Research Journal of Agriculture
Volume.15, Number 1; January-2024;
ISSN: 2837-3189 | Impact Factor: 9.83
https://zapjournals.com/Journals/index.php/rja
Published By: Zendo Academic Publishing

CULTIVATING AWARENESS: EXPLORING THE PERSPECTIVES OF CAMBODIAN VEGETABLE FARMERS ON PESTICIDE USE AND HEALTH RISKS

[1]Sophea Kimly Chan and [2]Sokha Vannak Lim

Article Info
Keywords: Cambodia, Vegetable Production, Pesticide Residues, Import Dependency, Consumer Health\

DOI
10.5281/zenodo.10567027

Abstract
Cambodia, a prominent South East Asian country, has long relied on agricultural production as its primary economic pillar. With 4.5 million hectares of cultivated land, a substantial portion—70 percent—is dedicated to rice, serving as the predominant commodity and income source for the majority of farmers. The remaining 30 percent is allocated to various other food and industrial crops, with an annual increase in cultivation area fueled by the expansion of higher-value crop production and the integration of farmers into markets (ADB, 2021; WB, 2015).

In the realm of vegetable production, farmland represents a modest 1.3 percent of the total agricultural land, predominantly owned by smallholders with an average farming area of less than 0.5 hectares. Paradoxically, despite the available arable land, over 50 percent of the country's vegetable consumption relies on imports, particularly from neighboring Vietnam. This import dependency is attributed to factors such as price competitiveness, logistical challenges, and the capacity for year-round production (SNV, 2022; NIS, 2015; FAO, 2014; Schreinemachers et al., 2017). However, concerns arise as pesticide residues in imported vegetables often surpass maximum residue limits, posing a significant risk to consumers (Skretteberg et al., 2015).

Compounding this issue, Cambodian vegetable producers are similarly reliant on pesticide use as an indispensable measure for crop protection and a pivotal component in production, crucial for ensuring their income (Schreinemachers et al., 2017; Damalas, 2009). This dual dependence on pesticides in both domestic production and imports raises pressing questions about the overall safety and sustainability of vegetable consumption in Cambodia.

This study aims to scrutinize the intricate dynamics of Cambodia's vegetable supply chain, investigating the interplay between domestic production and imports, the prevalence of pesticide residues, and the associated risks to consumer health. By shedding light on these critical

[1]Division of Research and Extension, Royal University of Agriculture, Phnom Penh, Cambodia
2Division of Research and Extension, Royal University of Agriculture, Phnom Penh, Cambodia

aspects, the research seeks to inform policy interventions, promote sustainable agricultural practices, and enhance the safety of the vegetable supply chain in Cambodia.

Introduction

One of the South East Asia countries, Cambodia has relied on agricultural production as the main economic source. The country's agricultural resources consist primarily of 4.5 million hectares of cultivated land, of which about 70 percent devoted to rice as primary commodity and source of income for most of the farmers, and around 30 percent dedicated to other food and industrial crops. The cultivation area is increasing every year due to the expansion of higher value crop production and integration of farmers into markets(ADB, 2021; WB, 2015).For vegetable production, farmland accounts for around1.3 percent of total agricultural land and belongs to mostly smallholders with an average farming area less than 0.5 hectares. However, more than 50 percent of all vegetables consumed in the country are imported from the neighboring countries, particularly Vietnam, due to price competitiveness, challenges in logistics, and the ability for year-round production (SNV, 2022; NIS, 2015; FAO, 2014; Schreinemacherset al., 2017). Pesticide residues in the imported vegetables have been found above maximum residue limits, concerning the consumers (Skretteberget al., 2015). On the same way, the Cambodian vegetable producers are also dependent on pesticide use as the essential measure in crop protection and a vital component in the production to assure their income (Schreinemacherset al., 2017; Damalas, 2009).

Inadequate use of the pesticides develops exposure to the human body causing adverse effects on human health including several diseases and poisoning, polluting water, air and soil; and affectingnon-target organisms in the ecosystem (Damalaset al., 2001; Aktaret al., 2009). Growth in pesticide imports has been estimated about 10 times in quantity over the last ten years (FAO, 2022). The fast rate of this increase poses enormous challenges tothe management of the associated risks to applicators, consumers, and ecosystems.

World Health Organization estimates every year about four million cases of chronic and acute pesticide poisoning worldwide. Cambodia is a developing country in which the related risks are much greater where a majority of the population is involved in the agriculture(WHO, 1990).Only few studies on farm-level risk assessment associated with pesticide use have been conducted. In a survey, the Environmental Justice Foundation found that a majority of the Cambodian farmers use pesticides at the inadequate time, at the inadequate strength, and in a manner that does not comply with the specific usage written on the label of the pesticide containers. The safety measures are often ignored or misunderstood. The impropriate use is exacerbated by a lack of appreciation of risks associated with pesticides, inadequate training given by untrained sources such as neighbors and pesticide sellers who themselves are unaware of pesticide risks, and incomprehensible labelling that is usually in foreign languages(EJF, 2002). A study with water spinach farmers conducted by Jensen team found that the farmers used around 50% of the pesticides belonged to WHO class I+II including the banned pesticides, and inadequate PPE. Consequently, many of these farmers had experienced symptoms of acute pesticide poisoning (Jensen et al., 2011).Other study conducted with leaf mustard and yard-long bean farmers revealed that pesticide dependence and the health risks reached entry points for intervention (Schreinemacherset al., 2017).However, causes of higher pesticide residue levels in food and food poisoning in agricultural practices associated with pesticide use have not been revealed yet (ADB, 2008; Wang et al., 2011).So, there is a need to provide more information on pesticide management practices and to estimate environmental health risks associated with pesticide usebythe Cambodian farmers at farm-level for the development of policies and regulations to address the issue. The purpose of this study aims to assess pesticides used, knowledge, attitudes, safety and agricultural practices of the farmers leading to analyzing associated risks to themselves, consumers and environment.

Materials and Methods

Conceptual framework

The study followed a similar method reported by Schreinemachers team (Schreinemacherset al., (2017), which applied the concepts of knowledge, attitudes and practices (KAPs) in a survey to assess what the farmers know about problems associated with the pesticide usage, how they feel about it, and how they behave. Knowledge here refers to farmers' understanding of pesticides, safety, and agricultural practices. Attitude here refers to farmers' beliefs about pesticide effectiveness and effects on human health and environment. Practices are the observable actions of the farmers who were asked about vegetable production practices, pesticides used, rates and intervals of application, pesticide mixture, re-entry and pre-harvest intervals, sources of pesticide management information, personal protection equipment when applying pesticides.

Data collection

Farm-level data from three provinces were collected between November 2021 - February 2022 through a farm survey by face-to-face interviews with farmers during farm activities. 360 farmers who sprayed pesticides and had vegetables in Siem Reap, Kandal and Takeo were randomly selected for interviews. The interviews, using a list of questions, covered the following topics: socio-demographic characteristics, knowledge, attitudes, safety and agricultural practices.

Analytical approach

Quantitative data were analyzed using descriptive statistics, showing means and standard deviations in SPSS version 25. For qualitative data, the analysis was carried out using manual coding of open-ended question into common themes relevant to farmers' decisions.

Results

Demographic characteristics

Table 1 shows results of farm sizes, farmer ages, education levels and pesticide use experience. An average age of the farmers was 45 years in Siem Reap, 48 years in Kandal, and 46 years in Takeo. Most farmers had lower education levels than high school but the proportion was similar among the study areas. Vegetable production in Cambodia is a family scale which the average farm size was 0.22 ha in Siem Reap, 0.33 ha in Kandal, and 0.28 ha in Takeo. An average year of farmers' pesticide use experience was 9 years in Siem Reap, 15 years in Kandal, and 12 years in Takeo. All the farmers reported that they faced many problems associated with pests and diseases in every seasons.

Knowledge and attitudes

Knowledge and attitudes of the farmers regarding pesticide use are shown in Table 2. Insects were the main cause of yield loss in the vegetable production. Insecticide use was very useful to protect the crops and increase income. Farmers were aware of harmful effects of pesticides to human health and environment. However, they did not know hazard levels of the pesticides. Most farmers sought advice from pesticide sellers. The proportion was higher in Siem Reap, followed Takeo and Kandal. Persons in contact with the farmers including neighbors, friends and relatives were in second position to give them the advice while only few farmers received training given by the extension officers.

Table 1–site demographics

	Seam Reap (N=160)	Kandal (N=160)	Takeo(N=160)	Total(N=480)
Women as sprayers (%)	17	10	15	14
Men as sprayers (%)	100	100	100	100
Farms				
- Farm size average (ha)	0.22± 0.18	0.33± 0.4	0.28± 0.32	0.275±0.34
Farmers				
-Age average (year)	45±12	48±14	46± 9	46± 13
-Education level (%)				
• No education	12	10	13	11
• Primary school	51	48	52	50
• Secondary school	22	25	24	24
• High school	15	17	11	15
-Pesticide use experience average (year)	9 ± 6	15± 9	12± 7	12± 8

Table 2 Farmer' knowledge and attitude regarding pesticide use

Statements	**Siem Reap**	**Kandal**	**Takeo**	**Total**
Insect pests are the main cause of yield loss(%)	**100**	**100**	**100**	**100**
Pesticide use is useful to increase income from production(%)	**100**	**100**	**100**	**100**
Pesticides can be harmful to human health(%)	**96**	**1**	**99**	**98**
Pesticides can be harmful to environment(%)	**92**	**98**	**94**	**95**
Sources of advice on pest management (%)				
Retailers	**84**	**70**	**78**	**77**
Neighbors, friends and relatives	**14**	**25**	**20**	**20**
Course	**1**	**5**	**2**	**3**

Table 3 Practices of pesticide usage

Statements		Siem Reap	Kandal	Takeo	Total
		(%)	(%)	(%)	(%)
Main control method					
Chemical pesticides		100	100	100	100
Biopesticides		10	2	5	6
When do you decide to spray?					
Due to pest appearance		89	75	84	83
On schedule		11	25	16	17
Application rates					
Respected		71	24	54	50
Above application rates		29	76	46	50
Mixture of active ingredients					
1		22	4.17	8.34	11
2		50	20	52.5	41

□ 3		16	42.5	27.5	29
□ 4		12	29.16	9.16	17
□ 5		0	4.17	2.5	2
Critical application intervals	(day)				
Cabbage, Chinese kale, tomato, yard long bean, and green mustard	(3-4)	32	54	40	42
	(5-6)	68	48	60	58
Cucumber and bitter gourd	(4-5)	42	68	60	56
	(6-7)	58	32	40	44
Eggplant and wax gourd	(7-8)	51	74	63	62
	(9-10)	49	26	37	38
Water spinach	-	-	-	-	-

Practices

Farmers used open farming system to produce their vegetables. All farmers depended on chemical pesticides in pest management control for their vegetable production while a minority of the farmers reported to have experience in using biopesticides prepared by themselves (Table 3). A majority of the farmers assessed pest appearance when decided to spray the chemicals. The proportion of the farmers was higher in Siem Reap, followed by Takeo and Kandal. 4 fungicides and 16 insecticides were found in use by the farmers in the study areas (Table 4) and listed according to their WHO hazard classification. A majority of the pesticides belonged to WHO class II (75%), followed by class I (10%), class III (5%) and class U (10%).

All pesticide containers were found with label instructions in Khmer language but there was a lack of important instructions such as application intervals, pre-harvest intervals, and safety measures. Most farmers in Kandal used greater application rates than the recommended rates while most farmers in Siem Reap and Takeo followed the recommended rates. Farmers mixed one to five active ingredients of the pesticides in one spraying of which a majority of the farmers in Siem Reap and Takeo used one to two active ingredients while most farmers in Kandal mixed three to 5 active ingredients. The results of application intervals showed that the interval between two applications varied with crops and locations. In general, the intervals were shorter in Kandal, followed by Takeo andSiem Reap.During harvesting, the farmers reported that they waited at least one day after pesticide spraying to harvest their vegetables while the adequate pre-harvest intervals were not applicable.

Most farmers had inadequate safe practices including PPE use, body cleaning after spraying, and empty pesticide container disposal (Table 5). The PPE use, body cleaning and the pesticide container disposal done by the farmers were better in Kandal, followed Takeo and Siem Reap, respectively. Most farmers used long pants and shirts, cotton mask and hat while less farmers wore goggle, rubber boot, raincoat and traditional scarf. Gloves were used by 42%, 65% and 46% of the farmers in Siem Reap, Kandal, and Takeo, respectively. A majority of the farmers cleaned their hands and faces immediately after spraying, while showers done when reached back home. Most farmers threw empty pesticide containers into agricultural fields such as lake, rivers, channels, and ponds.

Table 4 - Pesticides used by farmers

WHO hazard classification (2020)	Active ingredient	Main use
Ib	Abamectin, carbofuran	Insecticide

II	Difenoconazole, Metalaxyl	Fungicide
	Acetamiprid, Acephate, Chlorfenapyr, Chlorpyrifos, Cypermethrin, Deltamethrin, Emamectin benzoate, Fipronil, Imidacloprid, Lambda-cyhalothrin, Permethrin, Nitenpyram, Thiamethoxam.	Insecticide
III	Buprofezin	
U	Azoxystrobin, Carbendazim	Fungicide

Table 5 Safety practices

	Siem Reap	Kandal	Takeo	Total
PPE use (%)				
Gloves	42	65	46	51
Cotton mask	76	96	90	87
Goggle	12	26	15	18
Rubber boot	18	45	24	29
Long pants	94	100	100	98
Long shirt	96	100	100	98
Raincoat	14	24	17	18
Hat	92	100	96	96
scarf	32	45	40	39
Body cleaning after spraying (%)				
Washing hands and face immediately	100	100	100	100
Taking shower after back home	95	85	92	91
Taking shower immediately	5	15	8	9
Empty container disposal (%)				
Throwing in agricultural fields (lake, river, channel etc.)	93	71	85	83
Burying	5	14	9	9
Burning	2	15	6	8

Discussion

Cambodia is one of the developing countries in South East Asia. Vegetable production is a small and family scale with an average of farming areas less than 0.5 ha(Schreinemachers, et al., 2017, Pinnet al., 2020). In the study areas, the difference in the higher farming areas could be due to supplier levels of the vegetables to the Phnom Penh capital (Kanika & Moustier, 2004). Because of this, the farmers in Kandal have longer experience in vegetable production and subsequently pesticide use. Education is an important factor for reduction of health risks associated with pesticide exposure in Cambodia (Jensen et al., 2011). Most farmers with lower education levels in the study areas might be at higher risks when using pesticides, possibly because of being unable to comprehend the pesticide exposure and label instructions. General in Cambodia, men have more responsibilities in the family than women and do heavy and dangerous works. As can be seen in the results, main pesticide sprayers were men and a minority of the female farmers reported that they had experience in spraying when men were busy or unable to work. Pesticide retailers were the main source of the problem solving in the vegetable production by giving the farmers advice and selling them the pesticides. Due to longer experience, more farmers in Kandal could made themselves decision to buy the pesticides. Furthermore, a minority of the farmers received advice from their neighbors, friends and relatives of the farmers but these farmers made also the final decision with the pesticide retailers.

Only very few farmers were trained by the extension officers on pest management and pesticide use of which was very similar to a result previously reported by Schreinemachers, et al., (2017). This finding suggests that training on pest management and pesticide use is needed to enhance the farmers' knowledge. The chemical pesticides were found to be the main method of pest control for all the farmers which was similar reported by Schreinemachers, et al., (2017).This dependence may be due to knowledge lack of the pest management. As a result, the farmers needed to assess symptoms or pest appearance when decided to carry out the spraying. In spite of awareness of harmful health effects of the pesticides, farmers lacked knowledge of hazard levels, adequate safety and agricultural practices which might bring negative consequence in pesticide handling and application, and subsequently health risks. The vegetable production in open field of the Cambodian farmers may have some disadvantages about problems associated with pests and diseases of which greenhouse production system could be substituted in the nearest future (Qasimet al., 2021). The 20 pesticides found in the study were with permission for sales in the agrochemical markets of Cambodia according to National Profile on Chemical Management in Cambodia (MOE, 2004). Furthermore, the label instructions on the pesticide containers were in the native Khmer language, meaning that the pesticide risk management in the country has been improved by a new regulation of the use of the hazardous pesticides in comparison with the previous studies in which the author found Cambodian farmers used banned pesticides with Vietnamese and Thai languages in the labels (MAFF, 2012; Jensen et al., 2011; EJF, 2002). However, there was a need to provide more information about use restriction of class I insecticides, pre-harvest interval, application interval, and details of adequate PPE into the label instructions. As a result of these, application and pre-harvest intervals required for safe use were not applicable. Furthermore, pesticide sellers were the main source of the technical knowledge in pesticide use for the farmers across the country. The seller recommendation and effectiveness obtained were shared to the others which was similar reported by Flor team (Flor et al., 2020). This inadequate knowledge transfer might cause inappropriate safety and agricultural practices, and subsequently environmental health risks. Otherwise, the seller recommendation had intention of profit themselves in selling more products, particularly in Kandal. At harvest, the farmers were aware of the pre-harvest intervals of the pesticides but they did not know the correct values. Due to the awareness of pesticide hazards, farmers harvested the vegetables at least one day after the pesticide application during the harvest period. Having the inadequate pre-harvest intervals influences pesticide residue levels in the vegetables and health risks to the consumers (Angioniet al., 2011; Malhatet al., 2018). Furthermore, using higher application rates would increase values of the pre-harvest intervals and health risks, particularly in Kandal. This malpractice of pesticide use may have been the cause of high pesticide residue levels in foodstuffs (Wang et al., 2011), and food poisoning in Cambodia (ADB, 2021). Hence, the health risks to the consumers in Cambodia might vary with types of pesticides used, application rates, farm location, vegetable types, pest and disease appearance in the crop cycles. So, the vegetables produced in Kandal represented higher health risks, followed Takeo and Siem Reap, respectively. However, in water spinach production, there was no pesticide use among the farmers in the study areas. This finding is totally contrary to a study previously reported by Jensen team (Jensen et al., 2011), of which the author claimed that pesticide use played an important role in water spinach production. The difference might be due to crop systems for which they carried out the study in permanent crop of water spinach cultivated in the flooded land (lake), while our study was in the crop with one harvest of a cycle ranging 21 to 30 days. In the permanent crop system, there was possibly pest and disease establishment in the agro ecosystem; while in the crop with one cycle harvest there was possibly no enough time for pest and disease establishment.

PPE use is a risk prevention method of hazardous chemicals, especially pesticides in agriculture, protecting the users from pesticide exposure through skin and eye contact, and inhalation. Despite awareness of the harmful effects of the pesticides, farmers did not protect themselves adequately from pesticide exposure. All farmers wore inadequate personal protective equipment leading to pesticide exposure to them when they mixed and sprayed. This might be due to no legislative control which required pesticide users and sellers to be formally trained in safe work practices (Jensenet al., 2011). Assessment of PPE use showed that the use level of PPE varied among the farmers andregions. Higher PPE use level belonged to the farmers in Kandal, followed by Takeo and Siem Reap, respectively. This might be influenced by the work experience. Mostfarmers used a mask when mixing and spraying in study areas. From farm-level observation, it was noticed that the used masks were disposable and no manufactured for pesticide spraying and the level of protection of such masks is unknown. While face protective screen and impermeable helmets were not found in the use among the farmers, they wore simple hats and small proportion of them used cotton scarf as face and head protective equipment. A minority of the farmers used goggles in protection of their eyes. All farmers wore simple clothes such as long pants and shirt during pesticide operations.

Small proportion of the farmers wore raincoat and rubber boots when spraying, at the same time, they complained about thermic and physical discomforts, respectively. The reason for the low use level of personal protective equipment might be due to cost, availability, thermic and mechanical discomforts (Garrigouet al., 2020). In humid condition of work, breathing difficulty caused them to take off the masks or not to use. The impermeable PPE was not comfortable in the humid and hot climate like in Cambodia. Rubber boots were mentioned to have physical discomforts when walking, especially on the wet farms. Cambodia is not PPE producer; the cost might be very high for the small farmers as Cambodiansin relation to their income. Furthermore, the adequate PPE was not always available in the markets. The lack of PPE among the farmers was revealed by several studies previously reported in South East Countries (EJF, 2002; Jensen et al., 2011;Migheli, 2021;Panuwetet al., 2012; Snelderet al., 2008; Jambariet al., 2020; Joko et al., 2020;Peeterset al., 2015).

With regard to the other safety practices adapted during and after application operations, the study found that most farmers were with good behavior of protecting themselves according to farm-level observations and answers. Most of the pesticide applicators did not smoke, drink, or eat when mixing and spraying; and face washing was conducted immediately after spraying. The health risks faced by pesticide sprayers and vegetable consumers will be reduced by improving safety and agricultural practices through training and education to the farmers and pesticide sellers on safe operation, correct application and preventive measures; and strengthening regulation of use restriction of the extremely hazardous and persistent pesticidesfor achievement of good agriculture practices. The practical implication of these measures to decrease the associated risks might be a complex task. This requires the active participation of allstakeholders including non-governmental organizations, farmers, pesticide sellers, local regional agricultural departments and government. Furthermore, farmers should be trained to adopt useful alternative measures such ascultural, biological, and mechanical controls, and integrated pest management. (Flor et al., 2018; Vincent et al., 2001; Baker et al., 2020; Matsukawa et al., 2015).

Conclusion

Lack of knowledge of the Cambodian vegetable farmers on pest management results independence on the chemical pesticides. Inadequate safety and agricultural practices regarding pesticide use among the Cambodia farmers could cause severe risks to human health and the environment. The health risks to consumers vary with the pesticides used, application rates, pre-harvest intervals conducted, vegetable types and region. The vegetables produced in Kandal expose higher health risks to the consumers.

Acknowledgments

The work was funded by Cambodia Higher Education Improvement Project (Credit No. 6221). The authors would like to thank the great teams from the SGA03 project, Faculty of Agro-industry and Division of Research and Extension of the Royal University of Agriculture for their help in survey and data collection.

References

ADB (Asian Development Bank). (2008). Cambodia Sanitary and Phytosanitary Quality and Standards Report. Asian Development Bank, No. 7056-CAM.

ADB (Asian Development Bank). (2021). Cambodia agriculture, natural resources, and rural development, sector assessment, strategy, and road map. Manila, Philippines, 2021.

Aktar, M. W., Sengupta, D., & Chowdhury, A. (2009). Impact of pesticides use in agriculture: their benefits and hazards. Interdisciplinary Toxicology, 2(1): 1-12.

Angioni A., Debola F., Garau A., Sarai G., Cabras P., &Caboni P. Chlorpyrifos residues levels in fruits and vegetables after field treatment. Journal of Environmental Science and Health, Part B, 46(6), 544-9.

Baker, B. P., Green, T. A., &Loker, A. J. (2020). Biological control and integrated pest management in organic and conventional systems.Biological Control, 140,104095.

Damalas, C. A., &Eleftherohorinos, I. G. (2001). Pesticide exposure, safety issues, and risk assessment indicators.International Journal of Environmental Research and Public Health, 8(5): 1402-19.

Damalas, C. A. (2009). Understanding benefits and risks of pesticide use.Scientific Research and Essays, 4(10), 945- 949.

EJF (Environmental Justice Foundation). (2002). Death in Small Doses: Cambodia's Pesticides Problems and Solutions. Environmental Justice Foundation, London, UK.

FAO (Food and Agriculture Organization). (2010–2020) Statistics Division. Input—pesticides trade. https://www.fao.org/faostat/en/#data/RT. (December 15, 2022).

FAO (Food and Agriculture Organization). (2014). Cambodia country fact sheet on food and agriculture policy trends.

Flor, R. J., Chhay, K., Sorn, V., Maat, H., &Hadi, B. A. R. (2018). The technological trajectory of integrated pest management for rice in Cambodia. Sustainability, 10(6): 1732.

Flor, R. J., Maat, H., Hadi, B. A. R., Then, R., Krau, E., & Chhay, K. (2020). How do stakeholder interactions in Cambodian rice farming villages contribute to a pesticide lock-in? Crop Protection, 125, 10499.

Garrigou, A., Laurent, C., Berthet, A., Colosio, C., Jas, N., Daubas-Letoureux, V., Filho, J. M. J., Jouzel, J. N., Samuel, O., Baldi, I., Lebaily, P., Galey, L., Goutille, F., &Judon, N. (2020). Critical review of the role of PPE in the prevention of risks related to agricultural pesticide use. Safety Science, 123, 104527.

Hernández, A. F, Parrón, T., Tsatsakis, A. M, Requena, M., Alarcón, R., &López-Guarnido, O. (2013). Toxic effects of pesticide mixtures at a molecular level: their relevance to human health. Toxicology.

Jambari, N. S. A., Samad, N. I. A., Anua, S. M., Ruslan, R., &Hamzah, N. A. (2020). Knowledge, Attitude and Practice (KAP) on Pesticide Exposure Among Farmers in Kota Bharu, Kelantan. Malaysian Journal of Medicine and Health Sciences, 16(SUPP11), 56-62.

Jensen, H. K., Konradsen, F., Jørs, E., Petersen, J. H., &Dalsgaard, A. (2011). Pesticide Use and selt-reported symptoms of acute pesticide poisoning among aquatic farmers in phnompenh, Cambodia. Journal of Toxicology, 2011, 639814.

Joko, T., Dewanti, N.A.Y., &Dangiran, H. L. (2020). Pesticide Poisoning and the Use of Personal Protective Equipment (PPE) in Indonesian Farmers.Journal of Environmental and Public Health, 2020, 5379619.

MAFF (Ministry of Agriculture. Forestry, and Fisheries of Cambodia). (2012). Law on the management of pesticide and fertilizers. Phnom Penh, Cambodia.

Malhat, F., Kasiotis, K.M., &Shalaby, S. (2018). Magnitude of cyantraniliprole residues in tomato following open field application: pre-harvest interval determination and risk assessment.Environmental Monitoring and Assessment, 190(3):116.

Matsukawa, M., Ito, K., Kawakita, K., & Tanaka, T. (2016). Current status of pesticide uses among rice farmers in Cambodia. Applied Entomology and Zoology, 51, 571-579.

Matsukawa, M., Ito, K., Kawakita, K., & Tanaka, T. (2015). Farmer Perception and Management of rice plant hoppers in Cambodia.Japanese Agricultural Research Quarterly: JARQ, 49(2): 103-109.

Migheli, M. (2021). Income, wealth and use of personal protection equipment in the Mekong Delta.Environmental Science and Pollution Research, 28, 39920–39937.

MOE (Ministry of Environment). (2014). National Profile on Chemical Management in Cambodia. Phnom Penh,Cambodia.

NIS (National Institute of Statistics). (2015). Census of Agriculture of Cambodia 2013. Phnom Penh: NIS. www.nis.gov.kh/nis/CAC2013/CAC_2013_Final_Report_En .pdf.

Panuwet, P., Siriwong, W., Prapamontol, T., Ryan, P. B., Fiedler, N., Robson, M. G., & Barr, D. B. (2012). Agricultural pesticide management in Thailand: status and population health risk.Environmental Science & Policy, 17, 72-81.

Peeters, F. M., van Meggelen, J., &Schepers, H. T. A. M. (2015). Crop protection and pesticide risk assessment Myanmar: towards sustainable agricultural and export of high value crops. (Alterra-report; No. 2621). Alterra, Wageningen-UR. https: https://edepot.wur.nl/352659.

Pinn, T., Reach, S., Buntong, B., &Acedo, A. (2020). Vegetable Farming Practices in Cambodia: Case study of Smallscale Vegetable Farmers in Kandal, Kampong Chhnang and Battambang Provinces.International Journal of Environmental and Rural Development, 11(1): 57-62.

Schreinemachers P., Chen H., Nguyen, T. T. L., Buntong, B., Bouapao, L., Gautam, S., Le, N. T., Pinn, T., Vilaysone, P, & Srinivasan, P. (2017). Too Much to Handle? Pesticide Dependence of Smallholder Vegetable Farmers in Southeast Asia. Science of The Total Environment, 593–594, 470–77.

Skretteberg, L.G., Lyrån, B., Holen, B., Jansson, A., Fohgelberg, P., Siivinen, K., Andersen, J.H., Jensen, B.H. (2015). Pesticide residues in food of plant origin from Southeast Asia – a Nordic project. Food Control, 51, 225 – 235.

SNV (Netherlands Development Organization). [Online] Available: https://snv.org/project/cambodia-horticultureadvancing-income-and-nutrition-chain (December 12, 2022).

Thoeun, H. C. (2015). Observed and projected changes in temperatures and rainfall in Cambodia. Weather& Climate Extremes, 7, 61-71.

Snelder, D. J., Masipiqueña, M. D., &Snoo, G. R. (2008). Risk assessment of pesticide usages by smallholder farmers in the Cagayan Valley (Philippines). Crop Protection, 27, 747-762.

Vincent, C., Pannton, b., &Fleurat-Lessat, F. (2001). Physical control methods in plant protection. Springer, Germany. Wang, H., Sthiannopkao, S., Du, J., Chen, Z., Kim, K., Yasin, M. S. M., Hashim, J. S., Won, C. K., & Wong, M. (2011). Daily intake and human risk assessment of organochlorine pesticides (OCPs) based on Cambodian market basket data. Journal of Hazardous Materials, 192(3): 1441- 1449.

WHO (World Health Organization). (2020). Recommended classification of pesticides by hazard and guidelines to classification, 2019 edition, Geneva.

WHO (World Health Organization). (1990). World Health Organization and United Nations Environment Programme. Public health impact of pesticides used in agriculture. World Health Organization, 1990, Avenue Appia 20, Geneva, Switzerland.

WB (World Bank). (2015). Cambodian Agriculture in Transition: Opportunities and Risks. World Bank Group.

Qasim Q., Xia L., Lin S., Wan L., Zhao Y., Butterbach-Bahl K. (2021). Global greenhouse vegetable production systems are hotspot of soil N2O emission and nitrogen leaching: A meta-analysis. Environmental Pollution, 272(1), 116372.