Challenges in transportation policy: speeding up a sustainable agri-food supply chain

N C Kresnanto1, W H Putri1, R Lantarsih1, & F R Harjiyatni1
1Research Group Green and Sustainability, Janabadra University, Yogyakarta, Indonesia

E-mail: nindyo_ck@janabadra.ac.id

Abstract. A sustainable agri-food supply chain becomes a utopia when transportation policy has no support to develop a sustainable mechanism. This study conducts a literature review to understand the footprint of a sustainable agri-food supply chain based on robust transportation policy and modelling for optimizing efficiency and customer satisfaction. This study relies on the relevant search term and reference source selection with the keyword "transportation policy" and "sustainable agri-food value chain" between 2016-2020. Literature sources identified with online databases from Google Scholars, Science Direct, IEEE Xplore, and other online resources affordable by Google search engine. Based on 52 manuscripts that were studied in-line with the research context, we find the empirical study tends to conclude that the transportation policy is a critical part of developing a sustainable agri-food supply chain besides the internal process in the agri-food producer. Transportation issues focus on routing problems and acceptable government policy. Simultaneously, the agri-food company's internal process emphasized lead-time production and distribution, achieve the ultimate goals reducing logistics cost, zero waste production process, and customer satisfaction.

1. Introduction

The food system is the primary system that driven activity between production and consumption. Discussing food system not simple as talking about transportation, geographic distribution, infrastructure, and stakeholders in the production and distribution process as a part, but we have to find the global perspectives which culminate in enhancement quality of human being. Furthermore, A food system is a cycling process that needs sufficient supporting infrastructure involving the growing, harvesting, storing, processing, packaging, transporting, warehousing, distribution, consumption, and disposal of food. The food system consolidates various tasks from agriculture inputs to the final demand, including technological, environmental, economic, political, and social factors [1].

A recent study finds that the food system process will be better run on the Sustainable Food System (SFS) scheme with a more comprehensive perspective [2]. Furthermore, we find SFS or called as agriculture sustainable (because the most input in the food system (80-90%) based on agriculture product [1] will consider three essential elements, social sustainability, economic sustainability, and environmental sustainability [3][4].

The ultimate point of an SFS is food security, better quality, and safety for consumers (health/nutrition for the community) [4][5]. Ensuring the goals depends on the food distribution system

1 To whom any correspondence should be addressed.
(FDS) or efficient food supply chain (FSC) [1]. FDS efficient indicators consist of two criteria, on-time delivery to customers and zero waste food in the distribution system/supply chain [6]. FSC is the different distribution system compare with others, for example, -furniture-, because FDS must ensure the quality, safety, and freshness in the prime periods [7].

FSC needs more attention than other supply chains, especially the agri-food supply chain (ASFC). ASFC has more defining factors such as unpredicted weather, perishable goods, strict food safety regulation community, quickly change lifestyle, environmental problems, and multi-stakeholder interest. This phenomenon posed a significant challenge to develop robust AFSC [8]. AFSC has more attention in recent years because they have a unique product characteristic that aligns with the logistic activity, which needs an unusual approach and out of the box mindset. Some current value, such as customer perception about food freshness, is the one example as an intangible value that trigger sales growth [9].

A comprehensive design and planning in AFSC have to reach the optimum economic value, minimize logistic cost, and be aware of the environment. To make this purpose realize, a factor that has to consider is lead time reduction in the supply chain process [10]. Sufficient lead time can reduce the supply chain cost and intensify performance and customer service [11][12]. One of the critical factors in lead time reduction and reducing environmental degradation in AFSC is transportation planning. For example, routing planning is one of the key performance indicators in AFSC to contribute to on-time delivery (OTD) [11][13]. Another way to make on-time delivery is by implementing the sustainable policy in supply management, especially transporting management [14].

The policy is the one essential thing to support the AFSC. Some countries make special regulations to promote the alignments with sustainable AFSC. Indonesia is one of the countries that should establish a sustainable agri-food supply chain to achieve the main goals and ensure food security for all the Indonesian people. With the wider geographic areas, stakeholders need more effort to develop a food security system based on a sustainable supply chain approach. Apart from being a country with quite large agri-food products, Indonesia is also a high consumer of agri-food. In 2010, urban consumers in Indonesia spent 16% of their food budgets on rice, 15% on fruit and vegetables, and 22% on animal proteins (meat, fish, eggs, and dairy). Rural consumers spent 24%, 17%, and 20%, respectively [15]. Therefore, a comprehensive policy is needed to show the Indonesian government's attention speeding up developing the robust agri-food supply chains [16], especially transportation system policy. The transportation policy to accelerate the development of a robust agri-food supply chain is outlining in Presidential Regulation No. 26/2012 concerning the Blueprint for the Development of a National Logistics System.

In this paper, we will discuss the role of implementing the routing model in prior research and the effectiveness of implementing transportation policies to support AFSC.

2. Research Methodology

This study conducts a comprehensive literature review to understand the transportation policy, sustainability context, and agri-food supply chains. Subsequently, based on the literature review, elaborating transportation policy in the agri-food supply chain is developed on sustainable perspectives. We used the empirical practices that have been done in several countries and compared them with Indonesian phenomena.

The literature review uses a relevant search term and resource selection to fulfil the most relevant and quality publications. The period for literature review is five years, from 2015 until now. The search is focusing on transportation policy in agri-food supply chains in sustainable perspectives. Search terms "transportation policy" and "sustainable agri-food supply chains" were used in this study. The following criteria were developed to classifying the available literature, such as sources identified in the online database from Google Scholars, ScienceDirect, IEEE Explore, and other online resources. We selected the latest publication if two or more papers have the same theme. As the illustration, below is the figure of the literature search result in ScienceDirect from 2015 until now.
3. Literature Review

3.1. Optimal Routing in Agri-Food Supply Chain

One of the essential key performance indicators in AFSC is on-time delivery or minimum lead time. On-time delivery can be reached by efficiency in transport, and the most frequent that we find in the literature review is about the vehicle routing problem or distribution problem [17]. Prior research about transportation routing problem that we find is Clustering Based Location Routing (CBLR) [18], Multi Objectives Linear Programming (MOLP) [19], Multi-Period Inventory Routing Problem (IRP) [20], Multi-Objective Optimization (MOO) [9], Genetic Algorithm (GA), and Particle Swarm Optimization (PSO) [21], Perishable Inventory Routing Problem (PIRP) [22][23]; A Three-Echelon Fuzzy Green Vehicle Routing Problem (3E-FGVRP) [24]; and Mixed-Integer Programming (MIP) model [25].

The clustering-based location-routing (CBLR) approach and Travelling Salesman Problem (TSP) are used to optimize the distribution planning/supply chain. This approach used objectives functions to reduce environmental cost in transporting relevant with CO2 emission and minimize the total cost agri-food supply chain. This research generates not the only recommendation in economic sustainability but also environmental sustainability [18].

Using multi-objective linear programming (MOLP) to design beef logistic supply chain with objectives of the model are (i) minimizing total logistics cost and (ii) minimizing the total amount of greenhouse gas emissions from transportation operations [19], then developed by other methods, namely multi-period Inventory Routing Problem (IRP) [20]. A multi-objective optimization (MOO) approach was developed considering an economic indicator's maximization, minimizing environmental impacts, and FSC leads time [9].

Other models to accomplish the routing problem are genetic algorithm and particle swarm optimization. The two models used to design modes of transporting agricultural products from the farmers to the hub location and enable the farmers' most effortless activity. These models create the possibility of reducing costs and bringing through on-time delivery to the hub location (reach minimum lead time) [21]. Whereas Perishable Inventory Routing Problem (PIRP) applies to make routing plan from the perishable food supplier to some retails, with deliberation in inventory capacity for each retail. The focus for each retail is reducing inventory cost, transportation cost, food waste, and preparing perishable food to fulfil the stochastic demand. Using these models can suppress logistics cost and lead time [22][23].

A three-echelon fuzzy green vehicle routing problem (3E-FGVRP) is one of the models that consider designing a regional AFSC on a time horizon. The credibility theory of fuzzy sets implements a multi-objective fuzzy chance-constrained programming model to minimize the total costs and carbon
emissions [24]. The perishable product's routing problem is formulated as a multi-objective Mixed-Integer Programming (MIP) model to assist in planning a sustainable supply chain [25].

Another development is an Improved Ant Colony Algorithm (IACA) combined with Tabu Search (TS) (IACATS) was proposed to solve the above Low Carbon and Freshness Degrees Vehicle Routing Problem (LCFD-VRP) model. Implementation with this model has proven that the optimization in VRP at AFCS will reduce total costs by more than 4% and CO2 emissions by more than 8% [26].

Table 1. Previous research on VRP and its objective functions

| Researcher | Objective Function | Routing Method | Advantages |
|------------|--------------------|----------------|------------|
| [18]       | Minimum logistic cost | CBLR           | Allows shorter iteration times due to simplification of the objects in the group |
| [19]       | Minimum environment cost | MOLP           | Easily be further adapted to other emerging value-added |
| [20]       | Minimum environment cost | IRP            | Coordinate two components of the supply chain (the inventory management and the vehicle routing) |
| [9]        | Minimum logistic cost | MOO            | Coordinate more than two components of the supply chain |
| [27]       | -                  | GA and PSO    | Combining the two models to achieve maximum efficiency (nature model and robust stochastic optimization technique) |
| [22,23]    | Minimum environment cost | PIRP           | Specific for perishable product |
| [24]       | -                  | FGVRP         | Based on vehicle routing problem |
| [26]       | -                  | LCFD-VRP      | Combines location, inventory, and routing decisions |
| [25]       | -                  | MIP           | |

3.2. Transportation policy in global and Indonesian context.

Freight transportation was a critical issue for several countries in the past two decades ago. For example, in the United States, we find the National Freight Transportation, Policy Statement, published by the U.S. Department of Transportation, in 1997. According to the document, we see the backbones concept about a freight transportation system. The freight transportation system prioritizes ensuring the nation has a safe, reliable, and efficient system that supports economic growth and international competitiveness both now and, in the future, while protecting and contributing to a healthy and secure environment [28]. Furthermore, the U.S. Government was considering integrated supply chains and distribution networks operating in states, metropolitan areas, regionally, nationally, and internationally to establish transportation policy. Just-in-time production and current inventory management practices have become a trigger for making policies besides protecting the environment and conserve energy. Using advanced technology in the transportation system also aims to reduce costs and better serve the customer in providing timely and reliable service.
European Union (EU) freight transport policy prioritizes the role of that as a crucial component of the planning, practice, and sustainability of freight logistics [29]. A study based on the EU policy document finds seven key pillars of the EU transport policy. The most relevant to our research are transport planning, global supply chain, and green logistics [30]. Meanwhile, the EU has formulated a sustainable transport plan that includes crucial policy developments such as the Green Transport Package, aiming to consider all sustainability aspects since 2009. The policy journey in sustainable freight transport agenda refreshed with the statement released in 2007 as follows," stating that freight transport is 'essential to economic activity and quality of life…", and using innovation perspectives as a tool for sustainability to accomplish the action.

In the Indonesian context, we find several phenomena, especially in agri-food local products, that difficult to compete with other imported products. Food policy debates tend to give more attention to foreign trade than the domestic market. Meanwhile, the policy debate and the research have rarely considered the transformations afoot in domestic food markets. Yet, the structure and conduct of the domestic food economy, in general, and of rural-urban food supply chains, in particular, are transforming rapidly [16].

Government policy support needs in this situation because the urban food market and rural-urban food supply chains are crucial to Indonesian food security. If Indonesian farmers cannot access the supply chains that meet domestic consumer demand, foreign farmers will [16].

The transportation policy to accelerate the development of a strong agri-food supply chain is outlined in Presidential Regulation No. 26/2012 concerning the Blueprint for the Development of a National Logistics System [31]. According to that regulation, the chosen strategy is building the domestic connectivity (local and national) and global connectivity to support the national logistic system performance. One of the focuses is to provide a good transportation infrastructure network that operates efficiently. Meanwhile, in the policy area, the main focus is harmonizing regulation and logistic policy, especially in domestic trading, transportation, foreign trading, electronic information and transaction, and multi-mode transportation regulations.

4. Discussion
On-time delivery problems or lead time in AFSC can be solved with transportation planning. One example is implementing vehicle routing problems (VRP), a combinatorial optimization and integer programming problem that ask "What is the optimal set of routes for a fleet of vehicles to traverse to deliver to a given set of customers" [32].

Optimization with VRP in AFSC, in general, will reduce logistic cost and lead time. VRP is a model based on artificial intelligence (AI). Meanwhile, prior research, not statute the logistic reduction cost and lead time in strict percentage, but another study claimed with a good algorithm, logistic reduction cost can reach 4%, and the CO2 reduction emission level in 8% [26]. So, AFSC optimization can be done with careful transportation planning with the help of AI.

Meanwhile, AFSC also has various vulnerabilities and risks that should be mitigated to make AFSC more effective and efficient. Prior research finds that the weather-related and political factor is the highest driving power to disturb the AFSC flow and must be managed carefully [33]. Related to the lead time problems, we find that weather-related factor is the most significant contribution to a disturbance in lead time. In the Indonesian context, the weather-related element also has an immense contribution to disturbing the AFSC flow; for example, in the input stage, weather-related such as fail harvesting caused by a flood can make the supply volume of food stock and demand unbalance. The model based on artificial intelligence suggests that it might become a comprehensive way to solve the on-time delivery problem smoothly.

5. Conclusion
Studies about VRP for AFSC prove to support SFS in economic sustainability and environmental sustainability but haven't calculated social sustainability. The emerging research needs to implement other AI methods to choose the best method with the various objective function.
In the policy context, we find that the United States, for example, has had backbone regulation to organize a logistic system. US concern that the transportation system prioritizes has a safe, reliable, and efficient system that supports economic growth and international competitiveness. The transportation system also planned to contribute a healthy and secure environment. Besides, the EU also takes more attention to innovation perspectives as a sustainability tool, as a good quality of life. But in Indonesia, although we have Presidential Regulation concerning the Blueprint for the Development of a National Logistics System, the policy still can't take effect in implementing a national logistic system. Strong conjecture, the regulation can't implement effectively because the law level is in a lower grade than the constitution level, so it can't bind another sector that contributes to the national logistic system to obey the regulation. A strong recommendation to this situation is to change the law level of Blueprint for the Development of a National Logistics System from Presidential Regulation to Constitution level.

6. References

[1] Rodrigue J-P The Logistics of Global Food Systems | The Geography of Transport Systems
[2] Béné C, Oosterveer P, Lamotte L, Brouwer I D, de Haan S, Prager S D, Talsma E F and Khoury C K 2019 When food systems meet sustainability – Current narratives and implications for actions World Dev. 113 116–30
[3] Dekeyser K, Rampa F, D’Alessandro C and Bizotto Molina P 2020 The food systems approach in practice: Our guide for sustainable transformation
[4] Food and Agriculture Organization of the United Nations (FAO) 2018 Sustainable food systems. Concept and framework 1–8
[5] Pothukuchi K and Wallace R 2009 Sustainable food systems: perspectives on transportation policy ... Transp. Policy ... 113–29
[6] Gustavsson J, Cederberg C, Sonesson U, Otterdijk R van and Meybeck A 2011 Food loss and food waste: Causes and solutions (Rome: Food and Agriculture Organization Of The United Nations)
[7] La Scalia G, Settanni L, Micale R and Enea M 2016 Predictive shelf life model based on RF technology for improving the management of food supply chain: A case study Int. J. RF Technol. Res. Appl. 7 31–42
[8] Tsolakis N K, Keramydas C A, Toka A K, Aidonis D A and lakoulov E T 2014 Agrifood supply chain management: A comprehensive hierarchical decision-making framework and a critical taxonomy Biosyst. Eng. 120 47–64
[9] Gomes A C, Pinto-Varela T and Barbosa-Póvoa A P 2016 Multimodal Green Food Supply Chain Design and Planning under Uncertainty vol 38 (Elsevier Masson SAS)
[10] De Treville S, Shapiro R D and Hameri A P 2004 From supply chain to demand chain: The role of lead time reduction in improving demand chain performance J. Oper. Manag. 21 613–27
[11] Ghaderi H, Dullaert W and Van Amstel W P 2016 Reducing lead-times and lead-time variance in cooperative distribution networks Int. J. Shipp. Transp. Logist. 8 51–65
[12] Li Z, Fei W, Zhou E, Gajpal Y and Chen X 2019 The impact of lead time uncertainty on supply chain performance considering carbon cost Sustain. 11 1–19
[13] Dinu D 2016 Supply chain performance within agri-food sector Ekon. Poljopr. 63 919–28
[14] Bourlakis M and Matopoulos A 2010 Trends in food supply chain management (Woodhead Publishing Limited)
[15] Reardon T and Timmer C P 2014 Five inter-linked transformations in the Asian agrifood economy: Food security implications Glob. Food Sec. 3 108–17
[16] Reardon T, Stringer R, Timmer C P, Minot N and Daryanto A 2015 Transformation of the Indonesian Agrifood System and the Future beyond Rice: A Special Issue Bull. Indones. Econ. Stud. 51 369–73
[17] Anily S and Bramel J 1999 Vehicle Routing and the Supply Chain 147–96
[18] Boudahri F, Aggounne-mlalaa W, Bemekrouf M and Sari Z 2013 Application of a Clustering
Based Location-Routing Model to a Real Agri-food Supply Chain Redesign Application of a Clustering Based Location-Routing Model to a Real Agri-food Supply Chain Redesign

[19] Soysal M, Bloemhof-Ruwaard J M and Van Der Vorst J G A J 2014 Modelling food logistics networks with emission considerations: The case of an international beef supply chain Int. J. Prod. Econ. 152 57–70

[20] Soysal M, Bloemhof-Ruwaard J M, Haijema R and Van Der Vorst J G A J 2015 Modeling an Inventory Routing Problem for perishable products with environmental considerations and demand uncertainty Int. J. Prod. Econ. 164 118–33

[21] Patidar R, Venkatesh B, Pratap S and Daultani Y 2019 A Sustainable Vehicle Routing Problem for Indian Agri-Food Supply Chain Network Design 2018 International Conference on Production and Operations Management Society, POMS 2018 (Institute of Electrical and Electronics Engineers Inc.)

[22] Onggo B S, Panadero J, Corlu C G and Juan A A 2019 Agri-food supply chains with stochastic demands: A multi-period inventory routing problem with perishable products Simul. Model. Pract. Theory 97 101970

[23] Violi A, Laganá D and Paradiso R 2020 The inventory routing problem under uncertainty with perishable products: an application in the agri-food supply chain Soft Comput. 24 13725–40

[24] Giallanza A and Puma G L 2020 Fuzzy green vehicle routing problem for designing a three echelons supply chain J. Clean. Prod. 259 120774

[25] Biuki M, Kazemi A and Alinezhad A 2020 An integrated location-routing-inventory model for sustainable design of a perishable products supply chain network J. Clean. Prod. 260 120842

[26] Chen J, Gui P, Ding T, Na S and Zhou Y 2019 Optimization of transportation routing problem for fresh food by improved ant colony algorithm based on tabu search Sustain. 11

[27] Patidar R, Venkatesh B, Pratap S and Daultani Y 2019 A Sustainable Vehicle Routing Problem for Indian Agri-Food Supply Chain Network Design 2018 Int. Conf. Prod. Oper. Manag. Soc. POMS 2018 1–5

[28] United States. Department of Transportation 1997 National Freight Transportation Policy Statement

[29] Islam D M Z, Zunder T H and Jorna R 2013 Performance evaluation of an online benchmarking tool for European freight transport chains Benchmarking 20 233–50

[30] Aditjandra P T 2018 Europe’s Freight Transport Policy: Analysis, Synthesis and Evaluation Adv. Transp. Policy Plan. 1 197–243

[31] Indonesian Government 2012 Presidential Regulation No.26/2012 Blueprint for the Development of a National Logistics System

[32] Anon Vehicle routing problem - Wikipedia

[33] Zhao G, Liu S, Lopez C, Chen H, Lu H, Mangla S K and Elgueta S 2020 Risk analysis of the agri-food supply chain: A multi-method approach Int. J. Prod. Res. 58 4851–76