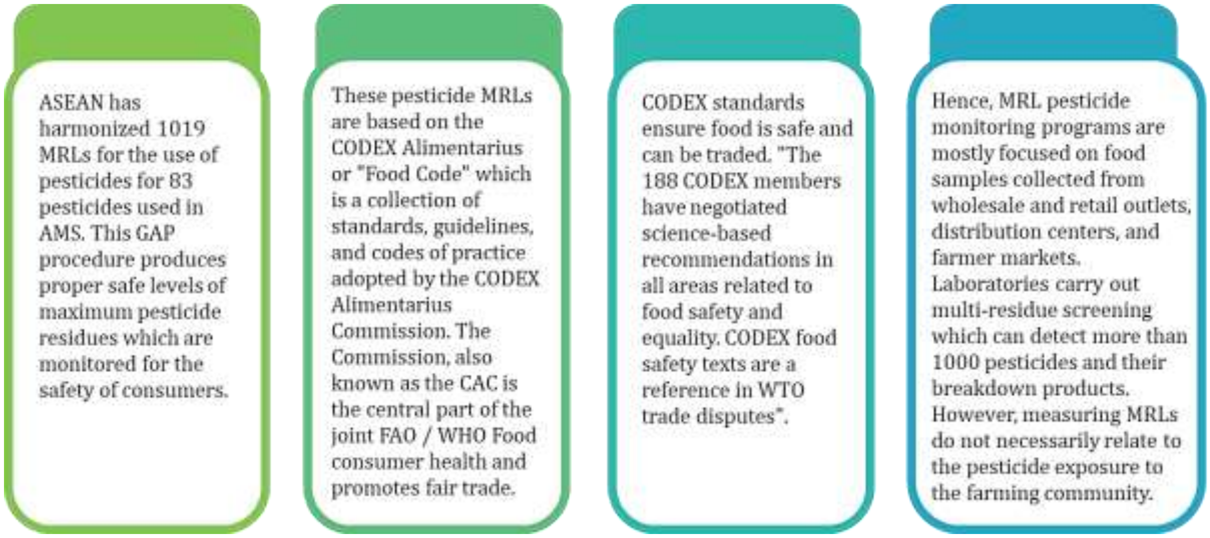
- Mandatory random monitoring and targeted programs required for export certification to a range of overseas markets.
- Analytical laboratories meeting strict accreditation and proficiency requirements prior to being contacted to conduct analyses each year.
- Trace back investigation should be undertaken by AMS, government agencies, in the event of a MRL exceedance.
- Information gained from residue monitoring programs is used to verify good agricultural practice and support market access.

Residue monitoring program consists of:

- Standardized guidelines for residue monitoring programs
- Coordination
- Consultations
- Consistent analytical methodology
- Improvements to analytical laboratory capacity and proficiency

A detailed explanation on the procedures for the development of import MRLs is provided in the "Import MRL guidelines for pesticides" – An APEC (Asia-Pacific Economic Corporation) document.

Diagram 5: MRL Monitoring Program in ASEAN



Authors Composition (Information Source: FAO)

The ASEAN Expert Working Group on Harmonized MRLs (2019) put forward the following:

- Where Codex MRLs are available and applicable, these should be adopted as harmonized ASEAN MRLs, subject to the agreement of AMS.
- Where Codex MRLs are available but not acceptable due to intake concern, modification of MRLs should be supported with residue trial data and/or risk assessment based on Codex procedures.
- Where Codex MRLs are not available, individual Member Countries could propose MRLs to be considered by the EWG-MRLs for harmonization. For such harmonization process, supporting data including residue trial data, GAP, food consumption data and/or risk assessment need to be examined by the EWG-MRLs.
- In generating regional data for harmonization process, a minimum of four residue trials are required for consideration and establishment of ASEAN harmonized MRLs.
- Relevant data should be provided for setting EMRL (Extraneous Maximum Residue Limit) of persistent pesticides.
- Pesticides proposed for setting up ASEAN MRLs should have registered uses in at least one ASEAN country, and the pesticides commodity combination is important for trade among AMSs. The pesticides should have been completely toxicological evaluated by JMPR or OECD countries, otherwise toxicological evaluation have to be submitted to EWG-MRLs by the proposing country.
- Harmonized ASEAN MRLs should be reviewed when it is needed in the situations.
- In addition, ASEAN should adopt Codex MRLs in its import tolerance MRLs and that ASEAN should maintain up-to-date MRLs and import tolerances.

(ii) ASEAN Policy Framework and Initiatives related to Food Safety

The ASEAN Food Safety Network (AFSN) was established in 2003 and is developed as a platform for information sharing on food safety initiatives amongst AMS. The ASEAN Food Safety Regulatory Framework Agreement (AFSRFA) provides a comprehensive and integrated overall approach to food safety in AMS. It allows AMS to adopt coherent integrated approaches to legal frameworks, comprehensive frameworks for pesticide management and harmonized food safety across the food chain. This framework is built in order to provide a structure and the instruments to realize the free flow of safe food in the ASEAN. Therefore, each AMS has the opportunity to establish a comprehensive pesticide risk management framework via existing ASEAN governments' food safety initiatives.

(iii) MRLs: Codex Alimentarius, ASEAN & Other Countries MRLs

The AMS adopt the Codex MRLs as the main reference. The differences in MRLs are compared in **Table 8 (Appendix B: Comparison of ASEAN Pesticide MRLs among AMS)** and **Table 9 (Appendix B: Comparison of ASEAN Pesticide MRLs with a number of non-AMS).** Table 9 shown that there are large differences between the ASEAN (Codex MRLs) and countries such as Australia/New Zealand, United States, European Union. India, and China. Whereas Table 8 shown that MRLs across the AMS shows very small differences between countries. The data and information accumulated on the MRLs were extracted from various sources, including the latest ASEAN database, as well as the available country MRL list. However, the most up to date is the FAO report of 2021 – Situation Analysis Report: Pesticide monitoring programme in Association of Southeast Asian Nations (ASEAN). These consolidated responses from the individual AMS are represented in Appendix B and includes the responses to whether the AMS apply the Codex MRLs. Only 4 countries, namely Malaysia, Philippines, Singapore and Thailand set their MRLs in the FAO Report, 2021. Table 8 shows the status of adoption of ASEAN MRLs as National Standard as of May 2021 **(Appendix B: Table 10)**

(iv) Import MRL Process: What is a pesticide Import MRL Request

Essentially, a pesticide import MRL request is seeking approval from the importing economy to allow the importation of goods that may contain pesticide residues at a level that is not covered in their domestic standards. The nature of the requests will vary, with an importing economy asked to accept or adopt either a Codex or exporting economy MRL or amend their domestic standards to align with either internationally-established Codex MRLs, regional (e.g., ASEAN) MRLs or those of the trading partner for a pesticide/commodity combination (Bodnaruk, et al., 2016).

If approved, the import MRL may apply to commodities imported from other economies, as provided by domestic regulation. These are sometimes referred to either as "import MRLs" or import tolerances or any other form of MRL for food import control purposes. Such requests should contain specific information to enable the importing economy to undertake any required assessments (Bodnaruk, et al., 2016).

Prior to submission, discussions should be held between the proponent of the request and the relevant importing economy authority to clarify the form, minimum information requirements, and regulatory processes, to enable an import MRL to be established. The nature and type of information required may vary depending upon whether or not a Codex MRL exists for the particular commodity/pesticide for which an import MRL is requested. In the absence of a JMPR assessment and Codex MRL, agreement will be needed on the source and derivation of alternative values, i.e., their currency and methodological basis, and other additional information that the importing economy agency may require (Bodnaruk, et al., 2016). **(Appendix B: Table 11, Table 12, Table 13)**. This could include agreement on the submission language, clarification of what is required to verify authorized GAP, e.g., approved label or other authorization, the quality of data upon which the requested MRL is based, and the source of health-based guideline values in the absence of importing economy or JMPR established values (Bodnaruk, et al., 2016). The request should then contain information supporting the requested MRL. This should include information on the relevant authorized use pattern, applicable MRL, and relevant health-based guidance value where necessary. Additional information on the pesticide and commodity may be required such as summary information from supporting supervised residue trials. Finally, to ensure transparency, when an import MRL request is approved the importing economy's relevant authority should seek to inform other economies of the decision via the notification pursuant to the WTO SPS Agreement (Bodnaruk, et al., 2016).

(v) Harmonization of MRLs: Evaluation and Extent

(a) The Codex Regions

There are six Codex regions, each represented by a joint FAO/WHO Regional Coordinating Committee. Each committee is responsible for defining the problems and needs of the region concerning food standards and food control. These regions are as below:

- The CCAFRICA Region - Regional Coordinator Uganda (49)
- The CCASIA Region - Regional Coordinator China (24)

The CCEURO Region - Regional Coordinator Kazakhstan (52)

- The CCLAC Region - Regional Coordinator Ecuador (33)
- The CCNASWP Region - Regional Coordinator Fiji (14)
- The CCNE Region - Regional Coordinator Saudi Arabia (17)

(b) Overview of the Codex MRLs

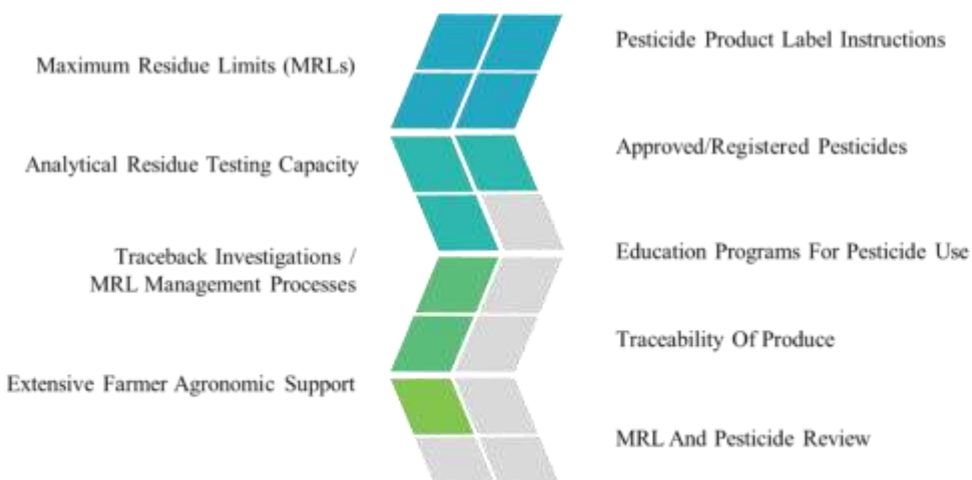
The differences in National Implementation of Maximum Residue Limits (MRLs) continue to exist despite extensive efforts towards international harmonization for pesticide residue in foods. The MRLs are set based on the supervised residue trials in which the pesticide is applied according to Good Agricultural Practices (GAP). Each country is inclined to establish appropriate MRLs for its local agricultural condition and the usage of pesticides. However, international harmonization of MRL does not yet exist at a global level and even though Codex Alimentarius has fixed MRL levels, they are not statutory for countries to follow. Codex MRLs have not been established for many pesticide/tropical fruit combinations, especially "minor crops". These "minor crops", often termed "specialty crops", are crops of low pesticide usage on a global scale. In reference to harmonization of pesticide registration requirements and MRLs in many parts of the world, there is little or no harmonization of requirements for the registration of new, reduced risk pesticides, especially for use on "minor crops"; rather, each country sets its own requirements.

(c) Current Situation Analysis

A situation analysis survey which was conducted by the FAO – Pesticide Monitoring Program in ASEAN (2021) recognizes this as summarized in **Table 14 & 15 (Appendix C).** One of the main priorities of ASEAN countries' agricultural policies is to increase food productivity to ensure sufficient food for a growing population. The use of pesticides together with other technologies help in increasing crop yields. However, the increased use of pesticides in the region may lead to an increase of food safety problem if there is insufficient controlled use of pesticides in the agriculture sector. Globally, there is an increased attention on chemical residues in food and consumers are becoming highly concerned about pesticide residues on agro-products. Fruits and vegetables are the important food and export goods for many Asian countries. Many Asian developing countries find it difficult to meet today's market demand on safety due to insufficient education, training, and a lack of a regular and effective pesticide residue monitoring system. Residue monitoring programs exist in more than half the AMS but a lesser proportion claim to have established a pesticide risk management system that encompasses pesticide registration, verification of GAP through monitoring, trace back, and pesticide review.

Many of the AMS confirmed a lack of technical capacity to undertake basic regulatory functions such as pesticide registration. On the ability to develop and manage residue monitoring programs, four (4) AMS (Lao PDR, Brunei Darussalam, Myanmar and Cambodia) believe that their capacity to develop and manage residue monitoring programs is basic. The other six (6) AMS (Philippines, Malaysia, Indonesia, Thailand, Singapore and Viet Nam) assessed themselves as having intermediate capacity to both manage and develop residue monitoring programs (FAO Pesticide monitoring program in SE Asia Nations, 2021). Those countries which identified themselves with basic capacities listed a lack of analytical instrumentation and technical capacity as the largest impediments. Countries which identified themselves as having intermediate capacity, cited underwhelming national coordination to having a comprehensive residue monitoring program. Produce sampling and accredited analytical capability are critical to the integrity of any residue monitoring program. Most member countries have indicated that international standards and guidelines such as Codex General Guidelines on Sampling (CAC/GL 50-2004) and the International Laboratory Accreditation Cooperation mutual recognition are recognized by them.

Diagram 6: A National Monitoring Program Should Be Supported by the Following:



Authors Composition (Information Source: FAO – Pesticide Monitoring Program in ASEAN (2021))

2.1.3 THE GROWING PROBLEM OF PESTICIDE RESISTANCE IN BOTH AGRICULTURE AND PUBLIC HEALTH: THE IMPORTANCE OF AN INSECT-RESISTANT MANAGEMENT (IRM) STRATEGY

(a) Insecticide Resistance to Persistently-used Agricultural Pesticides and the Spill Over into Public Health Areas.

Although insecticides were once effective in controlling mosquito-borne diseases, the increasing trends of mosquito-borne diseases may indicate an increasing resistance to or ineffectiveness of insecticides in controlling the transmission of the diseases. Furthermore, insecticides may also significantly influence the environment and ecosystems.

(b) Growing Public Health Problems: Insecticide Resistance and Dengue

The global incidence of dengue has grown dramatically in recent decades – about half of the world's population is now at risk. There are an estimated 100 to 400 million infections each year. The number of dengue cases reported to WHO increased over the last two decades from 505,430 cases in 2000 to 5.2 million in 2019. The prevalence of dengue fever and the increasing trend of resistance towards different categories of insecticides are alarming in many Southeast Asian countries (Gan, et al., 2021). The relationship focused on here is the development of resistance of the Aedes mosquito and the increased use of similar insecticides in the region for insect control, both in agriculture and public health and the link as expressed in various research papers.

"Development of insecticide resistance in mosquito species is due to the excessive use of chemical compounds in both vector control and agricultural pest management" (Yang, et al., 2017).

"The insecticide resistance development among mosquito vectors is not only due to the extensive use of insecticides in the mosquito control operation of public health, but also as a result from the pesticide utilization in the agricultural sector…"Organochlorine and Organophosphates susceptibility of Aedes albopictus (Skuse) larvae from agricultural and non-agricultural localities in Peninsular Malaysia" (Othman Wan-Norafikah et al, 2020)

Table 16: Dengue fever and insecticide resistance in Aedes mosquitoes in Southeast Asia

Country		No. of Dengue Cases Annually	Resistance to:
Cambodia		185,000	Permethrin, Temephos, Deltamethrin
Indonesia		65,602	Malathion, Pyrethroids, Temephos, Permethrin d-allethrin, Transflutrin, Metofluthrin
Lao PDR		No Data	DDT, Malathion, Permethrin, Temephos, Deltamethrin
Malaysia		88,074	Permethrin, Pyrethroids, DDT, Carbamate, Bendiocarb, Dieldrin, Bromophos
Myanmar		4,121	Permethrin, Pyrethroids, DDT
Phillipines		420,000	Only susceptible to Malathion, Resistant to others
Singapore		701	Permethrin and Cypermethrin DDT and Pyrethroid
Thailand		129,906	Deltamethrin, Permethrin, Fenitrothion, Temephos. Propoxur, DDT, Cyfluthrin and Alpha-Cypermethrin
Vietnam		837	Permethrin, Lambda cyhalothrin, Resmethrin

DDT (a Persistent Organic Pollutant, POP)

Both DDT and Dieldrin, which belong to the organochlorine class of insecticides are Persistent Organic Pollutants (POPs) (Rahman, 2013) and have been extensively used worldwide in public health and the agricultural sector. In the old days, the DDT has been used in the control of Aedes aegypti in Malaysia until 1957 before it was replaced with Dieldrin. (Macdonald, 1958; Nazri et al, 2009). However, as both insecticides are slowly degraded in nature (Jorganson, 2001; Ahmed et al, 2015), they could remain in the environment for such a long time. Hence, it is not surprising to perceive the presence of resistance phenotype against any of these insecticides among local mosquito species including Aedes albopictus and Aedes aegypti.

Levels of DDT were found to be higher in tropical South East Asia than from seas around Australia and the mid latitudes of the Northern Hemisphere. This was suggestive of the continued use of DDT in the tropics compared to the other regions. DDT was found to be the predominant organochlorine compound in fish from tropical South East Asia. All environmental media can become contaminated by POPs once they are released into the environment. For instance, spraying pesticides that are POPs on crops can contaminate vegetation and soil. POPs may also be transported long distance by rivers, ocean currents and as contaminants in wildlife. Due to the extensive release of POPs and long-distance transport they have become global contaminants (Allsopp & Johnston, 2000).

the named pesticides above are used in agriculture as well as the public health sector:

- Malathion
- Cypermethrin
- DDT
- Permethrin

- Deltamethrin
- Dieldrin
- Pyrethroids
- Fenitrothion
- Propoxur
- Cyphithrin
- Besmethrin
- Bendiocarb

Temephos is a larvicide and hence used in the public health sector for mosquito larvae only.

(c) A Growing Public Health Problem: Development of Insecticide Resistance in Aedes Mosquitoes

The development of Insecticide Resistance in the mosquito is a subject which has been studied well over the years and defense mechanisms which develop resistance in mosquitoes are impressive and include the resistance mechanism listed. Various Mechanisms of insecticide resistance have been studied in mosquitoes, including the following: These have provided mosquito species with a strong ability to adapt to unfavorable conditions:

- Target Site Resistance:
- Knockdown Resistance (AChE insensitivity)
- GABA Receptor Resistance
- Metabolic Resistance (P450s, etc.)
- Penetration Resistance
- Behavioral Adaption

(Cited from: Dengue Fever and Insecticide Resistance in Aedes mosquitoes in South East Asia: A Review. Soon Jian Gan et al, 2021)

Biological control strategies which target different stages of the mosquito life-cycle, such as the use of numerous copepods, including *Mesocyclops longisetus* and *M. thermocyclopoides* which prey on the young mosquito instars, could be an alternative control strategy (Soumare, et al., 2011, Mahesh, et al., 2012). As biocontrol agents, entomopathogenic fungi, bacteria, and viruses have been developed to specifically kill mosquitoes. The most commonly used microorganism is Bti which destroys the gut of the mosquito larvae by producing δ-endotoxin (Melo, et al., 2016). In summary, the prevalence of dengue fever and increasing trend of resistance towards different categories of insecticides are alarming in many Southeast Asian countries. A well-researched understanding of the mechanism of resistance and susceptibility of the mosquitoes is of utmost importance for the development of an effective control method of Aedes mosquitoes in these endemic regions (Gan, et al., 2021). Similarly, a study done in Cote d'Ivoire found that agriculture pesticides use was responsible for the creation of resistance in *Anopheles coluzzi* mosquitoes responsible for the transmission of Malaria.

(d) Factors Driving Evolved Herbicide in Agriculture – Pesticide Resistance in Agriculture

Repeated use of agricultural chemicals for pest control has selected for the rapid evolution of resistance threatening health and food security at a global scale, strategies for preventing the evolution of resistance include cycling and mixtures of chemicals and diversification of management (Hicks, 2018). Populations resistant to one pesticide are likely to show resistance to multiple herbicide classes. Finally, it is shown that the economic costs of evolved resistance are considerable (Hicks, 2018).

Research has concluded that resistance is potentially inevitable, and weeds develop resistance to any new product introduced to the market. (The growing problem of pesticide resistance – Barbara Pinho, 26th April 2021). Similar to public health, agriculture also has a serious insecticide resistance problem. Insect pests cause chronic and often severe crop loss and, when insecticides fail, there are serious economic losses (Grafius, 1997) and consequences for food security. The evolutionary forces, mechanisms of resistance (for example, mutations in the sodium ion channel gene [Soderlund & Knipple, 2003]), and even the insecticides used are often the same, regardless of whether an insect is an agricultural pest or a vector of human disease. Thus, we might expect there to be common ground and perhaps common solutions for insecticide resistance in agriculture and public health. Insights from agriculture might help in addressing the challenges of insecticide resistance in public health. (Sternberg and Thomas, Insights from Agriculture for the Management of Insecticide Resistance in Disease Vectors, 2017)

These strategies for insecticide resistance management include:

- Reducing insecticide use
- Increasing insecticide diversity
- Resistance monitoring
- Selecting the appropriate targets for monitoring
- New vector control tools: adoption of biological control agents

The FAO, in 2012 produced "Guidelines on Prevention and Management of Pesticide Resistance" which detected the:

- Evaluation of the risk of resistance
- Pesticide resistance prevention and management, as well as
- Resistance detection and verification

In this document, pesticide resistance is defined as a "genetically-based characteristic that allows an organism to survive exposure to a pesticide dose that would normally have killed it. Resistant genes occur naturally in individual pests because of genetic mutation and inheritance. They spread throughout pest populations due to a process of selection brought about by repeated pesticide use. Resistant populations develop because the resistant individuals survive and subsequently reproduce, and the trail for resistance is "selected" in the next generation, while the susceptible individuals are eliminated by the pesticide treatment. If the treatment continues, the percentage of selected survivors will increase and the susceptibility of the population will decline to a point that the pesticide no longer provides an acceptable level of control." (Guidelines on Prevention and Management of Pesticide Resistance, FAO, 2012)

On October 21st 2020, ASEAN ministers of Agriculture and Forestry agreed to a comprehensive regional plan on the Fall Armyworm (FAW). The Fall Armyworm is a destructive pest which arrived in ASEAN in 2018. Known insecticide resistance in the Fall Armyworm (FAW, 2021):

- Carbamates, Organophosphates, Pyrethroids, Insecticide Resistance Action Committee (IRAC June 2021)

2.1.4 COUNTERFEIT / ILLEGAL PESTICIDES

1. General

The availability of counterfeit or illegal / fake pesticides is developing into a large problem in the world and in ASEAN. The growth of the fraudulent pesticide trade has become a threat to farmers' health, the agrochemical businesses, and agricultural sustainability as well as to the environment. However, assessment of the levels of farmers' exposure to fraudulent pesticides in the literature is often limited.

Pesticides are among the most popular fraudulent products in the agri-food market. The term fraudulent describes an array of illicit, illegal, and unauthorized imports or those with counterfeit labelling. These fake pesticides may contain no active ingredients, outdated ingredients or restricted/banned material and pose a danger to the farmers, economy and environment (Kassim, HS., 2021).

The share of counterfeit pesticides in the world has been estimated to be around 25% (Counteraction to Counterfeit and Contraband Pesticides by M. Malkor, 2015). The use of illegal pesticides is a serious problem around the world and especially in developing countries (UN, 2020)

The illegal pesticide trade has the highest impact on farmers; illegal products are often easier to access than legal products and farmers in a difficult economic situation are more likely to choose those products in order to protect their yields (UN, 2020).

The labelling of illegal and counterfeit pesticides is likely to be inadequate or misleading regarding their safe use (OECD, 2020). According to the European Crop Protection Agency (ECPA) the trade in counterfeit pesticides has grown into a major profitable criminal enterprise.

Results of a survey on Quality Control of Pesticides: FAO – Progress in Pesticide Risk Assessment and Phasing-Out of Highly Hazardous Pesticides in Asia

Some of the results of a questionnaire on illegal use of pesticides in Asia including 6 AMS by the FAO in 2015 are given below and it is recommended that ASEAN carries out an up-to-date survey and analysis on the availability and quantities of illegal pesticides being used presently in order to develop strategies to cut down the availability of illegal pesticides within ASEAN.

Quality control infrastructure and capacities		Cambodia	Lao PDR	Malaysia	Myanmar	Thailand	Viet Nam
Do you check the quality of pesticides at the time of registration application?		Y	N	Y	Y	Y	N
Do you monitor the quality of pesticides imported or manufactured in your country?		S	N	Y	Y	Y	Y
Do you monitor the quality of pesticides sold in pesticide shops?		S	Y	Y	Y	Y	S
Do you monitor the quality of pesticides applied in the field?		N	N	S	N	N	N
Total	Yes =	1	1	3	3	3	1
	S =	2		1			1
	No =	1	3		1	1	2
Y = Yes; S = Sometimes; N = No							

Observations

- The majority of countries monitor the quality of pesticides at registration, importation, or manufacture;
- Two-thirds of the countries monitor the quality of pesticides in pesticide shops;
- Few countries monitor the quality of pesticides applied in the field.

Conclusions

- Almost all countries have quality control infrastructure and capacities.

Source: FAO-Progress in Pesticide Risk Assessment and Phasing-Out of Highly Hazardous Pesticides in Asia, 2015

Alerts on Pesticides

Exchange of information and alerting responsible authorities may be an important factor in the fight against fake and substandard pesticides.

Results of a survey on Alerts on Pesticides: FAO – Progress in Pesticide Risk Assessment and Phasing-Out of Highly Hazardous Pesticides in Asia

	Cambodia	Lao PDR	Malaysia	Myanmar	Thailand	Viet Nam
Did you receive alerts about fake or substandard pesticides from information sources within your country?	Y	N	Y	Y	Y	Y
If yes, what were the sources: Cambodia: Through monitoring, some importers/dealers, some users Malaysia: Stakeholder Myanmar: Plant protection Division of Department of Agriculture (DOA) Thailand: Office of Agricultural Regulatory, DOA Viet Nam: Inspector, PPSD (Plant Protection Sub-Division Viet Nam), media						
Did you receive alerts about fake or substandard pesticides from other countries or other external information sources?	N	N	Y	N	N	N
If you do not receive alerts, do you think it would be useful to be alerted if neighbouring countries identify fake or substandard pesticides in their country?	Y	Y	Y	N	N	Y
Have alerts helped in identifying substandard pesticides in your country?	Y	N	Y	N	N	Y
Y = Yes; N = No						
How do you follow-up to such alerts? Cambodia: Monitor at an entry check point; Inform to concerned competent authorities at border check point; Stop issuance of importation. Malaysia: Enforcement action Myanmar: Inspection Viet Nam: Sampling and test- (Lao PDR and Thailand did not give any response to the question on following up of the alerts.)						

Observations

- Most countries have received alerts about fake or substandard pesticides from sources within their country; the information sources included all persons concerned about pesticides;
- In the majority of cases, alerts had been helpful in identifying substandard pesticides within a country and initiating enforcement actions.

Conclusions

- More information exchange and regional cooperation may be helpful in fighting fake and substandard pesticides.

  Source: FAO-Progress in Pesticide Risk Assessment and Phasing-Out of Highly Hazardous Pesticides in Asia

2.1.5 SAFETY OF APPLICATORS

Monitoring the Safety of Pesticide Applicators

The safety of pesticide applicators in the agricultural field can also be carried out as was done in studies carried out by Hughes, D., et al, 2021) on farmers in Thailand, Viet Nam and Lao PDR.

I. Interviews with agricultural workers on how they use pesticides,
II. Their knowledge of the risks and self-protection practices, and
III. Self-reported symptoms.

Currently, no regular acetylcholinesterase test is done on agricultural pesticide applicators although these regular testing are a feature of Public Health Occupational Safety Health Regulations. These should be made a part of a regular health monitoring system for farmers involved in pesticide application in order to record, advise and treat farmers involved in pesticide applications.

2.1.6 REDUCING THE USE OF HHPS / BROAD SPECTRUM PESTICIDES / NEONICOTINOIDS

(a) HHPs

The FAO/WHO joint meeting on pesticide management formulated the following specific recommendations for the Code of Conduct on handling and using HHPs:

3.6 PESTICIDES WHOSE HANDLING AND APPLICATION REQUIRE THE USE OF PERSONAL PROTECTIVE EQUIPMENT THAT IS UNCOMFORTABLE, EXPENSIVE, OR NOT READILY AVAILABLE SHOULD BE AVOIDED, ESPECIALLY IN THE CASE OF SMALL-SCALE USERS AND FARM WORKERS IN HOT CLIMATES.

Source: Progress in pesticide risk assessment and phasing out of HHPs in Asia – FAO/UN, 2015

Some recent statements on HHPs found in food imported into the European Union:

"THE EUROPEAN UNION SHOULD STOP IMPORTING AGRICULTURAL GOODS MADE USING PESTICIDES THAT ARE BANNED WITHIN THE BLOC, THE EU'S TOP FARMING OFFICIAL SAID ON THURSDAY."

Source: EU's Agriculture Commissioner, Janusz Wojciechowski said during a video hearing with French senators. (Gus Trompiz, Reuter, July 3rd 2020)

"REGARDING IMPORTS, I DON'T THINK WE CAN ALLOW THE IMPORT OF PRODUCTS MADE WITH PESTICIDES THAT ARE BANNED IN EUROPE"

Source: EU's Agriculture Commissioner, Janusz Wojciechowski said during a video hearing with French senators. (Gus Trompiz, Reuter, July 3rd 2020)

Overall, imported food has a higher percentage of residues than food grown in the EU. With such high percentages of pesticides in food, consumers remain unprotected, as we consume mixtures of pesticides on a daily basis through the food that we eat (Pesticide Action Network Europe, 2020).

The EU has now committed to support a global transition to sustainable agri-food systems and set up a trade policy that supports its ecological transition. It has promised to promote international standards that encourage sustainable agriculture and seek commitment by third countries, including in relation to the use of pesticides.

From the European Food Safety Authority (EFSA) Report (2021), the following was reported for the Exceedance and Quantification Rates by Country of Origin (Third Countries) and Frequency of non-compliant samples identified in the framework of the reinforced import controls under regulation (EC) No 669/2009 – (Please refer to **Appendix C Table 17** MRL)

In its 2019 report on pesticides residues in food, the European Food Safety Agency (EFSA) found that 7.6% of samples from countries outside the EU exceeded MRLs. This was higher than that for EU-produced food at 2.6%. If found to repeatedly exceed legal limits, they are placed on a list of high-risk imports that require further controls. This EFSA exercise tested 96,302 food samples. If the situation in these countries does not improve, imports of these products from the given country can be suspended. Trace back analysis may be effective to discover and rectify weaknesses in the system.

(b) Broad Spectrum Pesticides & Neonicotinoids

- Broad spectrum pesticides alter natural enemy communities and may facilitate secondary pest outbreaks (Matthew Hill, et al., 2017)
- Bees and other pollinators are increasingly under threat from human activities including the use of broad-spectrum pesticides (Bees, Bans and Broad-Spectrum Pesticides – UNEP, 2021)
- Neonicotinoids (neonics) are the most widely-used insecticides globally. They are used on more than 140 crop varieties to control a variety of pests. They are also commonly used in veterinary applications for tick and flea control.
- "Neonicotinoids use has increased rapidly in recent years with a global shift towards insecticide coatings rather than aerial spraying. While the use of seed coatings can lessen the amount of overspray and drift, the near universal and prophylactic use of neonicotinoid seed coatings on major agricultural crops has led to widespread detections in the environment (pollen, soil, water, honey).
- Pollinators and aquatic insects appear to be especially susceptible to the effects of neonicotinoids with current research suggesting that chromic sublethal effects are more prevalent than acute toxicity. Meanwhile, evidence of clear and consistent yield benefits from the use of neonicotinoids remains elusive for most crops." (Environmental Risks and Challenges Associated with Neonicotinoid Insecticides – Michelle L. Hladik, et al., 2018) Efforts should be made to reduce the use of both broad-spectrum pesticides and neonicotinoids in agriculture. A number of studies listed on neonicotinoids have been listed in **Appendix: Table 18**

2.1.6 Suggestions and Recommendations

In discussion with agricultural cooperatives, farmers, natural agricultural input companies as well as importers/exporters and private industries Svay Rieng Agro Products Cooperative, Malaysian Care NGO, National Land Finance Co-op Society Ltd (NLFCS), Kosingan Ventures LLP, Organization of Addiction, Prevention, Treatment and Rehabilitation (OAPTAR), Ministry of Science, Technology & Innovation (MOSTI), University Putra Malaysia (UPM), University College Sedaya International (UCSI), Fisheries Department Malaysia, Malaysia External Trade Development Corporation (MaTRADE), SME Corporation Malaysia, Ministry of Agriculture Malaysia, Cargill Viet Nam, University of Malaya (UM), etc. together with studying input from research studies conducted on the subject, it is recommended that:

- The need to reduce the use of HHPs would also have to be necessarily aligned to the replacement/use of lower toxicity pesticides or biological control agents (BCA)
- The development of new MRLs within ASEAN:
    1. MRLs for the use of lower toxicity, newer pesticides may not be available and thus the initial action would be to form an ASEAN group to work together to generate MRLs on the newer, less toxic pesticides. AMS to work together to identify both the pesticide and the targeted agricultural produce.
    2. The use of safer BCA and IPM with Agro-Ecological Systems should be encouraged as a circular and sustainable solution in agriculture, aquaculture and animal husbandry.

2.2. FERTILISERS

Throughout human history, manure has been the basic input of nutrients for plant production. With the development of agricultural production and increasing food demand, farmers searched methods to improve efficiency on their fields. Animals were not necessarily held on every farm and manure was not available to fertilize soils. With increasing urbanization, the circulation of nutrients from animals and humans into the soil became more difficult. With the development of commercial fertilisers, this nutrient gap has been somewhat closed. The application of fertilisers increases the production of biomass in the plant and thus yields. Therefore, it contributes to address the major challenge of feeding a growing world population (EU Agricultural Markets Briefs, 2019).

2.2(a) The Role of Nitrogen Fertiliser Use

As the population grows and per capita consumption patterns change, farmers alter food, feed, livestock, and fiber production as well as energy use, land-use composition, and social equity (Erisman, et al., 2011). All these changes, in turn, require use of nitrogen fertilisers. Erisman indicates that the availability of synthetic fertilisers enables an increase in food production responsible for feeding about half of the current human population (Erisman, et al., 2008). Nitrogen (N) plays an important role in controlling a species' diversity as well as the dynamics and functioning of many terrestrial, fresh water, and marine ecosystems. While added nitrogen is required to achieve higher crop yields, excessive use of nitrogen-enriched fertilisers causes environmental damage (Chen, et al., 2005).

2.2.1 MINERAL FERTILISERS

The over-application of synthetic fertilisers has negatively impacted the environment, caused food security issues, and reduced our dependency on the positive services that soil biodiversity provides for plant performance (McLaughlin, et al., 1995, Chen, et al., 2014, Cui, et al., 2018). In conventional agriculture, however, synthetic fertilisers are frequently used to obtain higher crop yields, but only 10% to 40% of the fertilisers applied can be directly absorbed and used by plants. The remaining fertilisers in the soil are in the form of insoluble inorganic salts or leached into adjacent rivers, which is considered a major threat to global soil biodiversity (Tilman, et al., 2001, Barlog, et al., 2004, Bahram, et al., 2018). The soil microbiota plays important roles, such as participating in the biogeochemical cycling of soil nutrients, helping to withstand abiotic stresses (Wu, et al., 2019, Rolli, et al., 2015), producing phytohormones that improve plant growth [13], and preventing infections by phytopathogens (Olivery, et al., 2020, Hussain, et al., 2018). Similarly, the plants host microbes and release root exudates that serve as a food source for soil microbiota (Jiang, et al., 2017). The use of plant growth-promoting rhizobacteria and fungi may provide a sustainable alternative to the use of synthetic fertilisers (Pieterse, et al., 2012, Campos, et al., 2018).

2.2.1(a) The Overuse and Misuse of Fertilisers

The overuse of fertilisers, both fossil fuel-based fertilisers and organic fertilisers, especially that of synthetic nitrogen is resulting in the significant increase in the production of N_2O, and GHG which is 300 times more potent as a GHG than CO_2 and lasts 114 years in the atmosphere. In addition, nitrogen and phosphorus can leach from soil and pollute both the waterways and the atmosphere. Nitrogen is essential for life on earth and vital for food farming. However, when used in excess, nitrogen becomes a damaging pollutant threatening climate, nature, and human health.

The use of chemical-based fertilisers can alter the composition of the soil microbiome and this results in both a loss in fertility over time as well as a reduction in the soils ability to store carbon within the soil. Maintaining a healthy balanced soil microbiome is critical for both long term productivity of the soil and the healthy ability of the soil to hold and store carbon within the soil mycorrhiza. Thus, a balance must be sought between the use of both mineral and organic fertilisers.

Table 19: Total Fertilisers (Nitrogen, Phosphorus & Potassium)/ha of cropland used in Southeast Asia

Country	2018
Viet Nam	415.3
Malaysia	716*
Indonesia	236.4
Thailand	148.9
Philippines	169
Brunei	141.8
Myanmar	49.3
Cambodia	34.3

Units are in Kilograms (Kg)
Source: The Global Economy 2017/2018 (FAO)
* Figures for Malaysia corrected by the DOA of Malaysia

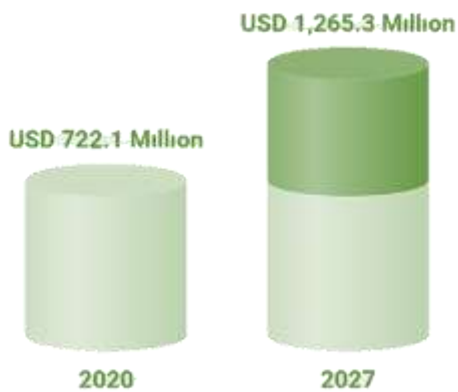
Research done by West, et al. (2014) found that although farmers applied 115 million tonnes of nitrogen to our crops, only about 25% is used by the crops while another 75 million tonnes of nitrogen runs off into our rivers, lakes, and natural environments. In addition, more than half of our applied phosphorus is lost to the environment.

2.2.2 ORGANIC FERTILISERS

Organic fertilisers contain plant and/or animal-based materials that are either a byproduct or end product of naturally occurring processes such as animal manure and composted organic materials. Organic fertilisers can reduce the necessity of repeated application of synthetic fertilisers to maintain soil fertility. They gradually release nutrients into the soil matrix and maintain nutrient balance for a healthy crop growth. They also act as effective energy sources of soil microbes which in turn improves the soil structure and crop growth. Organic fertilisers are generally thought as slow releasing fertilisers which contain many trace elements. However, the application of these, like synthetic fertilisers, should be managed well in order to ensure the effectiveness and prevent any detrimental effects.

Synthetic fertilisers have a much more pronounced effect on the soil in the long term than organic fertilisers. Organic fertilisers, having low NPK levels, do not have the detrimental run-off effect of synthetic fertilisers and are soil microbiome-friendly. They feed the soil microbiome well but presently, the use of organic fertilisers in ASEAN is not as large as synthetic fertilisers but it generated US$1 billion in 2019 and is expected to generate US$2.1 billion by 2027, with a CAGR of 7.4%. The Southeast Asia organic fertiliser market was valued at US$ 722 million in 2020 and forecast to reach US$1.2653 billion by 2027. CAGR is estimated to be 8.3% over the forecast period (Far Eastern Agriculture, 2021).

Diagram 7: Organic Fertiliser Market Forecast (CAGR of 8.3%)



Source: researchandmarkets.com/reports/5456932

The organic fertiliser market is mostly developed around the use of agricultural biomass waste from the palm oil industry, rice production, and other wastes. The oil palm industry alone in Indonesia, Thailand, and Malaysia produces around 850 million tonnes of biomass waste per year (Salleh, et al., 2020; The, C. 2016; Jusakulvijit, et al., 2021). Only a fraction of which is valorized into agricultural inputs. The market for organic fertilisers for the fruit and vegetable sectors is expected to grow with a CAGR of 7.9% during the period up to 2027 (Salleh, et al., 2020; The, C. 2016; Jusakulvijit, et al., 2021). Some key companies in the ASEAN organic fertilisers market are:

- AlphaBioGreen
- BaConCo Co. Ltd.
- Bio-Flora (Singapore) Pte. Ltd.
- SongGlanh Corporation
- Cropmate Fertilisers Sdn. Bhd.

- PT Jadi Mas Fertilisers Factory
- CropAgro
- Revisoil
- PT Pupuk Kaitim, and
- Thai Central Chemical Public Company Ltd.
  (Source: Allied Market Research, 27-Oct. 2020)

The new ASEAN sustainable and circular guidelines will act to spur the development of more valorization systems working on agricultural and food wastes to produce both cost-effective fertilisers and feeds for ASEAN agriculture. The use of newly developed cost-effective valorized fertilisers in recirculating smart systems which employ soil-based, reproducible, and productive semi-automated systems to use valorized liquid and solid agro-food waste, can play a major part in both rural and urban food production systems, including vertical systems.

Case Study:

In a study done on "Substituting Organic Fertiliser for Synthetic Fertiliser: Evidence from Apple Growers in China, (Pingping Fang, et al., August 2021), based on data over a 3-year period (2017-2019), the following was reported:

On a nutrient basis (N, P, and K), the substitutability between organic and synthetic fertiliser is found as we expected. Notably, the results indicate the presence of substitutability between organic matter and bacteria in organic fertiliser and synthetic fertiliser N, P, and K. This suggests that organic matter and bacteria can activate the N, P, and K that are already present in the soil, and, therefore, can help reduce the amount of synthetic fertiliser needed to achieve a potential level of nutrient uptake by apple trees. These findings suggest that developing organic fertiliser that contains sufficient organic matter and bacteria might work as an effective tool to promote the broader use of organic fertiliser. Further, it can lead to the reduced use of synthetic fertiliser and reduced cost of production, through optimizing the use of nutrients that are already available to plants. Moreover, a broader use of organic fertiliser can be a valuable tool for sustainable resource management—particularly water and land in semi-arid regions—where it can improve the ecological and economic benefits to local communities as well. [Substituting Organic Fertiliser for Synthetic Fertiliser: Evidence from Apple Growers in China, (Pingping Fang, et al., August 2021)]

The findings of this study provide several insights for farmers, policymakers, and institutions. First, the findings indicate that the partial output elasticities for organic matter in organic fertiliser are positive and statistically significant, both when the apple yield is measured in quantity terms (kg/ha) and value terms (yuan/ha). Thus, the provision of organic fertiliser containing a sufficient amount of organic matter and bacteria can reduce the use of synthetic fertiliser, hand-in-hand with the cost of production. Further, encouraging farmers to test their soil for nutrient deficiencies would offer a broader scope for better training farmers regarding the effectiveness of organic fertiliser and adopting related land management measures, i.e., drip irrigation, animal manure, and crop rotation. Third, the findings indicate that the partial output elasticity for phosphorus (P) in organic fertiliser is not significant, but neither is that for P in chemical fertiliser. Thus, promoting organic fertiliser use as a source for P and subsidized provision of advanced irrigation systems (i.e., drip irrigation), is recommended. Likewise, encouraging sustainable land management measures such as crop rotation and animal manure could help boost soil organic matter and water-holding capacity. (Substituting Organic Fertiliser for Synthetic Fertiliser: Evidence from Apple Growers in China, Pingping Fang, et al., August 2021)

2.2.3 BIO-FERTILISERS: THE IMPORTANCE OF EFFECTIVE AND BENEFICIAL MICROBES

i. Current soil management strategies are mainly dependent on inorganic, chemical-based fertilisers. Conventional agriculture plays a significant role in meeting the food demands of a growing human population which also led to an increasing dependence on synthetic fertilisers and pesticides. The overuse of both organic and inorganic fertilisers can cause land and water pollution and result in the eutrophication of water bodies. The exploitation of beneficial microbes such as Rhizobacter (PGRs), Endo and Ectomycorrhizal fungi, Cyanobacteria and many other useful microorganisms in biofertilisers has shown increased nutrient uptake, plant growth and plant tolerance to abiotic and biotic stress.

   Biofertilisers function as key players in sustainable agriculture by improving soil fertility, plant tolerance, and crop productivity (Deepak Bhardwaj, et al., 2014). The use of beneficial microbes as biofertilisers has been shown to be able to effectively reduce the application of synthetic fertilisers by 10% to 25%, reducing costs, and the potential for overfertilization (Deepak Bhardwaj, et al., 2014).

ii. Biofertilisers are the substances containing a variety of microbes having the capacity to enhance plant nutrient uptake by colonizing the rhizosphere and make the nutrients easily accessible to plant roots. Biofertilisers are known for their cost-effectiveness, environmentally-friendly nature, and composition (Debmalya Dasgupta, et al., 2021). Various types of microbial biofertilisers contain symbiotic and free-living nitrogen fixers, phosphorus solubilizers, and mobilizers.

iii. A number of studies on substituting organic fertiliser for chemical fertiliser have been listed in **Appendix: Table 20**

iv. Biofertilisers can prove a boon to sustain our agricultural production and to meet the demand of increasing population for sustainable agricultural-based products while conserving and sustaining the natural resources for future generations. The importance of biofertilisers in enhancing both the productivity and quality of agricultural products has already been demonstrated in numerous research programs carried out worldwide. However, despite their potential, biofertilisers remain mostly underutilized (Kamini Gautam, et al., 2021).

   Biofertilisers can play an important part in achieving better agricultural sustainability, productivity, and reproducibility and stabilize the soil microbiome (Kamini Gautam, et al., 2021).

2.2.3 (a) Biofertilisers: Suggested Steps Forward on the use of Biofertilisers

- Awareness should be created among farmers on the benefits of biofertilisers in providing good soil health, sustaining productivity of natural resources, and attaining high productivity and a higher cost-benefit ratio.
- More work should be done in developing the production system for biofertilisers, with emphasis of cost-effectiveness, quality control, and biochemical analysis of the major parameters.
- Governmental policies should encourage the valorization and use of biofertilisers with farmers.
- Research on biofertilisers with multi-strain and multi-microorganism groups should be carried out on a large scale for the improvement in crop productivity as compared to single-strain biofertilisers; multi-strain and multi-microorganism consortia can achieve higher productivities even under hostile growing conditions.
- Biofertilisers should be made easily available for farmers, and large-scale production of biofertilisers should be initiated by providing both the training and capacity building to farmers, farming communities, and private industries on the production, quality control, and use of biofertilisers (Kamini Gautam, et al., 2021).

2.2.4 THE USE OF ANTIMICROBIALS IN AQUACULTURE & ANIMAL HUSBANDRY IN ASEAN

2.2.4 (a) Antimicrobial Resistance (AMR)

Antimicrobials are drugs which may be either of natural or synthetic origin that have the capacity to kill or inhibit the growth of micro-organisms. In 1945, Alexander Fleming who discovered penicillin, said that "The time may come when penicillin can be bought by anyone in the shop. Then there is the danger that the ignorant man may easily underdose himself and by exposing his microbes to non-lethal quantities of the drug, make them resistant" (Fleming, A. 1945). Recently, the WHO stated that "Anti-Microbial Resistance (AMR) in bacteria, viruses and parasites is one of the greatest challenges of public health." (WHO, 2015)

Anti-Microbial Resistance (AMR) is one of the greatest human health and sustainability challenges of the 21st century. Excessive use of antibodies for treatment of people and in aquaculture and animal husbandry has altered natural bacterial communities and led to the increase in AMR. Recently, Moshen Naghan, et al., 2020, at the University of Washington in the article "Global Burden of Bacterial Antimicrobial Resistance in 2019: A Systematic Analysis", devised a model to estimate how many people died in 2019 from bacterial infections that could previously have been treated were it not for antimicrobial resistance (AMR). This unique model was based on the medical records of 471 million people with antibiotic resistant infections from 204 countries. On the basis of this study, 1.27 million deaths were attributed to bacterial AMR while 4.95 million deaths are associated with AMR and a review on microbial resistance published in 2016 estimated that 10 million people could die annually from AMR by 2050 (WHO, New Report Calls for Urgent Action to Avert Antimicrobial Resistance Crisis, 2019). The emergence and spread of Antimicrobial Resistance have been documented and studied in wastewater treatment systems as well as in the use of antimicrobial in animal husbandry and aquaculture.

The reliance on antimicrobial in aquaculture and animal husbandry is high. In addition to posing direct and indirect threats to human health, it threatens food systems as well as wildlife. Overall antimicrobial use in the livestock sector is increasing and the estimates of total use range from 63,000 tonnes to 240,000 tonnes per year. This alone is the equivalent of the amount used for human medicine. (Statistics by Global Trends in Antimicrobial Use in Food Animals, Proceedings of the Natural Academy of Sciences of the USA). There is an urgent need to develop and institute a positive alternative plan for the aquaculture and animal husbandry industry to adopt. Southeast Asia has been named as an epicenter for emerging infectious diseases and AMR. (Coker, et al., Emerging Infectious Diseases in Southeast Asia, 2011), (Walther B. A., et al., Biodiversity and Health; Lessons and Recommendations from an Interdisciplinary Conference to Advise Southeast Asian Research, Society and Policy, 2016). Recent intensification of aquaculture systems to boost food productivity has resulted in increased usage of antimicrobial. The use of antimicrobials in aquaculture and animal husbandry has been divided into 4 main areas of usage:

1. Therapy: Antimicrobial use to treat infections. Antimicrobials may only be used until the animal had recovered from the infractions.
2. Metaphylaxis: The use of antimicrobials in a herd or group comprising both infected and healthy animals to prevent the spread of infection.
3. Prophylaxis: The use of low dosage of antimicrobials as a disease prevention measure used on healthy animals.

4. Growth Promoters: The use of antimicrobials at low levels as growth promoters in aquaculture and animal husbandry.

AMR is a serious global health threat. To address the multifaceted AMR problem, the WHO endorsed a Global Action Plan (GAP) in 2015, urging member states to develop their own context-specific, One Health Approach-based, National Action Plans (NAPs) on AMR. By 2018, over 100 countries developed their NAPs based on GAP while another 67 had initiated the process.

During an ASEAN summit in 2017, it was acknowledged that activities against AMR were still inadequate and multi-sectoral collaborations were required (Heads of State of Member States of ASEAN, ASEAN Leaders' Declaration on Antimicrobial Resistance (AMR), ASEAN, 2017). The framework for assessment of National Action Plans (Amended from Anderson, et al., 2019). It is well-known that extensive use of antimicrobials in aquaculture can result in the development of reservoirs of antimicrobial resistant bacteria in fish, aquatic animals as well as the aquatic environment, creating detrimental consequences for both humans and animals. (Determinants Influencing Antibiotic Use in Singapore's Small Scale Aquaculture Sectors. A Qualitative Study. (Jane Mingjie Lim, et al., 2020).

On an equivalent biomass basis, estimated antimicrobial consumption in 2017 from aquaculture (164.8 mg/kg) is 79% higher than human consumption (92.2 mg/kg) and 18% higher than terrestrial food producing animal consumption (140 mg/kg), shifting to 80% higher than human (91.7 mg/kg) consumption and remaining 18% higher than terrestrial food producing animal consumption projected in 2030.

Determinants influencing antimicrobial use in ASEAN:

- Individual personal experiences, local regulatory factors, market-related factors.
- (Lack of) knowledge about the purpose and proper usage of antimicrobials by farmers.
- (Lack of) knowledge of any other successful / cost-competitive disease control method.
- (Lack of) a successful alternative model farm.
- (Lack of) cost-effective safe alternatives to antimicrobials on the market.
- (Lack of) a coordinated movement to introduce a safe, cost-effective aquaculture, and animal husbandry in ASEAN.

ASEAN is presently moving forward with its guidelines for sustainable and circular agriculture, which will form an important theme in the future ASEAN agriculture. The need for alternative safer disease prevention program is obvious and this will need to be developed in an organized manner. A good background analysis of the BCA industry in ASEAN has already been done by the regional BCA industry in ASEAN has already been done by Thomas J. et al., (ASEAN Guidelines on the Regulation, Use and Trade of Biological Control Agents, 2014.).

3. ALTERNATIVE STRATEGIES

3.1 BIOLOGICAL CONTROL AGENTS (BCA)

In order to develop a BCA industry, AMS could adopt the regulatory requirements as prescribed suggested in the detailed work done on the "ASEAN Guidelines on the Regulation, Use and Trade of Biological Control Agents", adopted by the 36th AMAF Meeting in 2014.

Regulatory Harmonization of BCA includes the need for:

- A common set of data requirements.
- A standardized regulatory procedure.
- Agreed ways or mechanisms on how to achieve mutual agreements and how to communicate advance regulatory issues across AMS.

Table 21: Key Characteristics of Biocontrol Markets in ASEAN

	ASEAN
Key Products and Markets	Rice, vegetables, fruits, industrial crops; insecticides & fungicides
No. of Companies	Viet Nam (>200), Indonesia (119), Malaysia (41), Thailand (18), Lao PDR (13), Singapore (8), Philippines (7), Cambodia (3)
Area of Arable Crops	62 Mio ha; about 15 Mio ha irrigated; Indonesia and Thailand largest agricultural land holders; ASEAN about 50% under rice
IPM Policies	ASEAN Knowledge Network (ASEAN IPM) active from 1997 to 2011 linking Gov. institutions
Pesticide Issues	Overuse and misuse of chemical pesticides
Growth Prospects	Good for microbials and natural products; semiochemicals promising once better regulation

Source: The Global Economy 2019

Table 22: Some Major BCA Active Ingredients in ASEAN

	ASEAN
Microbials	*Bacillus thuringiensis (143)* *B.t. var. israelensis (9)* *Beauveria bassiana (15)* *M. anisopilae (14)* *Spodoptera litura NPV (1)* *Bacillus subtilis (8)* *B. coagulans (1)* *P. fluorescens (3)* *Streptomyces lydicus (2)* *Trichoderma spp. (19)* *T. harzianum (5)* *Sarcocystis singaporensis (3) (rodenticide)*
Natural Products	*Abamectin & similar (472), Azadirachtin (57)* *Citronella oil (6), Eucalyptol (1)* *Garlic extract (4), Ginseng extract (15)* *Matrine (20), Pyrethrin (10), Rotenone (14)* *Kasugamycin (65)* *Ningnanmycin (33)* *Polyoxin (5), Validamycin (54)* *Chitosan (22)* *Gibberellic acid (86), Oligo-alginate (2)* *Methyl Eugenol (23)* *Saponin (44) (molluscicide)*
Use Type	*Insecticide/Repellent. Fungicide & Bactericide*

*The numbers refer to the number of product branding available of that type
Source: The Global Economy 2019

3.1.1 The Use of Biological Control Agents (BCA)

BCA is grouped into:

- Microbial Control Agents
- Macro Organisms
- Semiochemicals
- Natural products

Present import regulations and classification, groups both biopesticides in the same grouping with chemical pesticides. Only Thailand, Malaysia, and the Philippines have clear guidelines on requirements on registration of biopesticides, but we see an increased in biopesticide registration in several ASEAN countries (Pukclai, 2021). As recorded in the ASEAN guidelines on the regulation, use, and trade of botanical products in the region is the inability of local manufacturers and the regulatory system to properly address characterization and risk assessment of plant extracts with multiple active ingredients. This is also a problem at the international level. A seminar on botanical extracts was organized by the OECD.

BioPesticides Steering Group (BPSG) (OECD, 2012); in their summary, key issues to be addressed included the following statements:

- "It is clear that the term 'botanical' covers a very diverse group of compounds therefore, depending on the characteristics of an active substance, flexibility and consideration on a case by-case may be needed."
- "It is also clear that the issue of specification for 'botanicals' is more complex than for conventional chemicals and there are problems of how to provide technical specifications."

Plant extracts are complex mixtures of a wide range of chemical compounds and biological activities. Various approaches are under evaluation including:

(i) The biomarker approach in which the key compounds of the bioactive plant extract are determined. This approach can be used for quality assurance but it is unclear how this is related to the efficacy of the substance/product.
(ii) Biocide 'whole extract' approach, but this may lead to 'variability issues'.
(iii) Blending (technical mixture of active substances) may be an option.

"It is still unclear how to deal with synthesized analogues or mimics, which are nature-identical but synthesized versions. Should they be treated as 'conventional chemicals'? In this respect it should also be mentioned that radio-labelling techniques are impossible to use for plant extracts. A more balanced approach is needed."

ASEAN regulatory experts worked together to define "Minimum data requirements for Botanicals" that consider some of the points mentioned above. In the meantime, while the present document was under preparation the EU has issued an updated guidance on the regulation of botanicals (EU SANCO, 2014), which could serve as a valuable source to develop further the issues discussed above. It was proposed in the work meetings that botanicals should not be compared directly with synthetic pesticides when it comes to measuring effectiveness in the field. Botanicals degrade quickly in the environment and are less rain-fast than synthetic products, which may result in lower short-term performance and requires different application tactics; this should be acknowledged by regulators and users as well. The value of plant extracts is most apparent during early growing stages, at low pest pressures and against young larvae rather than adult insects. These principles are documented in a field-testing protocol that was jointly developed by the regional BCA expert group.

3.1.2 Registration of BCA within ASEAN

A tiered system was proposed for regulatory harmonization for registration of Biological Control Agents within ASEAN as part of the ASEAN guidelines on the regulation, use and trade of Biological Control Agents (BCA) in April 2014.

Structured in an FAO template, this was based on a tiered system whereby:

- Tier 1 requirements constitute the "minimum" or basic requirements, and the rest of the requirements would be requested under Tier 2, if certain "triggers" make that necessary.
- Tier 1 requirements include biological/chemical characteristics, toxicological evaluation, bio-efficacy, as well as packaging and labelling.
- Tier 2 requirements are on residue data, human health exposure, environmental fate and effects data, and additional data as required.

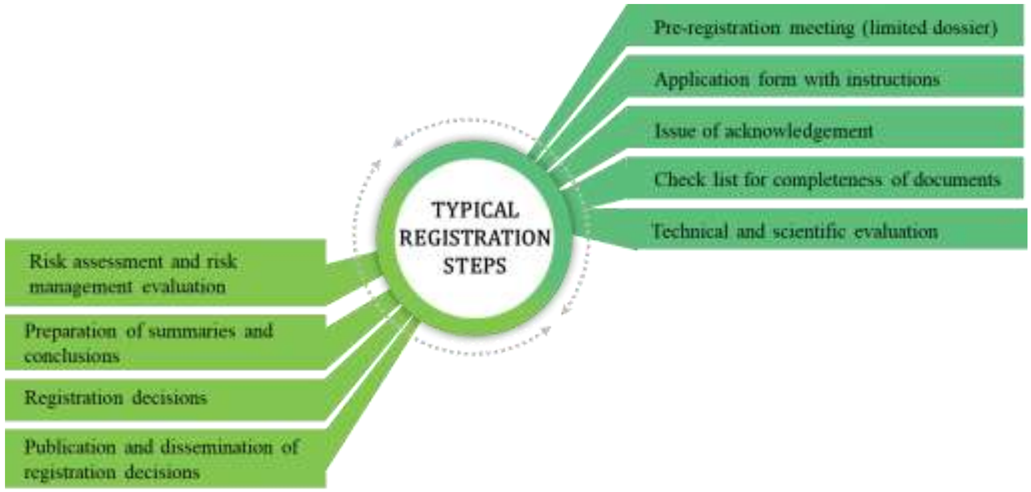


Diagram 8: Typical registration steps for BCA (Bateman, et al., 2014)

The process continues with evaluation by the regulatory authority and is usually terminated by a decision of the regulatory body on whether or not registration (and permission to sell) is granted or not. It was recommended that a division solely dedicated to BCA should be established within a pesticide registration department to ensure that BCA would be treated appropriately and proportionally. The regulatory authority will issue a validity period of a registration for each type of pesticide.

In order to promote mutual, cross-border acceptance of products, the ASEAN BCA experts on regulation indicated that data such as field test evaluations could be accepted; if these were appropriate for local situations in terms of crop, climate, and pest or disease. With regards to toxicological/infectivity data it was proposed that companies should be encouraged to share dossiers.

One of the goals of these guidelines to stimulate discussion among ASEAN Member States (AMS) on regulatory harmonization of BCA: It is important to consider what "harmonization" would actually mean. All data that have been generated for inclusion in Annex 1 and basic data (toxicity studies, environmental risk assessments, etc.) will be accepted by all EU Member States.

3.1.3 The Need for Simplification

FAO guidelines on registration of biopesticides (now updated 2017) proposed that import and export could be subject to the legal provisions of the "Rotterdam Convention on the Prior Informed Consent (PIC) Procedure for Certain Hazardous Chemicals and Pesticides in International Trade 1998". However, BCA are evidently not among the hazardous or banned pesticides and other chemicals listed (and by their inherent environmentally-friendly properties they certainly do not belong there).

3.1.4 ASEAN: Considerations for the development of alternative, safer strategies

- Development of appropriate national regulations.
- ASEAN regional cooperation and networking on biological control.
- Training and awareness for farmers and extension officers (role in IPM, resource material for farmer field schools).
- Use for agricultural certification (including “organic” production).
- Participation of the private sector.
- Developing protocols for BCA efficacy studies.
- “Good Manufacturing Practices” and testing of quality.
- Resource material that can easily be translated and used for making leaflets, posters, etc.
- Influencing policy on IPM, R&D, etc.
- Promoting trade of BCA among AMS.

3.1.5 Private sector needs for BCA technology promotion

- Effective but minimal regulation;
- Formulation of mutual goals and good communication between governments and the private inputs sector. In practice, this could be approached through designation of policies that actively encourage or even mandate the use of BCA and other sustainable crop management approaches. Introduction of biology-based IPM principles into ASEAN GAP protocols would be a good start;
- Incentives for the commercialization of products in research;
- Identification of further needs and resources to provide appropriate BCA;
- Improvement of access by farmers and growers to the premium markets for high-quality food.

3.1.6 National AMS Frameworks for BCA

The current regulatory situation for BCA in ASEAN was intensively discussed with AMS during work meetings of the BCA expert group on regulation (Bateman, et al., 2014). Before this group started its work at the end of 2012, FAO had conducted a first assessment on ‘biopesticides’ and found that most of the countries in Southeast Asia had, to varying degrees, data requirements and procedures in place that relates to the following: identification/characterization (A), toxicology (B), bio-efficacy (C), residue data (D), human health exposure/environmental fate and effects (F), and additional data requirements (G) (Bateman, et al., 2014).

However, harmonization in the sense of availability of a basic set of identical or closely-matching data requirements among AMS was not apparent. It was noted that: “Harmonized pesticide registration in the region would allow for the application of similar requirements and quality standards (Bateman, et al., 2014). Since many of the countries face similar problems, greater coordination and more information exchange among pesticide authorities would help overcome these challenges. However, insufficient trained manpower and quality control facilities are serious impediments in some countries.” (FAO,2012)

3.2 INTEGRATED PEST MANAGEMENT (IPM)

Integrated Pest Management or Integrated Pest and Disease Management

IPM is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control habitat manipulation, modification of cultural practices or use of resistant varieties. IPM is complimentary to other sustainable practices like improving soil health, selecting correct crop varieties, proper water management, crop rotation, diversification, etc.

3.2.1 Integrated Pest Management (IPM) and The Need for Biodiversity

An important role of ecosystem services in agriculture as well as many other production ecosystems is the biological control of pests by natural enemies (Oerke, 2006). Non-crop habitats and adjacent forests increase agricultural soil biodiversity (Yang, et. al., 2021, Nature Comm 4:979, etc.). The use of broad-spectrum pesticides means reduced biodiversity on farms (Lundgren and Fausti, 2015). Reducing the use of broad-spectrum pesticides strengthens ecosystem services which in turn increases yields (Pretty and Bharucha, 2015).

Better Rice Initiative Asia – Promotion of integrated pest management in Thailand was commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ), cofounded by CropLife International and operated from 2018 to 2021 with the lead operating agency being the Rice Department Ministry of Agriculture and Cooperatives of Thailand. This project addressed, amongst other things, the indiscriminate use of pesticides and poor pest management.

In addition, the publishing of Feed the Futures' "Fall Armyworm in Asia, a Guide for Integrated Pest Management" by USAID, CIMMUT and CGIAR and other works by groups such as ASEAN FAW Action Plan have helped to clear the way for more constructive work on IPM to be carried out in the region. Work done and research published by Professor K.L. Heong of Zhejiang University, Zijingang, Hangzhou China, the former principle of the International Rice Research Institute (IRRI) of the Philippines and winners of the International Plant Protection Award of Distinction is instrumental in understanding the overuse of pesticides in rice production and the application of IPM as a safe alternative.

In addition, the paper by Dr. Yunita T. Winarto on "The Behavior of Pesticide Purchasing and Use" on the workshop series on the ASEAN Action Plan on Fall Armyworm Control, 7-Sep-2021, explained the development of pesticide dependence in Indonesia, as well as the introduction of integrated pest management and the practical difficulties of mindset and policy change in Indonesia.

The introduction of IPM in Indonesia has not been an easy one with the existence of the pesticide dependence cycle, as shown in the following diagram (Diagram 9: The Pesticide Dependence Cycle) inspired from the above article. When Farmers Field Schools (FFS) funding ceased in 1999, Farmer Field Schools which improved and emphasized farmers' knowledge and adoption of beneficial practices and reduced overuse of pesticides, these practices which emphasized sustainable agricultural practices also ceased and pesticide usage increased by a large percentage. As noted by Dr. Thomas Jakel, IPM is also responsible for preventing and reducing losses due to pests and disease, not in increasing yields.

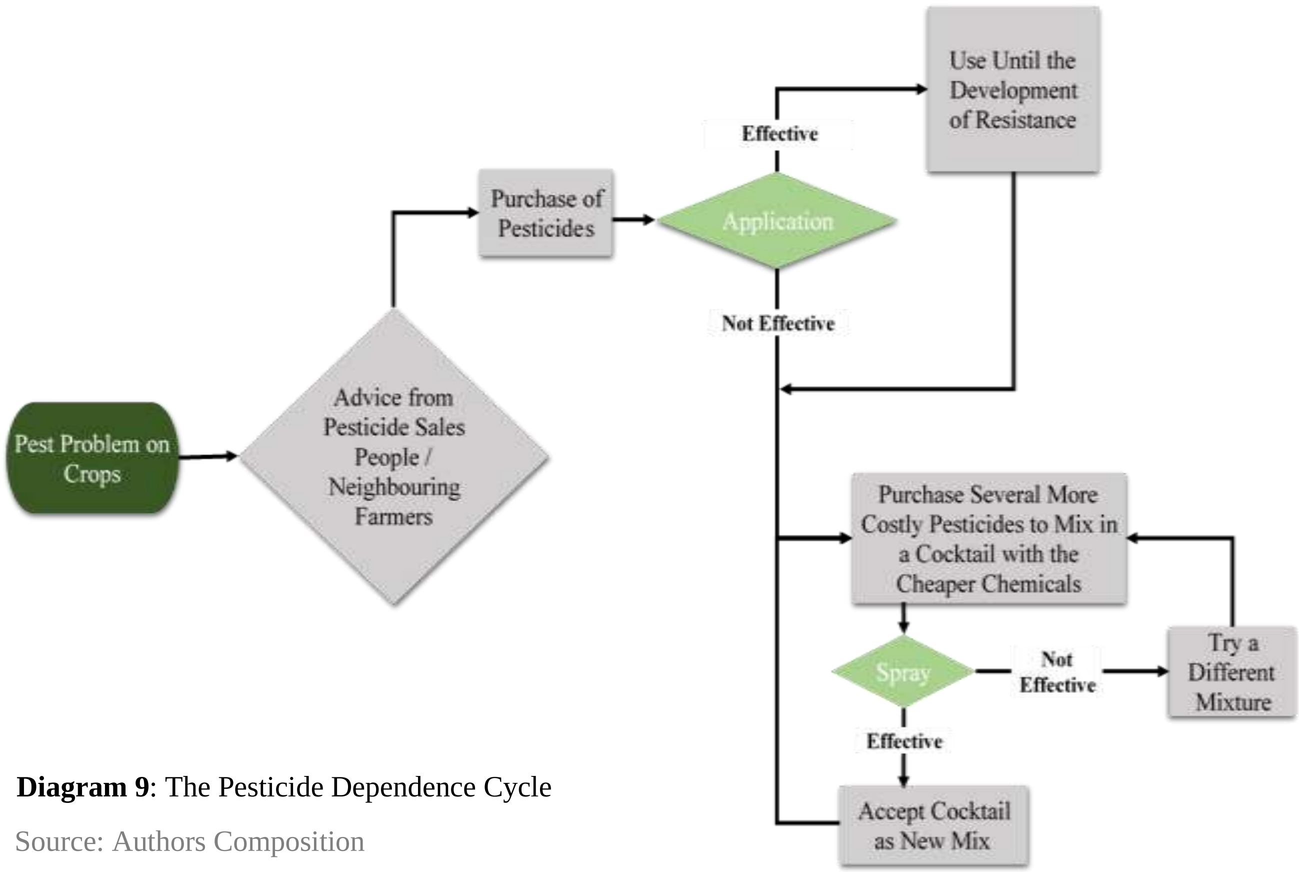


Diagram 9: The Pesticide Dependence Cycle

Source: Authors Composition

3.2.2 Developing IPM Strategies

- Promote and practice biological control.
- Develop in parallel ecological training of farmers who ultimately are the real implementers. This is to build their confidence.
- Researchers learn the constraints of farmers, their beliefs, perceptions, and practices.
- Develop new innovative ways to communicate to the millions and help them appreciate and practice biological control. The mass media can be a powerful platform to communicate to farmers and cultivate new norms.
- Initiate in parallel – policy and structural reforms or new policies to accommodate new practices. Without reforms, the new sustainable norms will not be sustainable as seen in the IPM FFS programs.
- Identify opportunities for new policies as well as to make adjustments to current policies to be able to implement sustainable agriculture. (Heong, K.L.2021)
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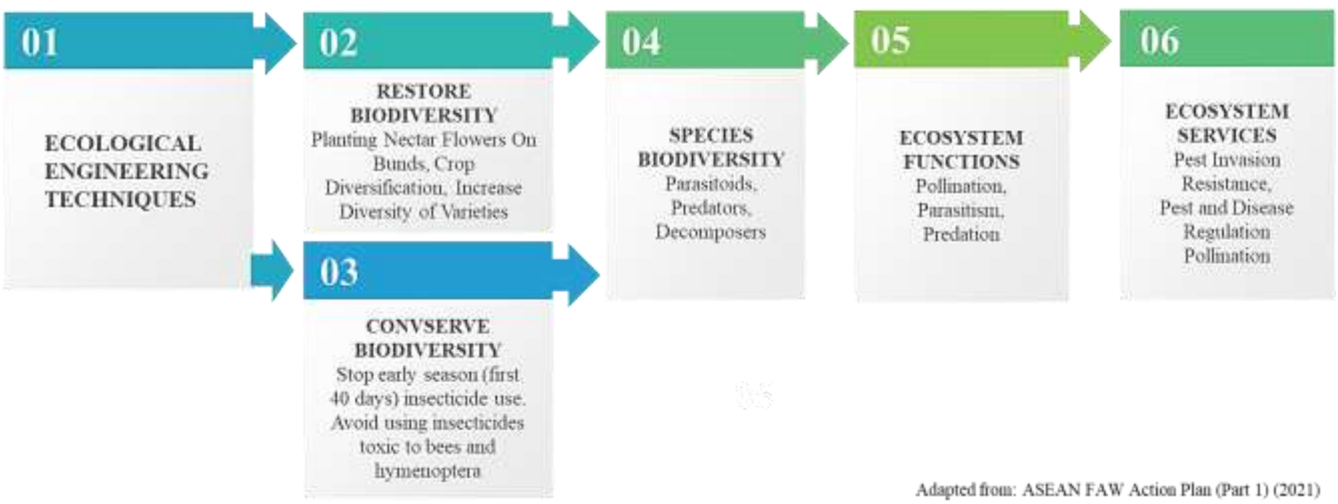
Diagram 10: Ecological Engineering Techniques



3.3 VALORIZING FOOD AND AGRICULTURAL WASTES IN ASEAN

3.3.1 FOOD WASTES

Reports have shown that the biological organic market is growing at a CAGR of 13.3% (Far Eastern Agriculture, 28th Aug. 2020). Food waste is another resource for valorization into organic fertilisers.

Food waste in general comprises more than 50% of municipal wastes in the region. The FAO estimates the carbon footprint of food waste is 3.3 billion tonnes of CO_2 equivalent per year and that one-third of all food produced, or 1.3 billion tonnes ends up lost or wasted every year. Food waste is a good source of suitable biomass for valorization into both organic fertilisers and feeds. The valorization processes for food and agricultural waste are well-documented – examples stated in **Appendix C-Table 23**, and the partial replacement of synthetic fertilisers with organic fertilisers will allow for both productivity and sustainability of agriculture to be maintained. A number of studies (listed below) have been

1. Anaerobic Diges tion of Food Wastes – Challenges and Opportunities – Fuqingxu, et al, 2017.
2. Valorization of Food Waste into Biofertiliser and Field Application – Chengyu Du, et al, 2018.
3. Turning Food Wastes into Value-Added Resources: Current Status and Regulatory Promotion in Taiwan – Wen-Tien Tsai, 2020.
4. Reducing the Impact of Wasted Food by Feeding the Soil and Composting – US EPA, 2022.

On the quality and function of anaerobic digestion residues by Kajsa-Risberg, 2015
"Addition of digestate to soil resulted in an increased wheat yield compared with control soil and mineral fertiliser. It can be concluded that the digestate from biogas plants has great potential as a fertiliser in crop production and does not seem to pose a greater risk of disturbing soil microorganisms than pig slurry and cow manure when spread on arable land. The elevated use of inorganic fertilisers due to poor soil quality and the need for an increase in food production has led to fertility decline in soil. Anaerobic digestion for the production of biogas and digestate is considered a sustainable alternative to non-renewable energy and inorganic fertilisers respectively.

The presence of higher amounts of mineralised nitrogen, reduced heavy metal content and plant growth promoting bacteria (PGPB) in the digestate highlighted the potential ability of the digestate to enhance soil activity." – Comparative Assessment of Bio-Fertiliser Quality of Cow Dung and Anaerobic Digestion Effluent – Moshuda Mukhuba, et al, 2018. Similarly, in a paper on the "Comparison of Effects of Chemical and Food Waste-Derived Fertilisers on the Growth and Nutrient Content of Lettuce (Lactuca Sativa L) by Sang Mo Kang, et al, 2022 states "The current results demonstrate the potential of food waste as a source of organic fertiliser and a significant substitute for chemical fertiliser in the conventional agricultural practice driven by high production cost and environmental pollution.

Another study on Black Soldier Fly frass fertiliser found that "Our findings demonstrate that Black Soldier Fly frass fertiliser (BSFFF) is a promising and sustainable alternative to commercial fertilisers for increased maize production. Exploring Black Solder Fly frass as novel fertiliser for improved growth, yield, and nitrogen use efficiency of maize under field conditions – Dennis Beesiqamukama, et al, 2020, (In addition, protein and lipid for animal and aquaculture feed obtained from the BSF larvae).

Food losses and food wastages take place at various sectors, particularly at the two main points, at the consumer level and also the food processing plants. Valorisation methodologies have been developed over many years with mechanization coming in in the 20th Century. Methodologies include insect-based bioconversion, which produces proteins and lipids for animal and aquaculture feeds, together with a fertilizer frass, while anaerobic digestion produces anaerobic digestate fertilisers as well as biogas to power biogas generators.

The use of tank biodigestors emerged in the 1920's and by the 1970's China had more than 6,000,000 small scale digestors on farms. – (A Big History of Anaerobic Digestion, 2018, Qube Renewables). Tank biodigesters also produce biogas which is trapped as a fuel for cooking, heating and lighting in farms and remote areas. Modern tank biodigesters can also be heated and with the addition of gas filters and storage are cleaner and remove the unpleasant odours involved in biodigestion.

Thermophilic anaerobic digestion and thermophilic aerobic digestion are also used to reduce food waste to compost fertilizers and have the advantage of speeding up the composting process from months to days and are particularly useful in urban areas, trapping the composting gases from polluting the atmosphere. Aerated static pile composting systems (ASP) are also designed to speed up composting while reducing the problems of malodour production. Processing wastes from various food production systems, including fish and chicken plants also are able to aid the development of circularity in the food production chain. Fish processing produces valuable fish meal, fish oil, fish gelatine, and other produce through the use of varied machineries and equipment. The processing of poultry on the other hand also results in the production of bone meal, blood meal, feather meal and other products which are able to be circularised in the agricultural cycle. Vermicomposting is another valuable method of composting, producing vermicompost, vermicast and vermitea.

The study commissioned by the Netherlands Enterprise Agency on " Food Waste Valorization in Singapore" and carried ouy by the Norwegian University in 2021 together with the National Environmental Agency (NEA) which overseas monitoring and reporting of food waste in Singapore details the valorization of food waste into feed by some Singaporean companies using insects such as Black Soldier Fly Larvae (BSF). Black Soldier Fly Larvae (BSFL), *Hermetia illeceus* have proven to convert organic waste into high quality nutrients for pet foods, fish and poultry feed, as well as residue fertilizer for soil amendment" (Siddiqui et al., 2022).

Table 24: Household Food Waste In ASEAN

Country	Food Wasted (tonnes/year)
Brunei Darussalam	34,742
Cambodia	1,423,397
Indonesia	20,938,252
Lao PDR	618,994
Malaysia	2,921,577
Myanmar	4,666,125
Philippines	9,334,477
Singapore	465,385
Thailand	5,478,532
Viet Nam	7,346,717

UN Environment Program Food Waste Index Report (2021)

As much as one-third of the food intentionally grown for human consumption is never consumed and is therefore wasted with significant environmental, social and economic ramifications. Food waste is one of the most challenging issues human kind is currently facing worldwide. Currently food systems are extremely inefficient. It is estimated that between one half and two thirds of the food produced can be lost before reaching a human mouth.

UN SDG12 includes a specific target for food waste reduction, halve per capita global food waste at retail and consumer levels by 2030 and the reduction of general food losses along the food supply chain. Food waste can be categorized according to the type of food or chemical composition ($C_1HN_1O_1S$ etc.). In the process of valorization of food waste, waste from domestic sources as well as food waste from food processing units can be the focus of a circular economy and systems with the object of transforming the chemical composition of the food wastes into feeds and fertilizers in a circular agricultural economy.

Composting of household food waste with anaerobic digestors is gaining traction while processing wastes from fish and poultry, processing plants, utilizing aerobic composting and biodigesters, coupled with Biogas generators to produce both valuable composted material as well as renewable electricity is also being developed. (Garcia-Garcia, G., Woolley, E., Rahimifard, S. et al, 2017).

3.3.2 AGRICULTURAL WASTES

The valorization of food wastes and agricultural wastes will be an essential component of the circular production of feeds and fertilizers for a circular, sustainable agricultural policy in ASEAN. Some of the common valorization products produced from both domestic and processing food wastes are:

- Fertilizers
- Feeds and
- Biofuels

Valorizing food wastes also lessens the production of GHGs from the food industry. Similarly, valorization of agricultural wastes is a key element in the development of the new sustainable and circular agriculture. The amount of agriculture biomass waste produced by the agriculture industry within ASEAN is large, with an estimated 850 million tons of oil palm biomass waste alone being produced within a year in just 3 AMS. The valorization of this waste into cost effective fertilizers and feed would help to provide for cost effective agricultural inputs for agriculture. Aquaculture and animal husbandry within ASEAN. Furthermore, the valorization of these wastes would remove the potential of this biomass from environmental degradation from the production of more Greenhouse gases. Common valorized products include:

- Solid fertilizers
- Liquid Fertilizers and
- Fish and Animal Feeds.

Oil Palm Yearly Agricultural Biomass Waste:

- Indonesia: 570 million tonnes (OPF, OPT, EFB) (Teh, C., 2016)
- Thailand: 174.1 million tonnes (Jusakulvijit, et al., 2021)
- Malaysia: 110 million tonnes (Salleh, et al., 2020)

This biomass waste has the potential to be converted into high value organic inputs which could partially replace much of the expensive fertilisers and feed inputs being used in AMS now. The present importation of large amounts of compounded fertiliser as well as raw materials for aquaculture and animal feed is non-sustainable and as recent price increases have shown, is not cost-effective either.

4. SUGGESTED STRATEGIES AND THE WAY FORWARD (PESTICIDES)

Most, or a major proportion of the pesticide residue data needed to establish Codex Maximum Residue Levels (MRLs) are generated in industrialized countries. Data for these setting of MRLs are very rarely developed in "Developing Countries" and as a consequence, very few Codex MRLs are established for the 'minor use crops' or crops of low pesticide usage on a global scale. These include the tropical fruits within ASEAN.

Thus, if MRLs are not generated for the newer, less toxic pesticides for these agricultural produces, the export markets are reluctant to deal with or accept the produce. This has a practical implication; unless MRLs are available or unless data is generated on the newer, less toxic pesticides within ASEAN on the local vegetable and fruit products, then the farming community will be forced to utilize the older, more toxic pesticides in their agricultural production. In order to generate this residue data to facilitate the registration of the newer, generally lower risk pesticides, national authorities within ASEAN should collaborate with each other, the private sector, and other international bodies to conduct coordinated and complementary pesticide residue programs. This is to address:

- A growing need to replace dangerous HHPs - Progress in Pesticide Risk Assessment and Phasing Out of HHPs in Asia (FAO, 2015).
- A growing need to comply with increasingly stringent food safety standards.

Upon completion of the residue studies, the residue data generated can be submitted to Codex to support the establishment of MRLs. Thus:

- ASEAN should, as expressed by the ASEAN Expert Working Group on Harmonized MRLs, adopt the Codex MRLs, and its import tolerance MRLs. ASEAN should maintain up-to-date MRLs and import tolerances. Growers, importers, exporters, distributors and retailers are involved with agrochemical products and the food supply chain and they need to be assured that the appropriate MRLs and import tolerances are in place.
- There is a proposal within ASEAN by the EWG-MRL to include the APEC Import MRL Guide.
- Import MRLs to be established as ASEAN Harmonized MRL based on request from the proposing non-ASEAN countries. This is under consideration by the respective AMS and will only be accepted if all members agree.
- All AMS will give guidance on the commodity and pesticide to be placed on the FAO/WHO JMPR Review Schedule.
- AMS will have full knowledge on how to prepare and deliver the data submissions.
- AMS will work together with other AMS to coordinate this.

In previous work done under the ASEAN Pesticide Residue Generation (STDF/PG/337) implemented by IR4/Rutgers University and supported by STDF over a four (4) year period ended in 30th November 2016 in ASEAN (collaboration between AMS and pesticide companies). The sectors were:

- Government National Bodies
- Private Sectors (Pesticide Manufacturers)
- Agricultural Export Organizations
- Farmers Organizations

The project established a new collaborative approach for pesticide data generation and exchange within ASEAN countries, based on public-private partnerships and regional cooperation. The participants from ASEAN member countries shared experiences on how to coordinate the work amongst many countries, between government regulatory officials, laboratory and field technicians, as well as pesticide manufacturers, and FAO/WHO. In order to improve cost-effectiveness and avoid duplication of efforts, the project facilitated collaboration among relevant national authorities and the private sector (including 2 multinational pesticide manufactures - Syngenta, Dow, and Valent/Sumitomo - local agricultural commodity export organizations, industry associations, and farmers). A regional minor-use expert group, comprising public and private sector partners, met regularly to discuss and develop solutions on regional minor-use issues, and identify and prioritize pesticide and MRL needs. This prioritization enabled countries to develop strategies to maximize outputs by dividing work, resources, and responsibilities to generate necessary residue data. The cost-saving of collaborative versus individual generation of data is estimated to be over 90%. (ASEAN. IR4/Rutgers; STDF/PG/337 – 2021)

Second and third generation, more toxic pesticides are now being phased out of developed countries (as in the European Union's ban the use of HHPs). However, farmers in Asia, South America, and Africa continue to use these more toxic pesticides. The lack of MRLs for the newer, safer, and less toxic pesticides for 'specialty crops' within ASEAN means that farmers do not have the full choice of using less toxic pesticides for some of their produce.

The continued use of HHPs however is not just a deterrent to exports. HHPs present a serious threat to the health of the farmer handlers and applicators as well as to the other pesticide handlers and applicators, to the environment and to the communities.

From communication with farmers and farmers organizations, cooperatives, chemical pesticide suppliers, and numerous studies done within ASEAN on the application of pesticides within ASEAN, we have a very clear picture of an overall problem with the application of pesticides which extends further than the need to establish and harmonize pesticide MRLs in the safe production of food.

True sustainability of food production is achieved while satisfying:

- The economic viability of the farm operation.
- Human needs including health – enhancing the quality of life for the farmer.
- Environmental needs.

ASEAN is presently undergoing an exercise to establish the guidelines for sustainable and circular agriculture within ASEAN. The amounts, methods, and use of pesticides and the effects of pesticides on the quality of life of the farmers and the effect of pesticides on the environment have been the subject of many studies through the years. The increasing use of high levels of agrochemicals including HHPs have exacerbated environmental problems and health problems for farmers and farming communities.

4.1 SUGGESTED STRATEGIES AND THE WAY FORWARD

- The EU Plans to ban HHPs in the near future. ASEAN should align our standards and practices to our export markets.
- ASEAN needs to remain resiliently competitive in food production.
- Better economic returns for our farming communities.
- Safer farming practices and monitoring.
- Develop a practical BCA industry and policies within ASEAN as soon as possible which will encourage the industry.
- Model alternative BCA/IPM farms as positive reinforcement programs to show the cost-effective implementation of BCA/IPM strategies.
- Greater initiative to encourage agricultural practices which will reduce the production of GHG and increase soil health within ASEAN.
- Policies to reduce the importation and use of chemical pesticides especially HHPs, as well as fossil fuel-based fertilisers and antimicrobials while promoting safer cost-effective replacements.
- ASEAN should encourage the valorization of agricultural and food waste as fertiliser and feed inputs
- Encourage the development of a sustainable and circular cost-effective input industry and establishing practical training centers on sustainable and circular methods.
- Encourage the development of cost-effective biological control agent (BCA) systems to reduce and eventually replace the use of antimicrobials in aquaculture and animal husbandry.
- Encourage the development of cost-effective smart, pesticide-free, recirculating, soil-based systems with organic fertilisers.
- Encourage the development of sustainable and circular, urban agriculture systems.
- Encourage the use of intercropping, sustainable systems in rubber and oil palm estates, and discourage monoculture.
- Encourage the use of Integrated Pest Management (IPM) systems with model farms.
- Encourage greater participation from marginalized groups/communities.
- Enact policies and strategies to encourage the use of BCA in the region: removing taxes and developing the BCA division with supportive policies.
- Encourage and fund efficacy testing of BCA.
- Develop programs to maximize healthy arable soils as a central agricultural component.

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APPENDIX A

Table 5: Value (US$ m) of the Southeast Asia Crop Protection Market

Region	Country	Crop Protection Sales (US$ m)
Southeast Asia	Thailand	669
	Viet Nam	552
	Indonesia	527
	Philippines	282
	Malaysia	238
	Myanmar	137
	Cambodia	73
	Other SE Asia	18
Total Region Sales		**2,497**

Source: Adapted from Agribusiness Global, 2020

Table 6: Estimated Amount of Pesticide/Mixture Exported by the EU to ASEAN Countries

Unique ID	Importing Country	Banned pesticide ingredient (s)	Year of planned export	Estimated amount of substance or mixture to be shipped, export notification (kg/l per year)*	Exporting country
A64	Cambodia	Zineb	2018	48,000	Bulgaria
A65	Cambodia	Zineb	2018	32,000	Bulgaria
A66	Cambodia	Zineb	2018	32,000	Bulgaria
A67	Cambodia	Zineb	2018	32,000	Bulgaria
A68	Cambodia	Zineb	2018	32,000	Bulgaria
A69	Cambodia	Zineb	2018	48,000	Bulgaria
A184	Indonesia	Zineb	2018	36,000	Bulgaria
A187	Indonesia	Zineb	2018	48,000	Bulgaria
A182	Indonesia	Paraquat	2018	500,000	United Kingdom
A185	Indonesia	Zineb	2018	50,000	Bulgaria
A186	Indonesia	Zineb	2018	64,000	Bulgaria
A188	Indonesia	Paraquat	2019	2,304,000	United Kingdom
A183	Indonesia	Cyanamide	2018	20,000	Germany
A180	Indonesia	Atrazine	2018	32	Germany
A181	Indonesia	Atrazine	2018	32	Germany
G168	Indonesia	Butralin	2019	12,000	France
G17	Indonesia	Butralin	2018	16,000	France
K19	Indonesia	Fipronil	2019	24,500	France
K4	Indonesia	Fipronil	2019	52,500	France
K48	Indonesia	Picoxystrobin	2019	30,000	France
K55	Indonesia	Picoxystrobin	2019	30,000	France
A244	Malaysia	Zineb	2018	20,000	Bulgaria
A240	Malaysia	Chlorate	2018	2,000,000	Finland
A241	Malaysia	Cyfluthrin	2018	532	Germany
A242	Malaysia	Cyfluthrin	2019	360	Germany
A243	Malaysia	Zineb	2018	100,000	Bulgaria
G277	Malaysia	Propanil	2019	72,000	France
E210	Malaysia	Propargite	2018	2,700	Netherlands
E211	Malaysia	Propargite	2018	1,600	Netherlands
E212	Malaysia	Propargite	2019	2,700	Netherlands
E213	Malaysia	Propargite	2019	800	Netherlands
G112	Malaysia	Propanil	2018	40,000	France
G164	Malaysia	Butralin	2019	20,000	France
G22	Malaysia	Butralin	2018	20,000	France
A292	Myanmar	Zineb	2018	30,000	Bulgaria
A294	Myanmar	Zineb	2018	32,000	Bulgaria
A295	Myanmar	Zineb	2018	30,000	Bulgaria
A296	Myanmar	Zineb	2018	30,000	Bulgaria
A297	Myanmar	Zineb	2018	32,000	Bulgaria
A293	Myanmar	Zineb	2018	32,000	Bulgaria
A325	Philippines	Zineb	2018	60,000	Bulgaria
A321	Philippines	Carbendazim	2018	20,160	Belgium
A322	Philippines	Carbendazim	2019	26,880	Belgium
A323	Philippines	Cyfluthrin	2018	300	Germany
A324	Philippines	Cyfluthrin	2019	360	Germany
A326	Philippines	Zineb	2018	60,000	Bulgaria
A341	Singapore	Paraquat	2018	150,000	United Kingdom

A342	Singapore	Paraquat	2019	208,000	United Kingdom
A344	Singapore	Picoxystrobin	2019	100,000	Spain
E3	Singapore	Diazinon	2018	10,000	Germany
K27	Singapore	Picoxystrobin	2019	100,000	France
A377	Thailand	Cyanamide	2018	20,000	Germany
A378	Thailand	Zineb	2018	260,000	Bulgaria
E226	Thailand	Propargite	2018	148,960	Netherlands
E227	Thailand	Propargite	2018	63,000	Netherlands
E228	Thailand	Propargite	2019	32,000	Netherlands
E229	Thailand	Propargite	2019	150,560	Netherlands
E230	Thailand	Propargite	2019	150,560	Netherlands
E231	Thailand	Propargite	2019	32,000	Netherlands
H22	Thailand	Diazinon	2018	4,000	France
A452	Viet Nam	Zineb	2018	32,000	Bulgaria
A441	Viet Nam	Ethoxysulfuron	2018	3,960	Germany
A442	Viet Nam	Ethoxysulfuron	2018	26,010	Germany
A443	Viet Nam	Ethoxysulfuron	2019	42,000	Germany
A444	Viet Nam	Ethoxysulfuron	2019	3,600	Germany
A445	Viet Nam	Ethoxysulfuron	2019	3,600	Germany
A446	Viet Nam	Ethoxysulfuron	2018	22,000	Germany
A447	Viet Nam	Ethoxysulfuron	2019	11,520	Germany
A448	Viet Nam	Ethoxysulfuron	2018	150,000	Germany
A449	Viet Nam	Flufenoxuron	2019	1	Belgium
A450	Viet Nam	Ametryn/Atrazine	2018	53,000	Hungary
A451	Viet Nam	Zineb	2018	600,000	Bulgaria
A453	Viet Nam	Zineb	2018	60,000	Bulgaria
A454	Viet Nam	Zineb	2018	64,000	Bulgaria
E148	Viet Nam	Propargite	2018	40,000	Italy
E243	Viet Nam	Propargite	2018	40,000	Netherlands
E244	Viet Nam	Propargite	2019	32,000	Netherlands
G189	Viet Nam	Cyfluthrin	2019	720	France
A440	Viet Nam	Trifluralin	2018	500,000	Italy
H14	Viet Nam	Cyfluthrin	2018	1,800	France
K10	Viet Nam	Fipronil	2019	450	France
K20	Viet Nam	Fipronil	2019	4,000	France
K46	Viet Nam	Picoxystrobin	2019	100,000	France
M2	Viet Nam	Zineb	2018	-	Bulgaria

* Banned pesticide ingredients indicate pesticides banned by the EU

Source: Adapted from AgroPages 2019

Table 7: Pesticides banned or severely restricted in the European Union

Substance	Use limitation	Regulation/Directive (Regulatory Decision excluding substance from Annex I of Directive 91/414)
Acephate	Ban	03/219/EEC
1,2-Dibromoethane	Ban	79/117/EEC
1,2-Dichloroethane	Ban	79/117/EEC
8-Hydroxyquinokine	Ban	Voted out 04/04/2006
Alachlor	Ban	Voted out 04/04/2006
Alanycarb	Ban	Incomplete dossier
Aldicarb	Ban	03/199/EC
Aldrin	Ban and export ban	79/117/EEC (1991) + 850/2004 (1)
Alkyl mercury compounds	Ban	79/117/EEC
Alkyloxyl and aryl mercury compounds	Ban	79/117/EEC
Amitraz	Severe restriction	775/2004 (04/247)
Ammonium sulphamate	Ban	Votes out 04/04/2006
Atrazine	Ban	04/247/EC
Azafenidin	Ban	02/949/EC
Azamethiphos	Ban	02/949/EC
Azinphos ethyl	Ban	95/276/EC
Binapacryl	Ban	79/117/EEC (1991)
Camphechlor	Ban	79/117/EEC
Captafol	Ban	79/117/EEC (1991)
Carbaryl	Ban	Voted out 29/09/2006
Chlordane	Ban and export ban	79/117/EEC (1981) + 850/2004
Chlorfenapyr	Severe restriction	01/697/EC
Chlorfenprop	Ban	01/697/EC
Chlozolinate	Ban	00/626/EC
Choline, K and Na salts of makeic acid	Ban	79/117/EEC
Cresylic cid	Ban	2005/303/EC
Cyhalothrin	Ban	94/643/EC
DDT	Ban and export ban	79/117/EEC (1986) + 850/2004
Diazinon	Ban	Voted out 29/09/2006
Dichlorvos	Ban	Voted out 29/09/2006
Dicofol containing more than 78% p,p*-Dicofol or 1 g/kg of DDT and DDT related compounds	Severe restriction	79/117/EEC (1991)
Dieldrin	Ban and export ban	79/117/EEC (1981) + 850/2004
Dimethenamide	Ban	Voted out 23/05/2006
Dinoseb, its acetate and salts	Ban	79/117/EEC (1991)
Dinoterb	Ban	Noted in 304/2003 (98/269)
Endosulfan	Ban	05/864/EC
Endrin	Ban and export ban	79/117/EEC (1991) + 850/2004
Ethylene oxide	Ban	79/117/EEC (86/355)
Fenitrothion	Ban	Voted out 14/07/2006
Fenthion	Severe restriction	775/2004 (04/140)
Fentin acetate	Ban	Noted in 304/2003 (02/478)
Fentin hydroxide	Ban	Noted in 304/2003 (02/479)
Fenvalerate	Ban	Noted in 304/2003 (98/270)

Ferbam	Ban	Noted in 304/2003 (95/276)
Flusulfamide	Ban	Application withdrawn
HCH containing less than 99.0% of the gamma isomer	Ban	79/117/EEC (1981)
Heptachlor	Ban and export ban	79/117/EEC (1984) + 850/2004
Hexachlorobenzene	Ban and export ban	79/117/EEC (1981) + 850/2004
Hexaconazole	Ban	Voted out 04/04/2006
Imazamethabenz	Ban	2005/303/EC
Kasugamycin	Ban	2005/303/EC
Lindane (gamma-HCH)	Ban	Noted in 304/2003 (00/801/EC)
Malathion	Ban	Voted out 29/09/2006
Maleic hydrazide and its salts, other than choline, potassium and sodium salts; choline, potassium and of sodium salts maleic hydrazide containing more than 1 mg/kg of freehydrazine expressed on the basis of the acid equivalent	Ban	79/117/EEC (1991)
Mefluidide	Ban	2004/401/EC
Mephospholan	Ban	2004/401/EC
Mercuric oxide	Ban	79/117/EEC
Mercurous chloride	Ban	79/117/EEC
Metalaxyl	Ban	03/308/EC
Methabenzthiazuron	Ban	2006/302
Monolinuron	Ban	00/234/EC
Naled	Ban	2005/788
Nitrofen	Ban	79/117/EEC (1988)
Other inorganic mercury compounds	Ban	79/117/EEC
Oxydemeton-methyl	Ban	Voted out 29/09/2006
Parathion-ethyl	Severe restriction	Noted in 304/2003 (01/520)
Parathion methyl (methyl parathion)	Severe restriction	Noted in 304/2003 (03/166)
p-Chloronitrobenzene	Ban	03/166/EEC
Permethrin	Ban	Noted in 304/2003 (00/817)
Phosalone	Ban	Voted out 14/07/2006
Polyoxin	Ban	2005/303/EC
Propham	Ban	Noted in 304/2003 (96/586)
Pyrazophos	Ban	Noted in 304/2003 (00/233)
Pyradafol	Ban	Application withdrawn
Quintozene	Ban	79/117/EEC (1991) (00/816)
Sodium tethrathiocarbonate	Ban	Voted out 04/04/2006
Tecnazene	Ban	Noted in 304/2003 (00/725)
Temephos	Ban	00/725/EC
Thiodicarb	Ban	Voted out 14/07/2006
Zineb	Ban	Voted out 29/09/2006
Zucchini yellow mosaic virus	Ban	Application withdrawn

(Source: https://www.pan-europe.info/)

APPENDIX B

Country	Public concern	Health incident	Compliance	Export	Comment
Brunei Darussalam			Yes		Improve food safety in domestic and imported product. improving the monitoring Standard operating Procedures in compliance to Pesticide Act, Public Health Food Act, Imported Country's Requirements and GAP certification programme, similar to Malaysia
Cambodia			Yes		Ministry of commerce is responsible for pesticide residue in market product and imported product
Indonesia	Yes		Yes		pesticide monitoring residue programme is important for public health (so that it is included in the regulation) and exports
The Lao People's Democratic Republic					
Malaysia	Yes		Yes		Pesticide Act 1974; Food Act 1983 and Food Regulations 1985; Importing country's requirements; GAP Certification programme
Myanmar	Yes		Yes		need both compliance for national food safety and export requirements with trading partners
The Philippines	Yes		Yes		Regulations- Import Risk Analysis
Singapore			Yes		need both compliance for national food safety and export requirements with trading partners
Thailand	Yes		Yes		Need both compliance for domestic and imported food product under regulations regarding MRLs for pesticide residues for consumer health protection.

Observations	• The common thread in most response was the need for monitoring programmes to cover both compliance and food safety concerns. • Participant countries appeared to place strong emphasis on domestic and imported product. • Residue monitoring in several participant countries is underpinned by legislation and regulations. • The country's import: export ratio appears to be determining factor in the importance of imported food testing and export testing for market access.

Table 11: Triggers to develop / improve pesticide residue monitoring (FAO,2020)

Country	Commodity	Commodity	Commodity	Comment
Brunei Darussalam	Leafy vegetable import and domestic	Imported spices	Celery	
Cambodia	Leafy Vegetable, Mango, Cashew	Other vegetables	cassava	Animal / fish products
Indonesia	Leafy vegetable and vegetable presumed to use high pesticide	fruit	Staple food of grain, such as rice	This is the focus of Agency for Food Security (Ministry of Agriculture). Other institutions (Directorate General of Animal Health/Ministry of Marine and fishery) have their own focus.
The Lao People's Democratic Republic	Leafy vegetable: cabbage	apple	Orange	
Malaysia	Leafy vegetable	Herbs	Spices	
Myanmar	Leafy vegetable	Export rice and sesame		Multiple pesticide applications in a short season
The Philippines	Imported rice			Regulatory requirement for food safety analysis
Singapore	Leafy vegetables			
Thailand	Leafy vegetable	fruit		High consumption products and results of annual monitory plan
Observations	• The common commodity group causing concern for almost all participants was leafy vegetables. • The group discussion indicated that leafy vegetables were a high volume consumption commodity and as such could potentially contribute to the overall dietary exposure to pesticide residues. • Further, participants also suggested that leafy vegetable production could involve multiple application of insecticides and fungicides. • Generally, multiple applications due to high pest pressures was identified as a potential residue risk, which warranted residue monitoring.			

Table 12: What commodities are of the biggest concern? Is it particular commodities or commodity groups? (FAO, 2020)

Options:

a. Residue monitoring programme, which involves all farmers selling fruit / vegetable / grain into the domestic market. The programme may support national quality assurance, which allows farmers to continue to trade. The residue testing result is compared to the national MRL
b. Random monitoring programme, which surveys the produce, traded domestically. (could also apply to exported product) A target number of samples is collected per annum from pack-houses, wholesale markets and supermarkets. The residue testing result is compared to the national MRL.
c. Export consignment testing programme, which involves the collection of representative samples from each consignment prior to export. The residue testing result is compared to the national MRL and the import MRL applying in the importing country.
d. Targeted export testing programme. Samples are collected based on a risk profile.
e. Targeted domestic testing programme. Samples are collected based on a risk profile.
f. Imported food testing programme. Based on a risk profile, a certain proportion of imported consignments are tested upon arrival. Some programmes involve 'test and hold', while others allow the commodity into the country and provide results of testing at later date.
g. Dietary exposure testing programmes. Programmes are designed to determine, based on consumption and residue monitoring data, the dietary exposure to a range of pesticides.

Additional comments	
	• Brunei Darussalam: More information from Ministry of Health • Cambodia: Targeted domestic testing at whole-markets, supermarkets and local markets • Indonesia: safety controls on fresh food of plant origin (including for pesticide residues) in the Ministry of Agriculture are carried out by cross-work units according to their duties: At the point of entry, they are carried out by the Indonesia Agricultural Quarantine Agency. On the pre-market and post market positions they are carried out by Agency for Food Security. Pre market controls assess the safety of fresh food of plant origin before it is circulated on the market: this is made through certification (which includes exports as requested by target country) and registration of fresh food of plant origin. Post market or control on fresh food of plant origin is made through inspection, surveillance and circulation inspection, both regular and incidental. The technical Directorate General provides guidance/assistance on cultivation practices. • Malaysia: Residue monitoring at farm level for GAP Certification • Myanmar: Residue monitoring programme which involves farmers who are implementing GAP on fruit, vegetables and rice.
	• The Philippines: all scenarios align • Singapore: Priority for import control and total dietary study • Thailand: compliance monitoring to confirm MRLs regulations of pesticide residues and to support GAP

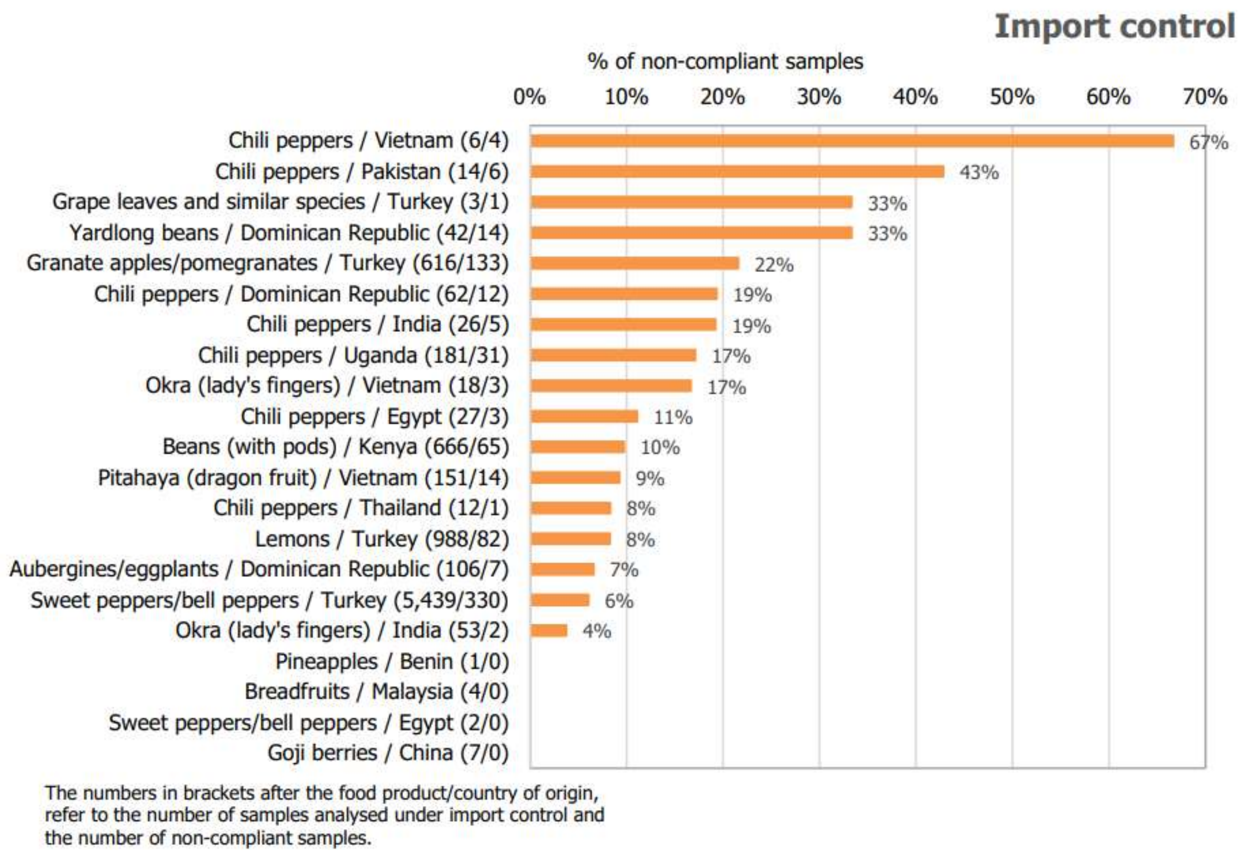
Country	a	b	c	d	e	f	g
Brunei Darussalam	Yes	Yes	Yes	No	No	Yes	Yes
Cambodia	No	No	No	No	Yes	No	No
Indonesia	Yes	Yes	Yes	No*	Yes	Yes	No
The Lao People's Democratic Republic	Yes	Yes	Yes	No	No	No	No
Malaysia	No	Yes	No	Yes	Yes	Yes	Yes
Myanmar	Yes	No	No	No	No	No	No
The Philippines	No	Yes	Yes	No	No	No	No
Singapore	No	No	No	No	No	Yes	Yes
Thailand	Yes	Yes	No	No	No	Yes	No

*for export testing, it depends on target country requirement.

Observations	
	• The focus of residue monitoring programmes varies significantly among the participating countries. • The types of monitoring are dependent on the level of domestic production and volumes of imports and exports. • Participant countries appear to be focused on compliance monitoring at a farm level to confirm GAP. • Countries which import a high proportion of raw and processed food focused residue monitoring on imported food testing.

Table 13: Residue monitoring scenarios (FAO, 2020)

Table 17: Frequency of non-compliant samples identified in the framework of the reinforced import controls under regulation (EC) No 669/2009



Source: European Food Safety Authority. EFSA Journal, 2021

Table 18: Studies on Neonicotinoids

Below are some studies listed on neonicotinoids:

- The conclusions of the worldwide integrated assessment on the risks of neonicotinoids and fipronil to biodiversity (Van der Sluijs, et al., 2014)
- Ecosystem functioning and the impact of systemic pesticides on biodiversity and ecosystems (Simon-Delso, et al., 2014)
- The effects of neonicotinoids and fipronil on non-target invertebrates (Pisq, et al., 2014)
- Will S. E. Asia be threatened by the neonicotinoid tsunami? (K. L. Heong, C.A.B.I., 2014)
- Ecological risks assessment of the increasing use of the neonicotinoid pesticides along the east coast of China (Yuanchan Chen, et al., 2019)
- Towards a non-toxic S. E. Asia Phase II (Final Progress Report, 2019)
- From the "Regional Programme" Towards a non-toxic S. E. Asia Phase II (Final Progress Report, FAO, KEMI, The Field Alliance, 2019 PANAP)

Table 20: Studies on Substituting Organic Fertiliser for Chemical Fertiliser

Case Study Examples:

- Substituting Organic Fertiliser for Chemical Fertiliser: Evidence from Apple Growers in China, Pingping (Fang, et al., August 2020)
- Effect of different fertilisers on oil palm (Elaeis Guineensis) growth and performance at nursery stage in Felda Sungai Tekam (Shampazuraini, et al., 2016)
- Efficient use of inorganic and organic fertilisers for oil palm (Khalid Heran, et al., 2015)
- Reducing fertiliser and avoiding herbicides in oil palm plantations (Ecological and Economic Valuations, Kevin F.A. Darran, et al., 2019)
- The effects of biofertilisers on growth, soil fertility, and nutrient uptake of oil palm (Elaeis Guineensis) under greenhouse conditions (Aaronn Avit Ajeng, et al., Dec 2020)
- Impact of organic and inorganic fertilisers on yield, taste, and nutritional quality of tomatoes (A Heeb, B Lundegårdh, et al., 2006)
- The effect of organic, inorganic fertilisers and their combinations on fruit quality parameters in strawberry (Neslihan Kilic, et al., 2021)
- Combination of inorganic and organic fertiliser in rice plants (Oryza sativa) in screen houses (H. Sunarpi, et al., 2021)

APPENDIX C

Table 23: List of Reference Reports and Example Cases on Valorization of Agricultural & Food Waste

Number	Journal/Article	Year Published
1	Biomaterial from Oil Palm Waste: Properties, Characterization and Applications – *Rudi Dungani, Pingkan Aditiawati, Sri Aprilia, Karnita Yuniarti, Tati Karliati, Ichsan Suwandhi and Ihak Sumardi*	2018
2	The Oil Palm Wastes in Malaysia – *N. Abdullah & F. Sulaiman*	2012
3	A Survey on the Usage of Oil Palm Biomass Wastes from Palm Oil Mills on Sustainable Development of Oil Palm Plantations in Sarawak – *K Y Phang, S W Lau*	2017
4	An Overview of the Oil Palm Industry in Malaysia and its Waste Utilization through Thermochemical Conversion, Specifically via Liquefaction – *Mohd Fahmi Awalludin, Othman Sulaiman, Rokiah Hashim, Wan Noor Aidawati WanNadhari*	2015
5	Understanding Circular Economy Implementation in the Agri-food Supply Chain: The Case of an Indonesian Organic Fertiliser Producer – *Ruth Nattassha, Yuanita Handayati, Togar M. Simatupang & Manahan Siallagan*	2020
6	Oil Palm Leftovers, Alternative Food for Livestock – Marieke Ploegmakers	2014
7	From Waste to Food: Optimising the Breakdown of Oil Palm Waste to Provide Substrate for Insects Farmed as Animal Feed – *Elizabeth Dickinson, Mark Harrison, Marc Parker, Michael Dickinson, James Donarski, Adrian Charlton, Rosie Nolan, Aida Rafat, Florence Gschwend, Jason Hallett, Maureen Wakefield, Julie Wilson*	2019
8	Development of Animal Feed from Waste to Wealth using Napier Grass and Palm Acid Oil (PAO) from Palm Oil Mill Effluent (POME) – *Farah Amalina, Ishaka Muhammad Haziq, Jamila Abdul Syukor Abd Razak, Nurul Huwaida, Anuar Zamania, Mohd Rashid Ab Hamid*	2019
9	Upgrading of Oil Palm Wastes to Animal Feeds – *Tamikazu Kume*	1994
10	BPPT Converts Palm Oil Waste into Cattle Feed – *The Palm Scribe*	2018
11	Utilization of Oil Palm Biomass and Waste as Animal Feed – *Palm Oil Indonesia*	2020
12	Palm Oil Mill Waste as Fertiliser - *Everchem*	2021
13	Compost Fertiliser from Palm Oil Mill Waste for Growing Organic Crops – *Universiti Malaysia Pahang*	2019
14	Bio-composting Oil Palm Waste for Improvement of Soil Fertility – *Allah Wadhayo Gandahi, M Hanafi*	2014
15	Composting for a More Sustainable Oil Palm Plantation – *Jajang Supriatna, Victor Baron, Xavier Bonneau, Rajiv Sadasiban.*	2018
16	Liquid Waste of Palm Oil Plantations as Liquid Fertiliser – *Elfidiah, Kiagus Ahmad Roni.*	2019
17	Sustainable Transformation of Palm Oil Mill Waste into Organic Fertiliser through Vermicomposting – *Ta Yeong Wu*	2017
18	Evaluation of Natural Rubber Serum Fertiliser (NRSF) for Vegetable Cultivation in Malaysia – *Vimala,P.; Chan.S.K.; A.B. Othman*	1994
19	Utilization of Waste from Concentrated Rubber Latex Industry for Composting with Addition of Natural Activators - *Jutarut Iewkittayakorn, Juntima Chungsiriporn, and Nirattisai Rakmak*	2018
20	Utilization of Wastes from Para Rubber Industry to Produce Compost – *Wassana Taenkaew, et. al.*	2014
21	Utilization of Rubber Latex Residue and Swine Dung as Fertiliser for Para Rubber Seedling Growth – *Thanya Uttraporn, Saranya Sucharitaku, Gritsanaruck Theeraraj, Chumporn Yuwaree, C. Navanugraha, R. Hutacharoen*	2012
22	Rubber Seed Residues as Animal Feed – *Maricke Ploegmakers*	2016
23	Potential Use of Mealworm Frass as a Fertiliser: Impact on Crop Growth and Soil Properties – *David Houben, et al*	2020

24	Nutrient Quality and Maturity Status of Frass Fertiliser from Nine Edible Insects – *Dennis Beesigamukawa, et al*	2022
25	Exploring Black Soldier Fly Frass as Novel Fertiliser for Improved Growth, Yield, and Nitrogen Use Efficiency of Maize Under Field Conditions - *Dennis Beesigamukawa, et al*	2020
26	Agricultural Value of Black Soldier Fly Frass as Organic Fertiliser on Rye Grass - *Regina Menino, et al*	2021
27	Excellent Excrement? Frass Impacts on a Soils Microbial Community, Processes and Metal Bioavailability - *C. Watson, et al*	2021
28	Applications of Food Waste Derived Black Soldier Fly Larval Frass as Incorporated Compost Side Dress Fertilizer and Frass Tea Drench for Soilless Cultivation of Leafy Vegetables in Biochar Based Growing Media - *Jonathan Koon Ngee Tan, et al*	2021
29	Cricket Frass: The High Quality Organic Fertiliser for Vegetable Growth Improvement – *Somchai Butnan, et al*	2021
30	Vermicompost as an Organic Fertiliser and Biocontrol Agent: Effect on Growth, Yield and Quality of Plants – *Rahesli Joshi, et al*	2014
31	The Effect of Vermicompost and Other Fertilisers on the Growth and Productivity of Pepper Plants in Guyana – *Vashie Ganeshnauth, et al*	2018
32	Earthworms Vermicomost: A Powerful Crop Nutrient Over Conventional Compost and Protective Soil Conditioner Against the Destructive Chemical Fertilisers for Food Safety and Security – *Sinha, Rajiu, et al*	2009
33	Bioconversion of Food Wastes into Vermicompost and Vermiwash – *Merci Manyuchi, et al*	2013
34	Effect of Biochar Prepared from Food Waste Through Different Thermal Treatment Processes on Crop Growth – *Hang Jia, et al*	2021
35	Assessing the Use of Food Waste Biochar as a Biodynamic Plant Fertiliser – *Rachel Mezac*	2016
36	Food Waste Anaerobic Digestate as Fertiliser: The Agronomic Properties of Untreated Digestate and Biochar Filtered Digestate Residue – *Shuang Song, et al*	2021
37	Effects of Palm Kernel Biochar and Food Waste Compost on the Growth of Palm Lily (Cordyline fructicosa), Coleus (Coleus sp.) and Boat Lily (Rheo discolour) – *Normaniza Osman, et al*	2021
38	Biochar from Vegetable Wastes: Agro-Environmental Characterisation – *Srighandubala Pradhan, et al*	2020
39	The use of Biochar for the Production of Organic Fertilisers – *Wojciech Czekala, et al*	2019
40	Liquid Fertiliser Products from Anaerobic Digestion of Food Waste: Mass, Nutrient and Energy Balance of Four Digestate Liquid Treatment Systems – *Elina Tampio, et al*	2016
41	Closing the Food Waste Loop: Food Waste Anaerobic Digestate as Fertiliser for the Cultivation of the Leafy Vegetable, Xiao Bai Cai (Brassica rapa) – *Jia Chin Cheong, et al*	2020
42	Nitrogen and Phosphorus Recovery from Anaerobically Pretreated Agro Food Wastes: A Review – *Jose Luis Campos*	2019
43	Food Waste Digestion: Anaerobic Digestion of Food Waste for a Circular Economy – *Charles Banks, et al, IEA Bioenergy*	2018
44	New System to Convert Food Waste into Fertiliser for Greenhouse Use Gives Potential 95% Reduction in CO_2 Emissions – *European Commission, Science for the Environment Policy*	2016
45	From Sea to Soil: Adding Value to Fish Waste – Angus McNeil, et al	2008
46	The Effectiveness of Fish Silage as Organic Fertiliser on Post Harvest Quality of Pak Choy (Brassica rapa L subsp. Chinensis) – *Nurul Ulfah Karim, et al*	2015
47	Notes from the Field: Fish Waste Fertiliser, Five Resistance Trees and More – *Will McCarry*	2022

48	Possibilities of Using Organic Waste after Biological and Physical Processing – An Overview – *Wieslaw Szulc, et al*	2021
49	Recycling of Food Waste to Produce Chicken Feed and Liquid Fertiliser – *Zuhaib Siddiqui, et al*	2021
50	Multifunctional Food Waste Fertiliser Having the Capability of Fusanium Growth Inhibition and Phosphate Solubility: A New Horizon of Food Waste Recycle Using Microorganisms – *Ahman Mahmood, et al*	2019
51	The Challenges in Repurposing Food Wastes and other Residuals for Agriculture – *Tosiah Sadi, FFTC*	2021
52	Development of Organic Fertilisers from Food Market Waste and Urban Gardening by Composting in Ecuador – *J. Jara-Samaniego, et al*	2017
53	Closing the Loop of Food Waste: A Hawker Center Generates Energy and Biofertiliser – *FuturArc*	2021
54	Effect of Nutrient Enriched Organic Liquid Fertilisers on Growth of Albemonchus esculentus – *Achala Ranasinghe, et al*	2019
55	Fast Composting of Food Waste using Thermal Composter – *B. Zaman, et al*	2021
56	Decentralised Composting of Food Waste: A Perspective on Scientific Knowledge – *Antoni Sanchez*	2022
57	Pre and Post Consumer Composting – *Tiffany Hui, et al*	2014
58	Turning Food Waste into Value Added Resources: Current Status and Regulatory Promotion in Taiwan – *Tien Tsai*	2020
59	Food Waste Valorization – *Alessia Tropea*	2022
60	Valorization of Food Waste into Biofertiliser and its Field Application – *Chenyu Du, et al*	2018
61	A review on the Valorisation of Food Waste as a Nutrient Source and Soil Amendment – *James O'Connor, et al*	2020
62	Food Waste Valorisation Options: Opportunities from the Bioeconomy – *Enrica Imbert*	2017
63	Food Waste Solution at Home: Conventional and Rapid Composting Techniques – *Mohd Raimi, et al*	2020
64	Food Waste and Agro By-Products: A Step Towards Food Sustainability – *Ajit A. Tiwani, et al*	2021
65	Food Losses and Waste in the Context of Sustainable Food Systems – *Committee on World Food Security (CFS), HLPE*	2014
66	Utilisation of By-Products and Food Waste in Livestock Production Systems: A Canadian Perspective – *Kim Ominski, et al*	2021
67	Food Waste Valorisation in Singapore – *Wageningen University*	2021
68	Towards Sustainable Food Waste Management: A Reflection on Food Waste Evolutions in Singapore – *Teck Choon Teo, et al*	2021

Authors Composition