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Reverse logistics readiness assessment using the REVLI model and Delphi method: A case study in the bottled water industry

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Abstract

Plastic waste in Indonesia needs serious attention. One of the industries contributing to the plastic waste is the packaged water industry, such as PT. Tirta Investama Danone Aqua. This study aims to determine the level of readiness for implementing reverse logistics in one of the product variants, AQUA 240 ml, and provide recommendations that will be implemented at PT. Tirta Investama. There are three main variables in this study: variable enablers, variable inhibitors, and result variables. These variables will be interdependent and form a causal relationship. This relationship will analyze the problem that can identify the value of the Reverse Logistics Index (REVLI) in achieving a value of 1,000. The simulation results indicate that AQUA falls into the complacent category, achieving a REVLI value of 1,000 within 1.5 years. The research provides policy recommendations to enhance the application of reverse logistics, which are evaluated by experts using the Delphi Method. The recommended approach is the use of recycle packs that focus on increasing variable enablers and reducing variable inhibitors.

Keywords: Engineering; Reverse Logistics; Reverse Logistics Index (REVLI); Delphi Method; Sustainability

1. Introduction

Indonesia is one of the countries with the largest plastic bottle users in the world. According to the United Nations, as reported in The Jakarta Post [1], Indonesia produces approximately 3.2 million tons of unmanaged plastic waste, with over a third of it ending up in the ocean. The World Economic Forum [2] reported that 70% of plastic waste in Indonesia is mismanaged in various ways, including 48% being openly burned, 13% being dumped on land or in poorly managed official landfills, and 9% leaking into waterways and the ocean. Moreover, plastic pollution is estimated to increase by one-third in 2025 and more than double by 2040, even if the rates of plastic waste collection and generation remain constant.

According to Presidential Regulation (Perpres) Number 97 of 2017 concerning the National Policy and Strategy for the Management of Household Waste and Waste Similar to Household Waste [3], the target for reducing household waste and similar waste is 20.9 million tons, or 30%, by 2025. The regulation also explains that one aspect affecting regional government regulations on integrated waste management is the manufacturing industry, including the AMDK industry. In addition to the regulation meant to follow up on the national policy of waste development, which aims to reduce the volume of plastic waste through the 3R program (reduce, reuse, recycle) and Extended Producer Responsibility (EPR), there is a need for awareness and commitment from all stakeholders as producers of plastic waste to achieve an environmentally friendly and sustainable plastic waste management system [4, 5].

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PT Tirta Investama is one of the industries that has a significant influence on the Environmental Pollution and Damage Control Policy. This company is engaged in the production of packaged drinking water with the brand AQUA. The packaged drinking water has also been regulated by Regulation of the Minister of Industry Number 62 of 2024 concerning the Mandatory Implementation of Indonesian National Standards for Bottled Drinking Water [6]. Therefore, the company must ensure that its product quality meets the relevant regulatory standards. Compared to four other major brands in the packaged drinking water sector, AQUA achieved the highest brand comparison index, with a value of 46.9% in 2024 [7]. Aqua mineral water products are available in various packaging options, including SPS 240 ml, SPS 330 ml, SPS 600 ml, SPS 750 ml, SPS 1,500 ml, gallons, and bottles (glass). Currently, AQUA has 14 factories spread across Java and Sumatra, one of which is PT Tirta Investama Danone AQUA Wonosobo. This factory produces two products: 19-liter bottle products (referred to as 5-gallon or HOD products) and SPS 240 ml products (referred to as cup or glass products).

PT. Tirta Investama (AQUA) Wonosobo, as the largest bottled drinking water company in Indonesia, is the largest producer of packaged drinking water glass products and has also contributed to the current environmental problems. AQUA is a significant contributor to environmental issues, primarily due to its production process and the packaging itself, which is made of polyethylene terephthalate (PET) and polypropylene (PP). AQUA packaging also contributes to the problem of plastic waste in the environment because it has a short lifespan, typically one use, and is difficult to decompose naturally, as it takes approximately 20 years to decompose one packaged drinking water glass [8]. The high sales figures for AQUA glass, reaching 82,231,143 glasses per year, have led to an accumulation of packaging waste in this environment, given the lack of public awareness regarding plastic waste and the unclear process for collecting and recycling packaged drinking water glass packaging.

Based on the results of interviews with the logistics sub-sustainability section, the 240 ml AQUA glass product is considered to have a significant contribution to polluting the surrounding environment, so an evaluation of system improvements is needed. AQUA has implemented a product return process for 5-gallon packaging and has proven that it does not cause packaging waste. Therefore, AQUA also wants to implement a return process for 240 ml packaging products. The Reverse Logistics concept can help with this problem. The reverse logistics process, which emphasizes the idea of resource reduction and includes various product recovery options, is crucial in environmental management today. The application of reverse logistics in a company can make the company more environmentally friendly by recycling, reusing, and reducing the use of materials that have been used. This can also improve the company's image through the 3R process that the company employs.

The above conditions indicate the need for handling in the application of reverse logistics at PT. Tirta Investama Danone AQUA is a company with the potential to implement reverse logistics activities. This problem is a focus for all parties, especially those involved in its supply chain network. Shankar [9] stated that in the implementation of reverse logistics, there are three main variables: enablers, inhibitors, and results. Enabler variables are those that help increase REVLI (Reverse Logistic Index). Results variables show the outcomes of reverse logistics that can enhance REVLI, while inhibitors are variables that mitigate the effects of enablers or reduce REVLI. These criteria are interdependent and have dynamic interactions. According to Shankar [9], REVLI aims to determine the level of readiness for implementing reverse logistics within a company. The REVLI that is made can be improved by improving enabler variables or reducing inhibitor variables.

Dynamic system models can be used to present, analyze, and explain complex dynamic systems by detailing the observed system. Dynamic modeling can also help decision-making. According to Shankar [9], the dynamic system model is used to predict behavior. In this study, a dynamic system is used to identify the REVLI value, which is considered ready for implementation with RL when the REVLI value reaches 1,000. PT. Tirta Investama Danone Aqua already has a plan to implement RL, but does not yet have a measure of the readiness value for implementing the system. Therefore, REVLI calculations are needed to see the readiness of PT. Tirta Investama Danone Aqua. This REVLI value is a consideration in developing policy proposals that can enhance the implementation of reverse logistics activities at PT. Tirta Investama Danone Aqua.

2. Material and methods

2.1. Data Collection

The data obtained comprises both primary and secondary data. For primary data, it is obtained through direct interviews with parties who can provide researchers with direct information. For secondary data, it is obtained based on the results of research publications that can serve as sources of literature. The secondary data needed are customer data, product competition data, raw material purchase data, sales data, sales profit data, production data, economic cost calculation data, and material lab test data. A questionnaire is necessary to implement the Delphi method. The questionnaire is distributed in accordance with the Triple Helix principle, which encompasses companies, academics, and government.

2.2. Data Processing

This research begins with a preliminary study and a literature review, followed by the construction of the research design. This research is a type of causal predictive study employing a quantitative approach, with model development utilizing system dynamics. In determining the proposed policy strategy, quantitative techniques are used, specifically the Delphi method, by distributing questionnaires to companies, academics, and governments that have expertise in implementing reverse logistics processes within their organizations.

The results of interviews with managers in the company will be processed using a dynamic system, where the outcome of the processing will determine the condition of the company's base model. The selection of proposed policy strategies will be carried out using the Delphi method.

3. Results and discussion

3.1. Causal Loop Diagram

In the causal loop diagram described, several feedback loops interact between enablers, results, inhibitors, and REVLI, resulting in either positive or negative outcomes. The causal loop diagram of the implementation of RL activities at AQUA is shown in Figure 1.

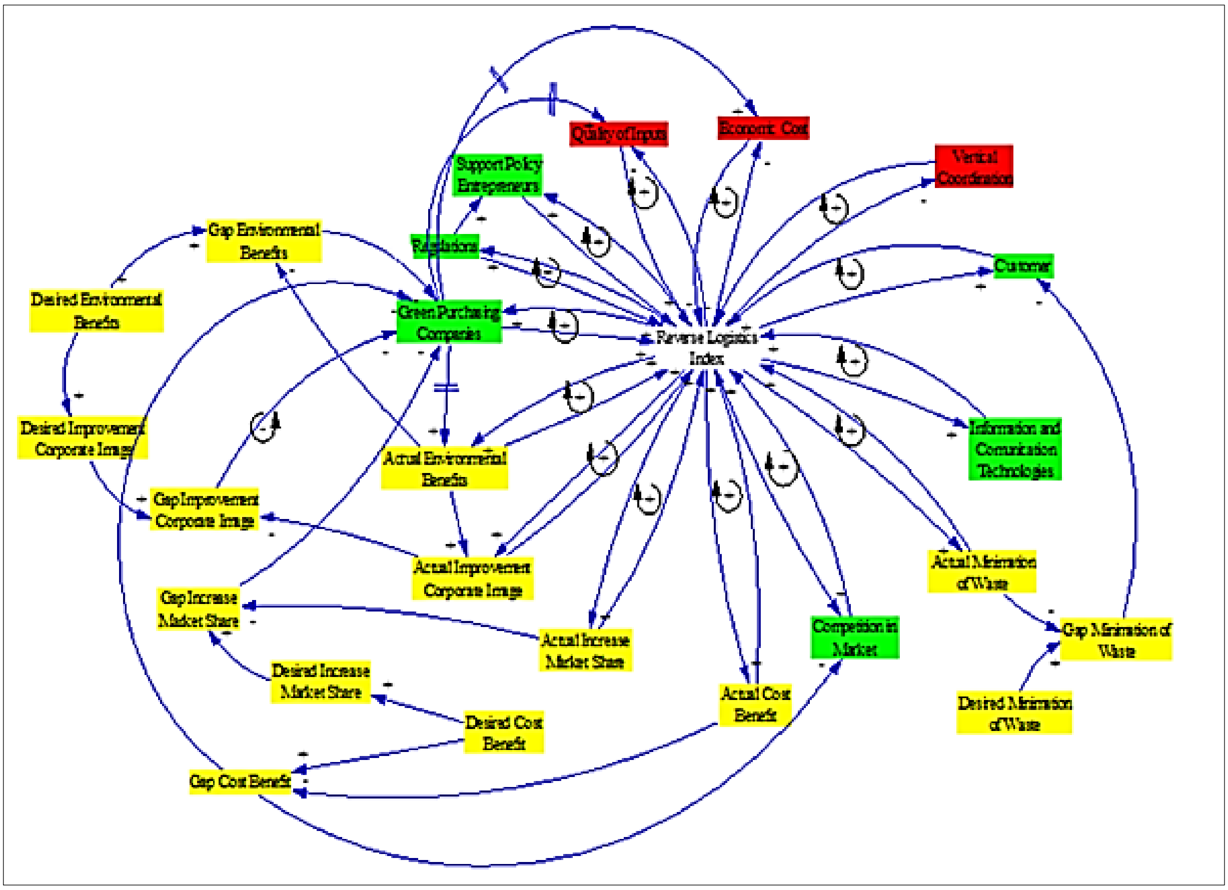

Figure 1 Causal Loop Diagram at AQUA

3.2. Stock Flow Diagram

A stock flow diagram is formed where the value of this model is obtained from the Focus Group Discussion by the Logistics and Production Manager of PT. Tirta Investama Danone Aqua. The value entered in the model is the initial level (initial state) of PT. Tirta Investama Danone Aqua. The initial value functions as a depiction of the real system of PT. Tirta Investama Danone Aqua. The composition of the assessment determination is as follows (9): not implemented (0-20), planning stage (21-40), low implementation (41-60), medium implementation (61-80), and high implementation (81-100).

3.2.1. Enablers and Results Subsystem

The Stock Flow Diagram of enablers and results subsystem is shown in Figure 2. Meanwhile, the outputs for the enablers and results subsystems are shown in Table 1 and Table 2, respectively.

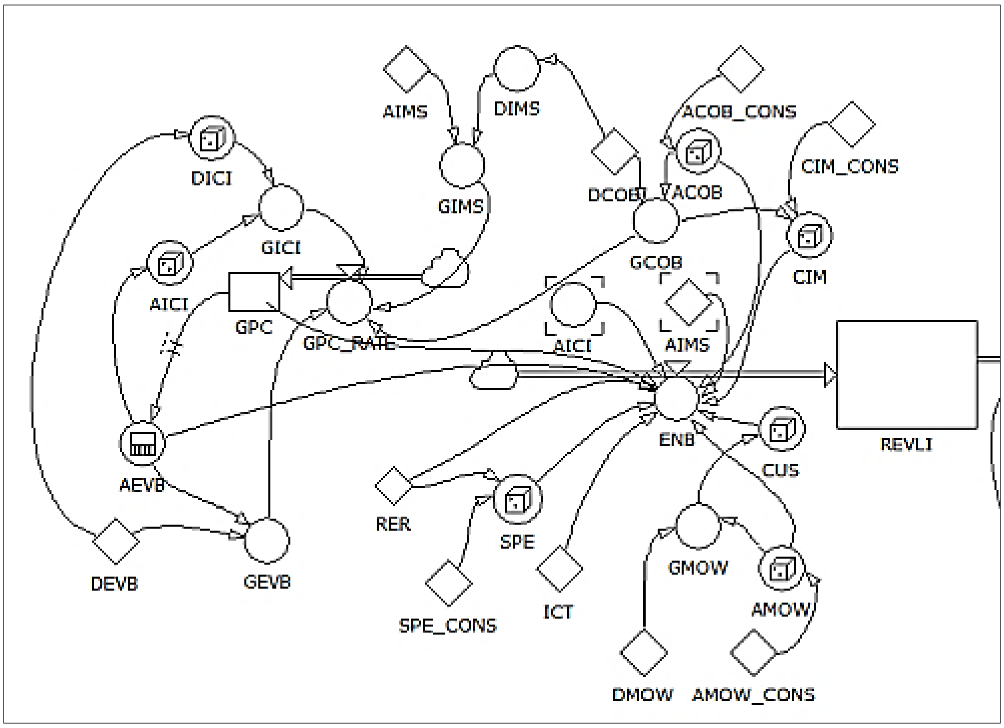

Figure 2 Stock Flow Diagram of Enablers and Results Subsystems

Table 1 Enabler Subsystem Output

Year	CIM	CUS	GPC	ICT	RER	SPE
0.0	91.81	81.17	85.00	85.00	100.00	83.75
0.5	91.93	81.72	85.38	85.00	100.00	84.05
1.0	92.06	82.28	85.76	85.00	100.00	84.36
1.5	92.50	84.20	86.13	85.00	100.00	84.05
2.0	92.94	86.11	86.51	85.00	100.00	83.74
2.5	92.00	86.35	86.88	85.00	100.00	84.27
3.0	91.05	86.59	87.25	85.00	100.00	84.80

Table 2 Result Subsystem Output

Year	ACOB	AEVB	AICI	AIMS	AMOW
0.0	66.90	70.00	60.02	60.00	59.18
0.5	66.82	70.00	59.59	60.00	59.47
1.0	66.75	70.00	59.17	60.00	59.76
1.5	67.23	70.11	59.18	60.00	59.59
2.0	67.71	70.23	59.20	60.00	59.43
2.5	68.21	70.41	59.53	60.00	59.19
3.0	68.71	70.60	59.87	60.00	58.95

3.2.2. Inhibitors Subsystem

The Stock Flow Diagram of the inhibitor subsystem is shown in Figure 3. Meanwhile, the output for the inhibitors subsystem is shown in Table 3.

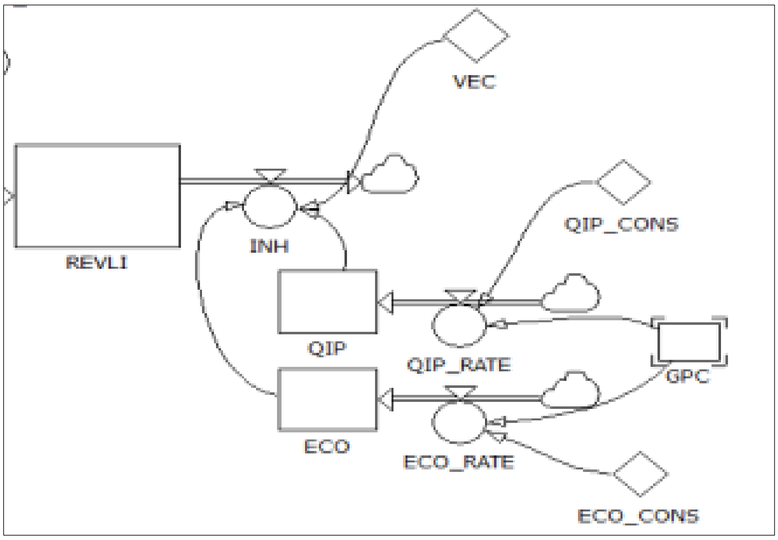

Figure 3 Stock flow diagram of Inhibitor subsystems

Table 3 Inhibitor Subsystem Output

Year	VEC	QIP	ECO
0.0	91.81	81.17	85.00
0.5	91.93	81.72	85.38
1.0	92.06	82.28	85.76
1.5	92.50	84.20	86.13
2.0	92.94	86.11	86.51
2.5	92.00	86.35	86.88
3.0	91.05	86.59	87.25

3.3. Validation

Subsystem validation involves verifying the model structure and validating the output. Based on the validity of the model structure, the construction of the subsystem computer program can be simulated and produces output values. Furthermore, the validation of the model output is done by conducting an interview session with the AQUA logistics manager and environmental management manager to assess the current conditions on a scale of 1-100. All variables will be discussed with the logistics manager. The initial level column represents the current state of AQUA. The desired level column represents the state the company wishes for a variable. At the same time, the average score column is a state that must be met to support the desired level, as perceived by the manager. The results column (based on standard deviation) represents the outcome of the model simulation conducted over 1 year.

Table 4 presents the validation results comparing the managers' assessments with the dynamic system simulation for 12 months. Based on the % deviation value, the % dev value is -4 <% dev value <4. This value indicates that there is no significant difference between the two groups of data, namely, actual and simulated data, and can therefore be considered valid.

Table 4 Validation Result

Variables	**Score of Variables in the 12 Month**				
	Initial Levels	**Desired Levels**	**Average Score (Manager Opinions)**	**Results (based on SD)**	**% Deviation from SD Prediction**
Enablers					
Green Purchasing by Companies (GPC)	85.00	90.00	87.50	85.76	2.03
Regulations (RER)	100.00	100.00	100.00	100.00	0.00
Competition in the Market (CIM)	90.00	90.00	90.00	92.06	-2.24
Support of Policy Entrepreneurs (SPE)	80.00	85.00	82.50	84.36	-2.20
Customers (CUS)	80.00	80.00	80.00	82.28	-2.77
Information and Communication Technologies (ICT)	85.00	90.00	87.50	85.00	2.94
Results					
Minimize of Waste (MOW)	55.00	65.00	60.00	59.76	0.40
Environmental Benefits (EVB)	65.00	80.00	72.50	70.00	3.57
Improvement of Corporate Image (ICI)	50.00	65.00	57.50	59.17	-2.82
Cost of Benefits (COB)	60.00	70.00	65.00	66.75	-2.62
Increase of Market Share (IMS)	60.00	60.00	60.00	60.00	0.00
Inhibitors					
Quality of Inputs (QIP)	10.00	15.00	12.50	17.00	-4.00
Economics Costs (ECO)	15.00	15.00	15.00	19.00	-4.00
Vertical Coordination (VEC)	0.00	0.00	0.00	0.00	0.00

3.4. Reverse Logistics Mapping

The implementation of reverse logistics poses a significant challenge for management due to the uncertainty surrounding the quality, quantity, and timing of product returns [10, 11]. The subsystems in this model, namely, the inhibitor subsystem as an inhibitor, must be effectively balanced by the enablers subsystem as a supporter of the implementation of reverse logistics. Thus, in this study, four categories of policies are compiled, namely the struggler category, the complacent category, the disillusioned category, and the star category. The growth of the enablers and inhibitors subsystems that affect the achievement of REVLI in reaching a value of 1,000 is categorized into four groups based on time. The growth rate in reverse logistics mapping for the enablers and inhibitor subsystems follows a study by Shankar [12].

3.5. Delphi Method

The Delphi method was employed to determine whether decision-makers truly understand production activities at PT Tirta Investama Danone Aqua and the environmental impact on society. Three experts in this study would be decision makers. Therefore, this study was limited to the production and logistics division of PT. Tirta Investama Danone Aqua and Its Environmental Impact.

The decision makers provided their answers regarding the extent of their understanding related to the implementation of the reverse logistics process at PT Tirta Investama Danone Aqua. The knowledge and understanding of decision-makers were more focused on the production process and environmental management, both of which were related to the reverse logistics process within the context. Generally, the selected decision-makers are suitable for use as sources for data collection using the Delphi method.

In this Delphi test, the results of the summary method are explained. The Delphi test aims to gather input and choices from decision-makers regarding the proposed strategy. Managers and experts are positioned as decision makers who are tasked with comprehensively assessing the five proposed policy strategies. The assessment was conducted on a 1-5 Likert scale.

The average assessment of each proposed policy strategy is presented in Table 5. In this iteration, one strategy has been selected that is a recommendation for PT. Tirta Investama Danone AQUA has a policy strategy for implementing the reverse logistics process. A proposed policy strategy, developing waste processing units that are owned and then utilized as materials for recycled AQUA Glasses packaging, is considered the best strategy for implementing the reverse logistics process at PT Tirta Investama Danone Aqua because it obtained the highest average score.

Table 5 Assessment of Proposed Policy Strategies

No.	Proposed Strategy	Average
1	Exchange used AQUA Glasses (48 cups) with a discount of Rp3,000 for each purchase of one box of new AQUA Glasses.	3.33
2	Prepare special trash bins for AQUA Glasses at certain points.	3.67
3	Develop waste processing units that have been owned and then used as materials for recycled AQUA Glasses packaging.	4.33
4	Exchange AQUA Glasses for public transportation tickets, such as buses, public transportation, etc.	4.00
5	Cooperate with collectors in collecting AQUA packaging waste	3.67

4. Conclusion

The variables in the implementation of the reverse logistics process at PT Tirta Investama Danone Aqua can be arranged in a causal loop diagram and stock flow diagram consisting of three subsystems and thirty-one variables. These subsystems include the enablers subsystem, the results subsystem, and the inhibitor subsystem. In the causal loop diagram and stock flow diagram that are formed, the enablers subsystem and the results subsystem are combined because these two subsystems are interconnected in increasing the value of REVLI. On the other hand, the inhibitor subsystem in the causal loop diagram aims to inhibit the growth of value in REVLI.

Based on the simulation carried out, the base model of PT Tirta Investama Danone Aqua falls into the complacent category, which is also able to achieve high growth in the enablers subsystem. However, the resulting inhibitors subsystem also experiences high growth, which will act as an obstacle in the reverse logistics process.

The proposed policy strategy is based on the results of a previously conducted simulation aimed at reducing the high growth of the inhibitor subsystem and based on the Delphi Method, decision makers, comprising companies, academics, and the government, selected the policy strategy of developing existing waste processing units, which are then utilized as materials to produce AQUA Glass recycled packaging.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare this article does not contain any conflicts of interest.

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