The Reverse Logistics Management of Agrochemical Packaging as a Dangerous Goods for Sustainable Agriculture Ecosystem

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Abstract—**The rapid growth of Thailand's agricultural industry causes the use of agrochemicals, which are dangerous goods (DG), to increase rapidly through imports from abroad. Those agrochemicals are beneficial for increasing yields and destroying, insects, and weeds but the packaging is not environmentally friendly. However, if farmers use careless and lack effective management, it will directly affect their quality of life. From the aforementioned issues, the dangerous goods logistics management throughout the reverse supply chain, especially transport and storage activities are therefore important. This paper proposes qualitative research on agrochemical reverse logistics management focusing on packaging as dangerous goods for a sustainable agriculture ecosystem in Thailand to improve farmer and community quality of life. The results of this study demonstrated the extractive factor through a systematic review by meta-analysis to obtain the compositions of factors in sustainable reverse logistics of DG management that can apply in practice appropriate to the Thailand context.**

Keywords— *Reverse logistics, Agriculture chemical, Agrochemicals, Dangerous goods, Agrochemical Packaging*

I. INTRODUCTION

The use of pesticides in Thailand ranks 7th in the world at 4.11 kg/ha. Hazardous agrochemicals mostly associate with the chemicals used to prevent and eradicate diseases, insects as well as weeds to earn fruitful yields of productivity[1] Such usages lead to wastes from packages of the hazardous agrochemicals such as parcels and containers of those chemical substances, namely fertilizer sacks and gallon bottles of herbicides, pesticides and fungicides. Those packages may be sacks, plastic bags, gallon bottles and plastic buckets that resist chemical corrosion. In Thailand, the issue on managing the packages of hazardous agrochemicals has not been concretely addressed, leading to a problem causing an impact on the entire ecosystem and environment.

The survey on agricultural hazardous wastes in Thailand has found that the people being affected are not only farmers, but those accidentally exposed to such chemicals such as their children and families, recycling collectors as well as nearby inhabitants. The leach of chemicals into water resources, through water, rainwater or dew, also bringing an impact into ecosystem and environment [2] show in Fig. 1

Fig. 1. *Improper disposal of agrochemical packaging*

While production and imports of agrochemicals are rising presently, the lack of appropriate management and control mechanisms in transportation, production and containment results in leakage, residues and spreads of the substances in the environment and , eventually, contamination in the ecosystem affecting health and livings of people[2]. The Department of Agriculture, The Office of Agricultural Economics states that during 2008 - 2018, Thailand had steadily increased the imports of pesticides, herbicides, insecticides and plant protection and control agents every year in both quantity and value.

From the behavioral view, Thai farmers also prefer to use pesticides in farming due to its ease of purchase and positive outcomes while they do not consider the effects on their health and consumers. The National Statistical Office reports that more than 50% of informal workers working in agricultural sector got ill by pesticide poisoning in 2017 at a rate of 16.81 cases per 100,000 population, increasing 1,117 cases compared to the figures in 2016 (14.47 of morbidity rate per 100,000 population). In addition, 502 cases of unintentional exposure by paraquat herbicide was found during 2013 – 2017 and the number was increasing, with the majority of patients was in the group aged 15-59 years with earning their lives by cultivation[3]. The National Health Security Office (NHSO) also reveals that, from the database of patients applied into the 'National Health Security' from hospitals nationwide, 3,067 patients received a treatment due to pesticide exposures and 407 deaths in August 2019.

The results from the survey on household chemical usage in January 2020, also has found that 70% of the survey population, 570,053 households, has a record of chemical usage while 85.29% of the sample were found to continually using agricultural chemicals, whose family members were often found to have symptoms such as numbness of hands and feet at 66.44%, dermatitis at 17.35%, tremors at 11.17%, kidney failure at 2.34%, necrotizing fasciitis at 1.28%, mental retardation at 0.78%, lymphoma at 0.40% and leukemia at 0.24%. [3].

In accordance to what was stated, this article aims to provide an understanding of the revers logistics management of agrochemical packaging as a dangerous goods for managing (RLAD) the recovery of empty agrochemical packaging more specifically, it describes and analyzes RLM's packaging, identifying the responsibilities of actors in the supply chain; the process of returning; recycling feasibility and market for recycled products. For a reverse logistics protection standard for DG was produced by this study. The quality of life in the community was consistent.

II. LITERATURE REVIEW

A. Problems in Transportation of Dangerous Goods

Problems in Transportation of Dangerous Goods (TDG) such as accidents from leakages during transportation cannot be predicted. To address the problem, the transportation of dangerous goods was optimized by using European Agreement concerning International Carriage of Dangerous Goods by Road (ADR) vehicle tracking [4]. As most carriers do not understand the TDG practices, there should be a law regulating the movement of this type of merchandises. TDG is an activity that can be considered as high-risk, not only the environment that will be affected, the life of a driver is also at high risk. Therefore, it should be stressed as well. Another important aspect to consider is the storage of hazardous goods in warehouses that the procedure should be certified with ISO 9 0 0 1 Quality Management Standard and ISO 1 4 0 0 1 Environmental Management Standard. In Thailand, agrochemicals are considered as one of hazardous substances highly imported each year, leading to the concerns on post-use of agrochemical packages, such as pesticide containers, which are considered to be hazardous to health and the environment when inappropriately disposed [5] . A review of the relevant literatures found that communication in freight forwarding of agricultural hazardous materials is lack of proper guidance from manufacturers or distributors. Knowledge of agrochemical life cycle and procedures on storing, cleaning, freight forwarding together with proper disposing should be shared with farmers to enhance awareness, reduce the uses of hazardous agrochemical and identify the consequences that damages people's health and the environment. The government should launch projects or establish agrochemical waste disposal stations to remove contaminants and provide proper handling for recycling or reuse. In case of the non-reusable substances, efficient elimination process should be resorted. In additional, the government should enact strict laws or regulations restricting the amount of imported dangerous substances as well.

B. Reverse Logistics of Dangerous Goods

Insufficient advice on proper handling illustrates inadequate product and packaging management[6] Hence, pre-distribution information and advice from manufacturers should be conveyed to the final agents and consumers. Promotion of knowledge and awareness on environment among farmers along the whole agricultural supply chain reflects the practices of reverse logistics of packaging[7] Information on classification and types of chemicals in a warehouse, including an emergency plan that employees must be trained on how to store dangerous goods and hazardous substances and how to deal with emergencies, is reported to related departments[8]

The Implementation of a System for Safe Transport and Handling of Dangerous Goods, mentions an interesting case study for reverse management of goods in the New York City, its waste management system. The system is a cooperation from both the public and private sectors, giving the opportunity to bring all empty beverage containers to certain retail stores or centers to redeem rewards [9] buy-back conditions are also set for used packaging from customers by the representative of companies. The customers will get a good price if the packaging is 9 0 percent reusable and used only once. If the packaging is not in a reusable condition, it will be bought as a scrap at another price. In the other hand, if the packaging is plastic, it must be washed at least three times. The buy-back campaigns are organized be 3 times in 1 year.

Upon acknowledgement of all conditions, sub-agents directly buy the packages from farmers and send back to the distribution center to collect and forward to the screening center for rechecking. The last action is to ensure that those packages can be sent to factories of manufacturer for repackaging and passing to farmers with new products again. The non-reusable portion will be eliminated [1].

From the literature reviews in relation to reverse logistics, most of the studies were conducted on inbound dangerous goods transportation, focusing on the transportation of dangerous goods from upstream to downstream. However, there has not been a study on hazardous waste from a proper use of final agricultural hazardous goods, this research therefore presents a conceptual framework for appropriate return of hazardous packages to the upstream, manufacturing plants, to alleviate the problem of chemical leakages on environment from hazardous wastes in the future. The framework is summarized as shown in Fig 2.

Fig. 2. The reverse logistics of dangerous goods packaging

III. Methods

A systematic literature review focuses on collecting primary studies to answer specific questions. The result is derived through systematic processes, which can be divided into 4 steps: problem formulation, data collection, research synthesis and result.

Step 1 Problem formulation; in this step, the problem is defined to clearly and appropriately scope the work. Good questions will lead to findings of the right answers. Operation problem formulation is a necessary starting point for a systematic review with the details of problem such as characteristics of the questions/problems, compositions of the questions and the users of the review's results, are as follows;

TABLE I. Keywords and Search String

Construct	Search String	Database
Reverse Logistics Management	ABS("Reverse Logistics") OR ABS("Reverse Logistics Supply Chain") OR ABS("Dangerous Goods Reverse Logistics") OR ABS("Agrochemical packaging Reverse Logistics) OR ABS("Sustainable Reverse Logistics")	Research Gate Journal Google Site Elsevier

Note Abs: Abstract

Upon the review, the researchers have found that only 26 of relevant literatures are left. With those resources, the researchers synthesize a trend, based on frequencies and groupings to summarize the contents of the closely related issues into each dataset under the Sustainable Assessment Framework. The data set of the Management of Packaging Dangerous Goods in Reverse Logistics can be summarized as shown in Table 2.

TABLE II. Approaches on Management of Packaging Dangerous Goods in Reverse Logistics

Sustainable	Authors
Social	[10], [18], [23], [28], [33], [34]
Economic	[26], [27], [29], [30], [32], [34]
Environment	[11], [18], [21], [22], [26], [28], [30], [31]
Reverse logistics irrelevant to sustainability	[12], [13], [14], [15], [16], [17], [19], [20], [22], [24], [25], [35]

Step 2 Data collection; this paper compiles the most relevant literatures on Packaging Dangerous Goods in Reverse Logistics in a systematic review to provide a sustainable perspective on the managing the used packages of dangerous goods. Most of literature reviews cover the concept of reverse logistics. The below analysis shows that reverse logistics reduces the impacts and alleviates problems on environment and health caused by the use of hazardous chemicals as shown in Table 3.

TABLE III. Literature Review Matrix

Author	Sustainable Item	Objective Detail	Ref
E. Garbolino and D. Lachtar , 2012	Social	proposes methods and tools to assist policymakers and private actors in assessing vulnerability of regulated areas with particular emphasis on toxin emissions and explosions	[10]
M. S. Akdoğan and A. Coşkun, 2012		logistics and its drivers. The drivers of reverse logistics from a manufacturer's perspective were analyzed in the Turkish home appliance industry.	
M. Hosseini et al, 2013	-	This paper summarizes and presents useful reasons beneficial to future RL research studies.	[12]
A. Ayyat et al, 2014	-	Develops a decision supporting system to assist company executives in selecting and evaluating various 3PRL service providers by using an the (AHP) and (TOPSIS).	[13]
M. Hosseini et al, 2014	-	Focuses on comparing the body of construction knowledge by taking specified central characteristic(s) of RL into account with those of the manufacturing industry.	[14]
R. F. Dos Santos and F. A. S. Marins, 2015	-	proposes information and communication technology (ICT) to help integrate the supply chain of electronic products and components in every step.	[15]
A. H. Vahidzadeh and R. B. M. Yousif, 2015	-	Comprehensive review to various publications regarding the concept of Reverse Logistics (RL) and related fields during 1998-2012 The findings present mathematical models by using the (MAIPM	[16]
S. Agrawal, R. K. Singh, and Q. Murtaza, 2016	-	develops a framework for deciding outsources in reverse logistics by using a graph theory	[17]
M. F. Melki and R. Scapin, 2016	Social Environment	Analyses and demonstrates how reverse logistics reduces the impacts and potential problems on environmental and health caused by improper disposal of pesticides in container service providers and groups of farmers	[18]
K. P. Yuet al, 2017	-	Identifies the causes linked to internal reverse logistics of hospital materials and medicines, also optimize the processes carried out by the department in charge	[19]
J. A. B. Souza, I. P. de Souza Xavier, and S. C. Vieira, 2017	-	Points out the importance of a professional agronomist in the process of informal environmental studies on the compliance with practices for returning empty containers of pesticides.	[20]
E. Fortunati, A. Mazzoglio, and G. M. Balestra ,2018	Environment	provide evidences on forming agrochemicals as well as nanomaterials to sustainably protect crops and food for the management in agriculture and packaging sector.	[21]
E. Lindström and V. Ottosson, 2018	-	Explores reverse logistics of dangerous goods packages on road transport The results are presented in types of	[22]

Autor	Sustainable Item	Objective Detail	Ref
		dangerous goods freight forwarding by road transport.	
D. Yanaglihara and C. Bogiagualo, 2018	Social Environment	conducted to analyzed costs and benefits from social and environmental views on the collection and control process of agricultural pesticide in Brazil. found that the process is still not feasible from an economic point of view.	[23]
M. Wagas et al, 2018	-	Identifies and examines barriers on the operations in reverse logistics using a two-step approach: Delphi method and structural equation modelling.	[24]
I. França, L. SÁ, and P. Dalpian, 2018	-	To study reverse logistics systems of empty pesticide containers from the experiences of units receiving packages that link to InpEV.	[25]
L. A. R. de Campos et al, 2019	Economic Environment	Investigates the impact of collaboration and IT capabilities on the development of reverse logistics capacity and studies efficiency of related strategies and their consequences in terms of economy and environment.	[26]
G. d. L. D. Chaves et al, 2020	Economic	determines evaluating measures for the performance of reverse logistics in Brazilian companies verifies whether a correlation exists between dimensions in performance measurements (cost, asset management, customer service, and productivity) and company sizes (micro, small, medium, and large)	[27]
S. M. Bonifaz and M. Cevallos	Social Environment	analyses the reverse logistics of pesticides packaging in Amphitea' AL with 8 pesticide dealers, 31 family farmers and technicians responsible for AGROAAL, AGROAL as well as State Public Ministry, through interviews, using semi-structured questionnaires.	[28]
S. M. R. D. Barcelos et al., 2021	Economic	Analyses the reverse logistics process of pesticide packaging through case studies in agro-industrial cooperatives.	[29]
H. Falkenrei, -t al, 2021	Economic Environment	presents streamlining reverse logistics with challenges in trends on increasing costs of packaging and the needs to meet sustainable development goals	[30]
P. D. S. RODRIGUES S.	Environment	support and explain how to properly dispose empty packages while protecting plants. As most environmental impacts are caused by farmers, reverse logistics helps solve the problems.	[31]
S. Allaga, L. Prodonos, and C. Contreras-	Economic	optimized collection process for household recyclable materials. The solution is characterized and designed	[32]

Autor	Sustainable Item	Objective Detail	Ref
Dekker		for cities with a low recycling level. The results suggest that the model is a practical tool for decision makers in making tactical and operational decisions to reduce recycling costs.	
P. Kashwaha, 2020	Social	suggests a model to taking hygiene into consideration in reverse logistics for online retailers in the post lockdown era.	[33]
P. C. P. W. Rebelly, 2019	Social Economic	Analyses the role of laws and public authorities, taking into account the relationship between globalization and environmental awareness on the wastes that recently arises.	[34]
K. Braga Macedo et al, 2021	-	the descriptive analysis of the reverse logistics (RL) of empty pesticide containers (EPCs), practiced under the Campo Limpo system in Brazil, to identify the factors enabling its success. the proposal of strategies to improve the collecting system with the combination of Technical visits and an approach on system dynamics, using the Behaviour Over Time graph and a causal loop model to describe the problem and propose strategies	[35]

Step 3 Data syntheses: The researcher has synthesized with the content analysis and the cumulative summarization technique under the reverse logistics management of DG in the sustainability principle that applies to the Thailand context. Finally, **step 4** will present the quality research result from the systematic review by describing the activity and the results of reverse logistics of DG of stakeholders (farmer, retailer, and manufacturing/DC) who will be operated. The results will present a strategy for managing transportation and operating costs in the reverse DG supply chain.

IV. Result

From the study of reverse logistics processes throughout the agricultural packaging supply chain, this article will focus on farmers who have a significant impact on both costs of production and quality of life, local retail stores, factories, or warehouses show the flow of finished goods and packages as shown in Fig 3. The activity and the results of reverse logistics of DG of stakeholders who will be operated the details summarize in Table 4.

Fig. 3. The Reverse Logistics Activity of DG in This Study

TABLE IV. STAKEHOLDERS ACTIVITY AND THE RESULTS IN REVERSE LOGISTICS OF DG (PACKAGING)

RDGL must be able to create benefits for all related sectors with minimum impact on the environment. Because the removal of chemical packaging is a complicated process, the problem must be solved through integration throughout the supply chain, from licensing, transportation, inspection, transportation, to storage, with its own differences. It is necessary to prepare a manual consisting of the followings.

1) User's responsibility, including requirements on cleaning and forwarding prior to the return to the nearest receiving unit as designated by the sellers. The users are required to present a valid purchase receipt, issued less than one year prior to the date of return, from the company.

2) Distributor's responsibility, including requirements on providing a location and a procedure for returning and organizing a training on cleaning a package. Also, the distributors are requested to be liable on storage and transportation, setting conditions and measures for the return of packaging.

According to the results of the study, RDGL currently focuses on requesting for cooperation in compliance only, without explicit measures or indications showing the importance of packaging, including the consideration on sustainability of RDGL in 3 dimensions. Although many researchers have attempted to integrate the principles of sustainability, majorities tend to focus on only specific aspects of society and environment. The study is consistent with the findings in that the RDGL issue has not yet been integrated into the economic sustainability dimension. This study aims to fill the academic gap by introducing RDGL in integration with all three dimensions of sustainability, from social, environmental and economic aspects, as established in Table 5 and Fig 4.

TABLE V. DIMENSIONS, FACTORS AND INDICATORS OF PACKAGING REVERSE LOGISTICS

Dimensions	Factors	Indicators
Economic	Cost reduction in purchasing new packages	Proportion of reduction in the cost needed to purchase a new package (%)
	Reduction in empty backhaul	Number of backhauls (%)
	Brand loyalty	Percentage of repeated customers (%)
Environment	Reduction in the amount of waste	Proportion of reduction in total waste (%)
	Reuse Policy	Proportion of bought-back packages for reuses (%)
Social	Social Health	Number of deaths by transportation accidents under a certain brand (persons)
	Quality of Life	Number of people affected by products of a certain brand (persons)
	Distribution of income to the community from the returns of wastes	Value of packaging redemption (Baht)

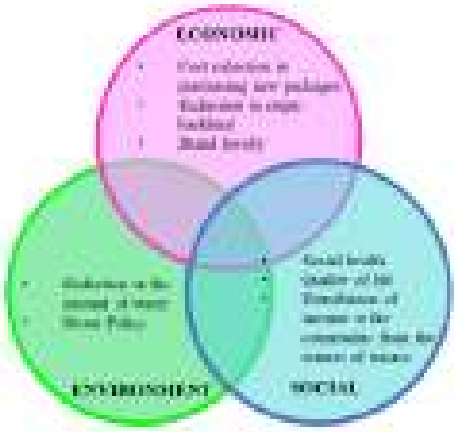

Fig. 4 Dimensions, Factors and Indicators of Packaging Reverse Logistics

V. CONCLUSION

The study 'The Reverse Logistics Management of Agrochemical Packaging as a Dangerous Good for Sustainable Agriculture Ecosystem', this paper proposes qualitative research on the management of reverse logistics for agrochemical as dangerous goods. The paper focuses on packaging for sustainable agriculture ecosystem in Thailand to improve the well-being of farmers and better quality of life for communities. According to literature reviews, strategies in reverse logistics are often implemented by requesting cooperation in the return of packages. Still, those actions encounter challenges due to a lack of motivation for stakeholders. The research therefore proposes a strategy, from the three-dimensions of sustainability, for the reverse

logistics of hazardous packaging, presents a strategy utilizing backhauls by repurchasing the packaging from customers by the manufacturer, in the same time, providing an incentive for the next purchase. The strategy yields satisfactory result that the company can reduce packaging cost from the reuse and lessen wastes that affect the environment. It also raises community incomes from the sale of packaging. In terms of transportation, the number of trips are reduced by carrying finished goods to the destination and returning the company the used packages for further recycling.

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