Smart Logistics System in Food Horticulture Industrial Products: A Systematic Review and Future Research Agenda

Rindra Yusianto[#1], Marimin[*2], Suprihatin[*3], Hartrisari Hardjomidjojo[*4]

[#]*Graduate Program of Agro-industrial Engineering, Faculty of Agricultural Technology, IPB University (Bogor Agricultural University), Indonesia*

[*]*Department of Agro-industrial Engineering, Faculty of Agricultural Technology, IPB University (Bogor Agricultural University), Indonesia*

[1]rindra@staff.dinus.ac.id

[2]marimin@ipb.ac.id

[3]suprihatin167@gmail.com

[4]sari_rce@yahoo.com

Abstract*— Food horticultural commodities are perishable products. Quality decreases rapidly after harvest. Therefore, timely handling and distribution of products must be considered to achieve customer satisfaction. The objective of this article is to analyze existing methods for logistics systems in food horticulture industrial products and develop new frameworks for smart logistics systems. This paper reviewed and synthesized 115 scientific articles published between 2009 and 2019. Articles reviewed are categorized into sensor Radio Frequency (RF), GPS systems for location and navigation, Internet of Things (IoT) and mobile applications. Most of the previous authors have applied the agricultural product approach. The dominant topic that we found in the literature is IoT, and tracking systems with RFID and remote sensing. Most of the literature focuses on agricultural logistics and there is a lack of discussion about food horticulture industrial product. The contribution of this paper was mapping methods in spatial logistics and logistical traceability and develops new frameworks. For the future agenda, we point to the development of systematic smart logistics that applies intelligent spatial logistic DSS to maintain the logistics system.

Keywords *— food horticulture, smart logistic, spatial logistic, traceability*

1. Introduction

At present, the development of food agriculture systems has increased dramatically and has transformed from areas of production, distribution and food consumption into modern systems [1]. The modernization and industrialization have completed the rapid socio-economic development [2]. In response to efficient global economic trends, a modern logistics model has attracted much attention from the industry [3]. Modern logistic is a comprehensive system that integrated transport, storage, loading, unloading, packaging, and distribution [4]. The geographical position of logistics is important. As a key node of the global logistic network, Distribution Center (DC) is developing in the direction of offering all round value added services. DC is used as a circulation industry node that specialize in processing, buying, and distributing agricultural products [5][6][7]. Research in agriculture is usually aimed at increasing efficiency, productivity, food security, and quality [8][9][10]. An important issue in agricultural is the imbalance between production and demand [11][12]. The framework for assessing food logistics is developed with four elements: quality, safety, sustainability and efficiency where these factors are integrated [13]. Logistic tracing enables the optimal balance of supply and demand for agricultural products in an efficient logistics system and storage optimization [14]. Increasing transparency and availability of transaction information, as well as setting reasonable prices for horticultural products are of particular concern in the agro-industrial logistics system.

Horticultural commodities such as vegetables are perishable products [15]. Quality product was decrease rapidly after harvest. So as to achieve customer satisfaction, it is necessary to consider timely product handling [16]. A reliable transportation system with efficient time in connecting all distribution centers is an important factor [17][18]. Logistics currently rely on sophisticated information and communication technology (ICT) solutions for processing and

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sharing information. So the method that is considered effective in food quality and safety is ICT-based traceability [19].

This paper aims to analyze methods in mapping spatial logistics and traceability in smart logistics then organizing a framework. First, spatial logistics and traceability will be analyzed, and then structured logistics based on fundamental theory. Finally, the conceptual definition and framework for smart logistics in the food horticulture industrial products will be mapped and the possibility of further improvements will be discussed.

2. Literature review

2.1 Smart logistics system

Logistics is an activity to increase customer satisfaction from the planning process to distribution [20]. Logistics related to processing raw materials from agricultural products are called agroindustry logistics, which includes actions to manage the planning, control of production, storage, transportation, and information, between agricultural producers and consumers [21]. Reliable and efficient logistics services have an increasingly important role in various activities. At present, most logistics companies have implemented ICT to increase productivity and automate their work. Logistics ensures product availability, with quality, on time, in quantities, on-site, and for the right customer, and at a fair price [22][23].

In horticultural logistics, traceability is very important for producers, distributors, and consumers [24]. The horticultural food is most benefited by advances in the fields of control and sensor RF, artificial neural networks (ANN) and robotics, which bring improvements to the production process [25][26]. Smart logistics typically use platforms with approaches to fuzzy logic, Radio Frequency Identification (RFID), remote sensing, IoT, big data and cloud computing, and mobile applications [27]. Logistics that implement ICT is primarily to improve efficiency and automate their work called smart logistics [4].

2.2 Traceability in food horticulture industrial products

In developing food horticulture, logistical support from cultivation to post-harvest is needed, increasing productivity and quality, as well as business institutions and improving post-harvest technology [28][29]. Logistics can be categorized into two perspectives, namely internal and external, both of which focus on time and cost efficiency. Internal perspective discusses the efficiency of material flow, while external discusses flow throughout the logistics chain to its distribution [30][31]. Internal and external perspectives are greatly influenced by technological progress. Advances in technology cause the goods produced and information to move very quickly [32][33].

In the last decades, the topic of traceability has dominated in food agriculture research. The food agriculture sector consists of suppliers, producers, wholesalers and retailers [34][35][36]. Traceability includes tracing and tracking, both of which require the identification of units to be tracked. Identification technology such as barcodes and RFID can be used for tracking and tracing, and integrated with existing logistics systems. In line with this, traceability is increasingly being developed with spatial data analysis [37]. Complex traceability problems can be solved by statistical methods that are integrated with spatial analysis uses GIS [38]. GIS facilitates the environment to calculate their spatial relationships with the application of geostatistics [39].

With increasing urbanization, tourism is growing rapidly so there is a greater demand for food, including horticultural food [40]. However, such demand is accompanied by increasing concerns about food safety and quality, making traceability even more important [41]. Traceability in logistics allows identification of causes of problems within the supply chain [42]. Traceability is believed to be an effective method in improving food safety and quality. [43]. Food tracking and tracing can provide information easily which areas have a surplus and other areas that have deficiencies. An integrated traceability system will provide of the quality for consumer safety [44]. Integrated traceability between RFID with spatial data analysis based on GIS will further ensure consumer satisfaction and can be applied to smart logistics in the food horticulture industrial product [45][46].

3. Method

3.1 Analysis of selected studies

The systematic review in this paper identified 115 papers from previous relevant journals in smart logistics. The scientific articles are 88 journals, 16 proceedings, 5 reports, 4 books, 1 PhD thesis and published between 2009 and 2019.

3.2 Critical review framework

We categorize this critical review into 4 main topics: RF sensors, GPS systems for location and navigation, mobile apps and Internet of things (IoT). Smart logistic describes the configuration models which are mostly discussed in the literatures. This paper focused on the approach applied for spatial logistic and traceability and we defined the framework. Smart logistics is a decision making framework to ensure food safety and quality and reduce the logistic costs. Finally, we suggest a global framework. Literature based on the main topics can be seen in Table 1.

Table 1. The number of scientific articles

Main Topic	Quantities
Sensor RF	35
GPS systems	29
Internet of Things (IoT)	46
Mobile applications	5
Total	84

In Table 1, it can be seen that the topic of IoT is the most dominant, then RF sensor and the smallest mobile application. The year of publication is illustrated as in Figure 1.

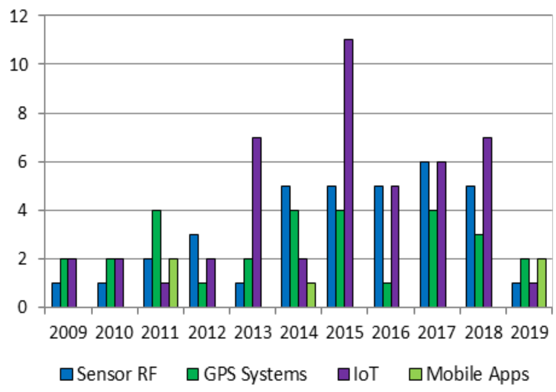

Figure 1 Year of publication articles

Figure 1 shows a smart logistics system that has become common topics in the last 10 years. However, in recent years, the most dominant topic is IoT. In 2015, this topic was mostly available in scientific articles and increased significantly in each year, which means this topic provides opportunities to explore and develop new approaches and frameworks. This paper proposes spatial logistics to establish a traceability system framework as a new approach to smart logistics systems, while the review framework can be seen in Figure 2.

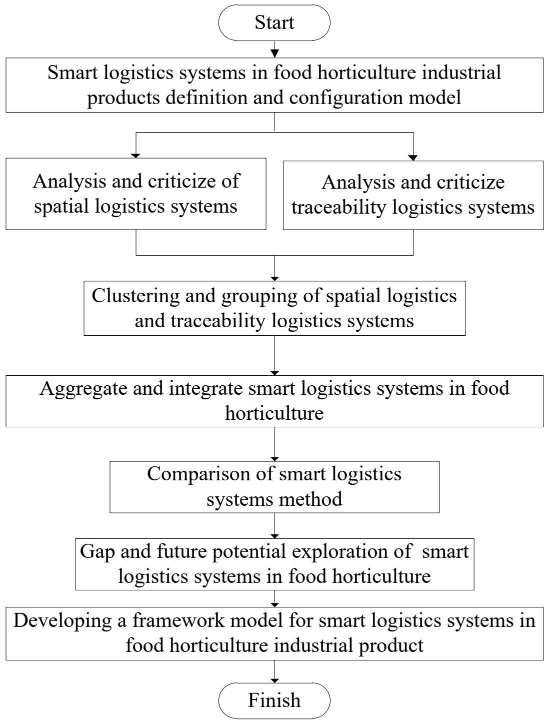

Figure 2. The review framework

4. Finding

4.1 Logistics system category

Nowadays, smart logistics has become an important area where industries can reduce costs, automate jobs, and increase the quality of their customer service [47]. Smart logistics in their practice they apply ICT with the aim of automating their work, such as the fast presentation of information in the logistics chain. Different information systems make it possible to work together and exchange data securely with a predetermined structure. Smart logistics also consider aspects of sustainability. The solution to reduce the negative impact of environmental damage is to use the concept of sustainable development with green logistics methods [48]. Green logistics as the environmental issues related to logistics activities [49]. The key elements of green logistics are objective design models that are reducing environmental impact of agroindustry business processes; improve the quality of packaging design in accordance with customer expectations and environmentally friendly [20].

Based on critical and systematic reviews of literature, logistics system in food horticulture industrial products related to logistics system, green logistics, agroindustry logistics, and smart logistics as in Figure 3.

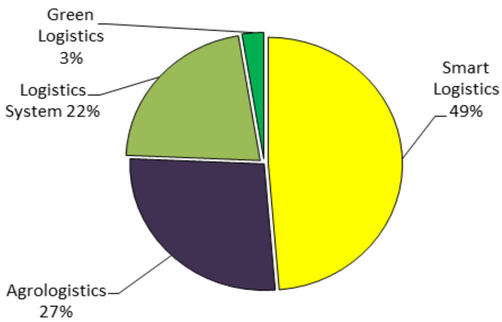

Figure 3. Percentage of publication

Based on Figure 3 it can be seen that smart logistics is the most discussed topic, then agrologistics, and the smallest is green logistics.

4.2 Summarize and classify of logistics system

Based on systematic reviews, smart logistics systems are classified into spatial logistics and logistics traceability systems in food horticulture. The total number of spatial logistics publications from 2009-2019 as in Figure 4.

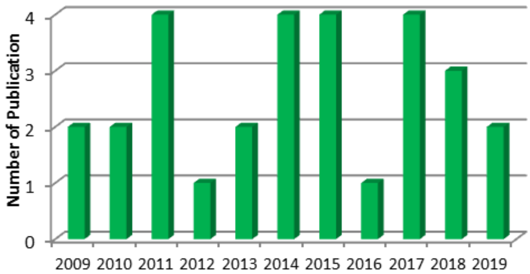

Figure 4. Spatial logistic publication

In Figure 4, it can be seen that fluctuation in the publication of logistical spatial topics by year.

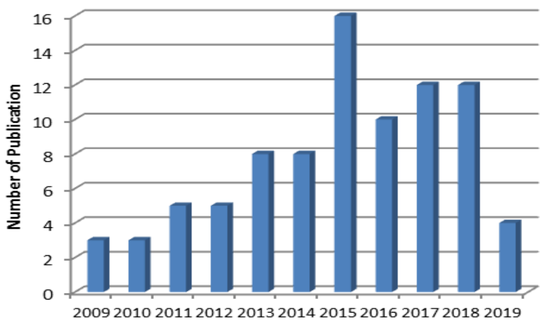

Figure 5. Llogistics traceability publication

Based on a literature review, the total number of logistical traceability publications in Figure 5, shows that the most common logistical traceability publication was in 2015, in 2006 it decreased dramatically, and then 2016 increased steadily. In general, logistical traceability is increasing every year.

4.3 Analysis smart logistics system

Food horticultural industry products are perishable. They need protection from damage after harvest. Losses occur due to overstock and natural decay that cannot be prevented [50]. Damage to fresh horticultural food is usually caused by physical, biological and chemical changes. This can reduce the shelf life of horticultural products [51].

Logistics companies implement ICT to improve efficiency and automate their work [52]. Based on previous research articles, logistics systems in horticulture apply various methods including fuzzy logic algorithms, logistic based on fuzzy, fuzzy inferences systems, genetic algorithms, tracking with RFID, traceability systems, RFID tracking logistics, sensing control, optimization logistics, spatial prediction, spatial logistics, spatial DSS, agri-food risk management, agri-food value chain, trust model, GIS and geostatistical, agrologistic platform, big data analysis, IoT and precision agriculture. Based on these various methods, smart logistics systems in food horticulture can be classified as follows:

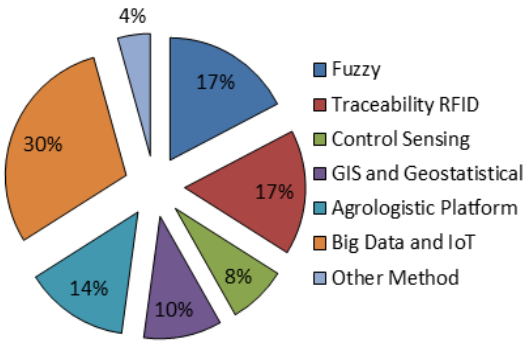

Figure 6. Percentage distribution of articles based on research method

Previous research has examined a lot of smart logistics but there is a lack of smart logistics related to food horticulture industrial products.

4.4 Aggregation and integration smart logistics systems

After classifying the previous article, it is known that in the development of food horticultural logistic it consists of two approaches, namely spatial logistics and logistics traceability system. The following approaches and methods developed in smart logistics as in Table 2.

Table 2. Smart logistics approach

Approach	Method
Smart logistics	Fuzzy Algorithm [53][54][55][56] Logistic regression [6] Genetic algorithm [57] Cloud computing [58] Big data analysis [55][59] Agrologistics platform [60][61]
Spatial logistics	Spatial modeling [37][62][63][64] GIS [65][66][67][68][69] Geostatistical [70][71] Precision agriculture [72][73][74] Spatial prediction [75][76][77]
Logistics traceability	RFID [78][43][79][80][81][82][83] Real time tracking [38][84][85] Safety and security [43][86] GPS [35][19] Traceability system [24] Big data [55][87][44] Control sensing [88][89]

Smart logistics approach discusses fuzzy, logistic regression, Genetic Algorithm (GA), cloud computing, big data and agrologistics. Spatial logistic discusses spatial modeling, GIS and geostatistical, precision agriculture (PA) and spatial prediction. And logistic traceability discusses RFID, real time tracking, safety and security, GPS, traceability, big data and control sensing.

Where based on a systematic literature review each approach has several methods. In Tayyebi research explained that in addition to spatial logistics can be used for identification; it can also be used to improve understanding of demographics, geospatial and geostatistical in logistics systems [57]. While Clarke & Rowley in their research explained that the spatial logistics system can be integrated with DSS to help the logistics system decision making [62]. Vasconcelos explain spatial patterns can be used for predictions, and in spatial, different patterns for different causes. In the development of logistical and neural network models, both showed an acceptable level of predictive ability [76]. In the logistics approach to traceability, the role of GIS, tracking logistics with RFID, geoinformatics in horticulture food agriculture, web-based GIS logistics is needed. The Directorate General of Horticulture of Indonesia has determined that horticulture consists of vegetables, fruits, ornamental flowers and medicinal plants such as ginger, while food horticulture only includes vegetables and fruit [90] . The focus of the discussion in this paper is the smart logistics system. An intelligent system used in the logistics of food horticulture industrial products, all vegetables and fruits. Smart logistics is a logistical approach that utilizes the role of ICT, IoT, fuzzy algorithms, control sensing and some that use ANN and genetic algorithms [4].

Based on previous literature analysis, aggregate and integrate smart logistics systems in food horticulture can be seen in Figure 7, that the food horticulture logistics system consists of spatial and traceability logistics. The focus of this article is the smart logistics. Based on the results of the analysis of previous articles, the spatial logistics research increased in 2010. The method used was spatial DSS (2009), spatial prediction logistics (2010), GIS in local food (2010), spatial logistics (2010), mapping system (2011), spatial control sensing (2014), precision agriculture (2014) and GPS based logistics (2017). Whereas research related to logistic traceability system is almost evenly distributed every year. The method used is traceability system (2009), RFID logistic tracking (2009), logistics optimization using GPS (2010), Web GIS (2010), RFID GPS based logistics (2012), real time tracking using RFID (2016), geoinformatics (2017) and GNSS logistics (2018). In addition, there are flexibility logistic methods (2010), trust logistic models (2011), green logistics (2014), organic food logistics (2014), agri-food logistics (2014), agri-food value chain (2016) and risk management in agri-food (2018). Most of the methods used ICT, such as control sensing (2009), E-logistics (2010), modern logistics (2010), smart logistics (2012), big data for logistic agriculture (2015), genetic algorithms (2016) and IoT for logistics. From the three approaches, there is an aggregation between the spatial logistic approach and the smart logistics spatial DSS (2009), spatial control sensing (2014), GPS based logistics (2017), while the aggregation between the traceability logistics and the smart logistic is the RFID tracking (2009), the web GIS based logistics (2010) and the RFID based logistics (2012).

From figure 7, it can be seen that the aggregation between the three approaches is the used real time tracking method (2016). Seeing the aggregation and integration of smart logistic systems in food horticulture, then in 2019 the Intelligent Spatial-Logistics Decision Support Systems will be developed. That is by developing real time traceability consists of tracking and tracing using RFID for food safety and quality in Food Horticulture Industrial Products (2019).

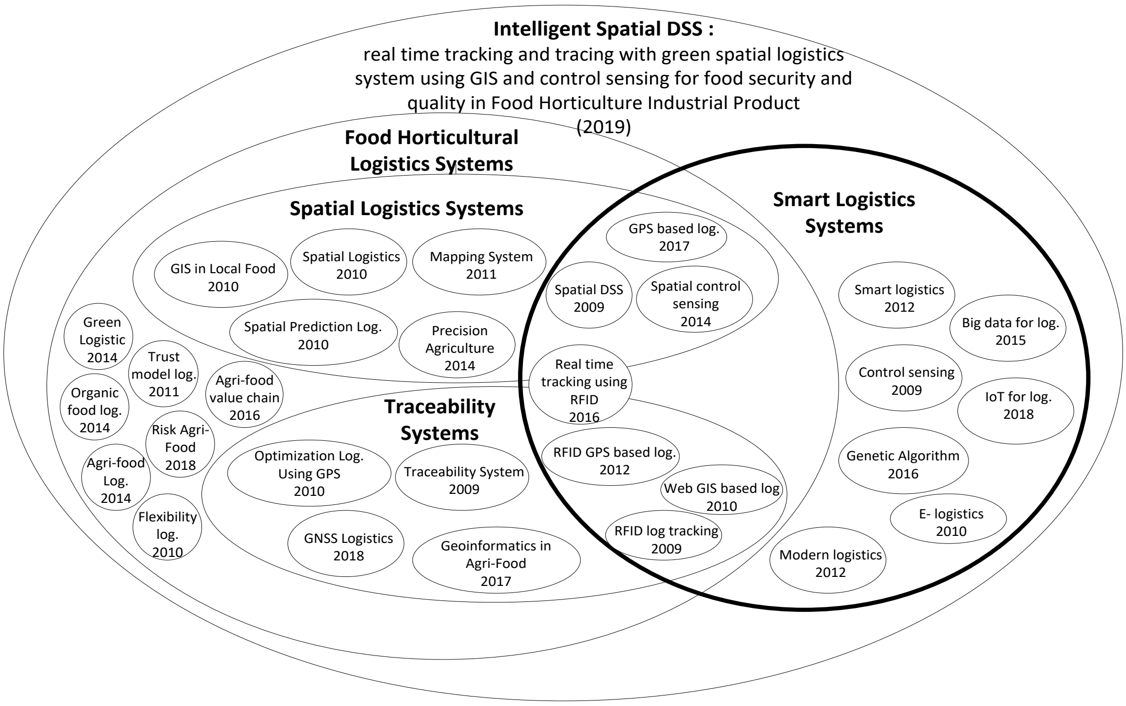

Figure 7. Aggregation and integration smart logistics systems in food horticulture

4.5 Comparison of smart logistics systems approach

Based on the systematic review of the previous articles after being analyzed and aggregated, the next step is to conduct critical success factors (CSF) and comparative approaches to the smart logistics with the spatial logistics and traceability logistics. In addition to these three approaches, in CSF agroindustry and food horticulture are also discussed as known horticulture such as vegetables and fruits. In this discussion the focus is on food horticulture. CSF is classified into three approaches, namely the smart logistics approaches, the spatial logistics approaches and traceability logistics approaches is described to see the description, content, author and year of publication. According to the objective of this paper then CSF also considers agroindustry and food horticulture. The critical success factors of smart logistics as shown in Table 3.

Table 3. Critical success factors of smart logistics systems

Approach	Description	Content	Authors
Spatial Logistics	Logistics that utilize spatial data, mapping, GIS and geospatial. Spatial logistic methods are used to produce interpolation maps of food producing regions	GIS and geostatistical, global positioning, global navigation, regional mapping, spatial prediction, spatial DSS	[37][66][91][92][93][94][95]
Logistics Traceability	Traceability methods can maintain the safety and quality of horticultural food by increasing revenue and reducing costs	RFID, fuzzy, ANN, IoT, control sensing, real time tracking, advance tracing, GPS, geoinformatics	[96][97][98][99][100][101][102]
Smart Logistics	Smart logistics applies ICT to improve performance in automating work from production planning to distribution.	Smart logistics, green logistics, agrologistics, spatial modeling, soft computing, Wireless Sensor Networks, spatial DSS, RFID GPS and GSM based logistics, real-time tracking and shelf life	[4] [41][55] [61] [67][103][104] [105][106][107][108] [109][110]

The next step is a comparison of smart logistics approach, as shown in Table 4.

Table 4. Comparison of smart logistics systems

Main finding	Key point	Author
Distribution route	Fuzzy	[93]
Distribution analysis	Fuzzy	[6]
Control systems	Fuzzy	[99]
Regression simulating	Regression	[111]
Optimal solutions	GA	[54]
Precision agriculture	Geostatistics	[70]
Tracing and navigate	Big data	[55]
Spatial modeling	Spatial DSS	[62]
Track and tracing	GIS	[72]
GPS based agriculture	PA	[68]
Traceability System	RFID	[80]
Real-time tracking	RFID	[85]
Control tracking	Sensor	[88]

We conclude key points in comparison of smart logistics approach are fuzzy, logistic regression, GA, geostatistical, big data, spatial DSS, GIS, precision agriculture, RFID and sensors. There are several articles that discuss in detail about the use of RFID and sensors for tracking and tracing. In addition, GIS has been used to map food security related areas. We find interesting is spatial DSS method, which combines the advantages of spatial logistics to support logistics decision making. Besides precision agriculture and GIS-based spatial prediction logistics enable the development of horticulture food to be better.

5. Result and Discussion

5.1 Gap and future potential exploration

Based on a systematic review, there were three approaches in the smart logistic system, where food horticulture focuses on vegetables and fruits [74]. The three approaches are smart logistics, spatial logistics and traceability, where each of we approaches gets several different methods. Then from these three approaches are compared. From comparison of smart logistics approach, it can be seen that dominant key points are fuzzy and RFID.

Fuzzy methods can be implemented in control sensing. In their research Escobar and Galindo explained that the platform that allows to simulate some types of control systems based on fuzzy [53]. According to Kawa, smart logistics is logistics that implements technology including IoT [4]. In addition, fuzzy methods are used more for remote and control sensing. Shao states that logistics monitoring and real time tracking can use RFID [84]. At present the location-based location tracking system features using GPS can be integrated with sophisticated data handling systems such as RFID and wireless sensors. As Keeratiwintakom research states that GPS tracking is a general approach that can provide real time vehicle location information [85]. Regarding fleet planning, Schoebitz explains that his study uses GIS for real-time data analysis tools based on a number of trucks installed with representative GPS units [112]. Simultaneously, Hussain in his research explained that currently in Asia is having food security problems mainly due to extreme climate change [113]. Furthermore, the big data analysis and IoT technology enables better information services in the logistics system [114]. Therefore, Food horticulture traceability actually becomes an integral part in logistics and supply chain management in addition to utilizing GIS can use fuzzy logic and RFID as part of control sensing.

Based on the description above, a gap study in the smart logistics system in food horticulture industrial product can be seen in Figure 8.

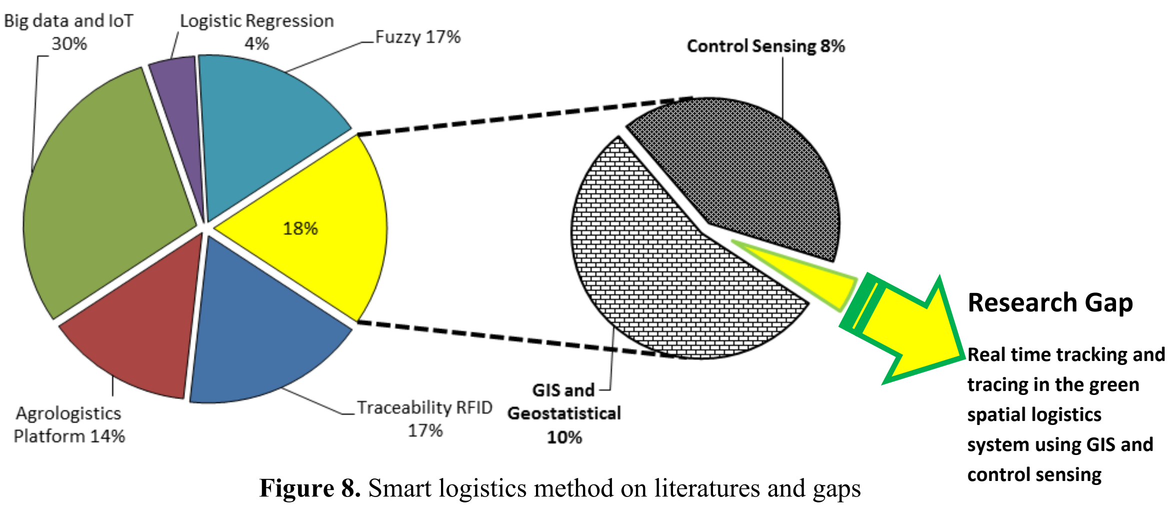

Figure 8. Smart logistics method on literatures and gaps

Based on the research gap in Figure 8 and the aggregation in Figure 7, future potential exploration of smart logistics systems in food horticulture is real time tracking and tracing in green spatial logistics system using GIS and control sensing for food horticulture industrial products.

5.2 Critics for smart logistic system

In the previous discussion, we can know that the logistic system approach consists of smart, spatial, and traceability logistic. Each approach develops a different method for each research in a different year. As is known in 2015 is the development of big data analysis and IoT where both of these methods are used in research on system logistics, but unfortunately the lack of discussion about agroindustry.

In smart logistics, information is one of the main topics. As stated by Kawa [4], the main competitive factor in logistics is access to data and information about consumer demand and supply opportunities. In the smart logistic approach, it is also discussed related to the big data analysis and cloud computing methods. But both are not connected with the logistics for horticulture. Big data analysis is developed for logistics and transportation but does not specifically using cloud computing [59]. Bronson and Knezevic [87] discussed big data in food agricultural. Actually this big data can be combined with spatial and sensors to facilitate farmers and stakeholders. In addition, cloud computing can be used and will make it easier for farmers so they do not require extra knowledge.

Based on the previous article, the discussion regarding green logistics is very lacking (3%). Yusianto *et. al* [36] has discussed green logistics and reviewed it from environmental factors but does not specifically discuss green technology. Actually, in spatial logistics systems, green technology can also be developed, for example, when shipping using trucks, the value of emissions, energy requirements, distance and time can be considered, whereas Alexandru [49] discusses sustainable conditions regarding transportation in green logistics. But according to him, innovative new transportation modes present a range of limitations: high technology costs, less reliable, depending on fuel temperatures, the fact that green logistics adoption in system logistics is a difficult task. This can be solved by using green spatial logistics, where spatial logistics, for example, provide data related to the route to be taken by considering environmental factors.

The most serious critique of smart logistics is that the method used is nothing that discusses food security. In previous studies, food security did not discuss logistical traceability especially food horticulture and there was no synergy between traceability and smart logistics. From the previous article, both food security and quality were also not discussed in terms of on farm, demand forecasting, purchasing, requirement planning, production process, storage and inventory, warehouse management systems, material handling, packaging and finished goods inventory, distribution planning and transportations by using real time traceability in the green spatial logistics using control sensing and GIS.

5.3 Proposed model of smart logistic system in food horticulture industrial product

Based on the critics for smart logistics in food horticulture industrial products, especially related to food security and quality, we propose a new model of smart logistics in the food horticulture industry product, using real-time spatial logistics based on remote sensing and GIS techniques includes forecasting demand from consumers, purchasing seeds, planning logistical needs, production planning, storage and inventory, warehousing management systems, handling materials, product packaging, distribution planning and shipping/transportation.

6 Pointers for future research

In fact, making the wrong decision will cause the domino effect. It is an opportunity to implement decision making into Intelligent DSS prototype [115]. So after grouping and classification carried out aggregating and comparing with articles in previous studies then design and develop Intelligent Spatial DSS (ISL-DSS) with configuration database management systems (DBMS), models and knowledge base. The new model that we developed will use spatial techniques in green logistics with sensing control and GIS that are integrated with tracing and tracking in real time. The intended logistic is smart logistics consisting of spatial and logistical traceability in food horticulture industrial products. This model uses a DBMS for GIS databases and food security, a model management system with a smart logistical approach and a knowledge management system using RFID, Arduino, GIS and maps in Google. The following is the development of ISL--DSS in the green spatial logistics system using GIS and control sensing including database management systems, model base and knowledgebase as shown in Figure 9.

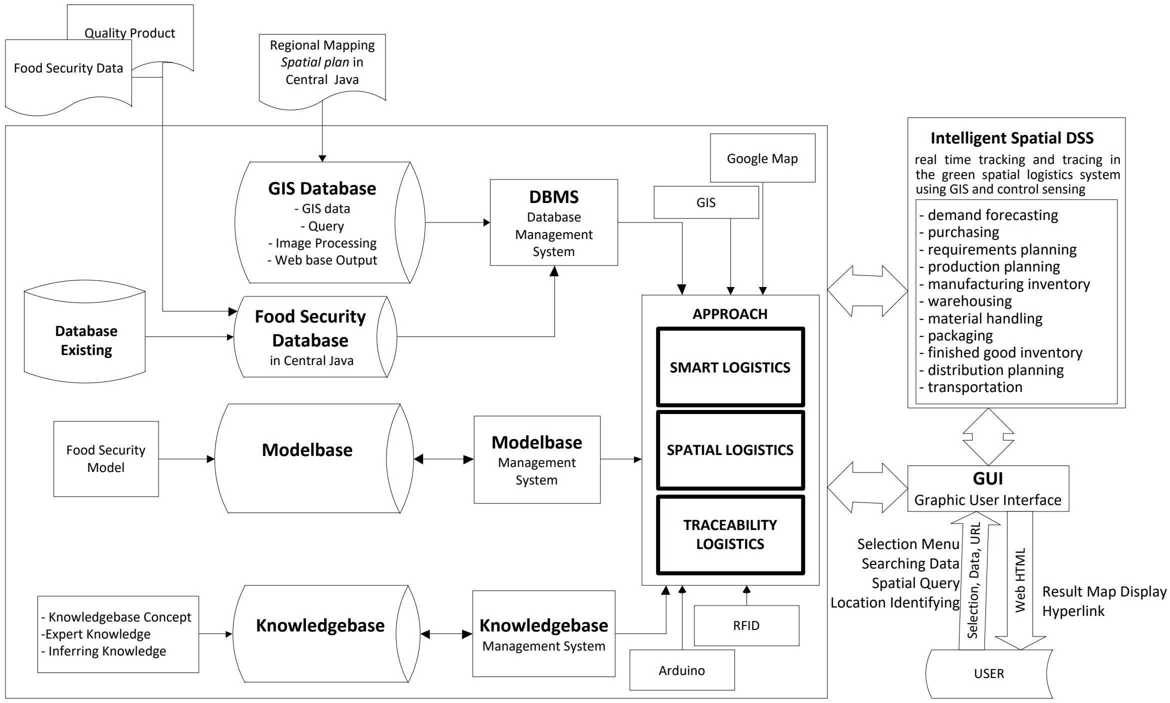

Figure 9. A new model framework for developing intelligent logistics systems

Data configuration, knowledge, modelbase, inference engine, central processing system, dialog management system as in Figure 10.

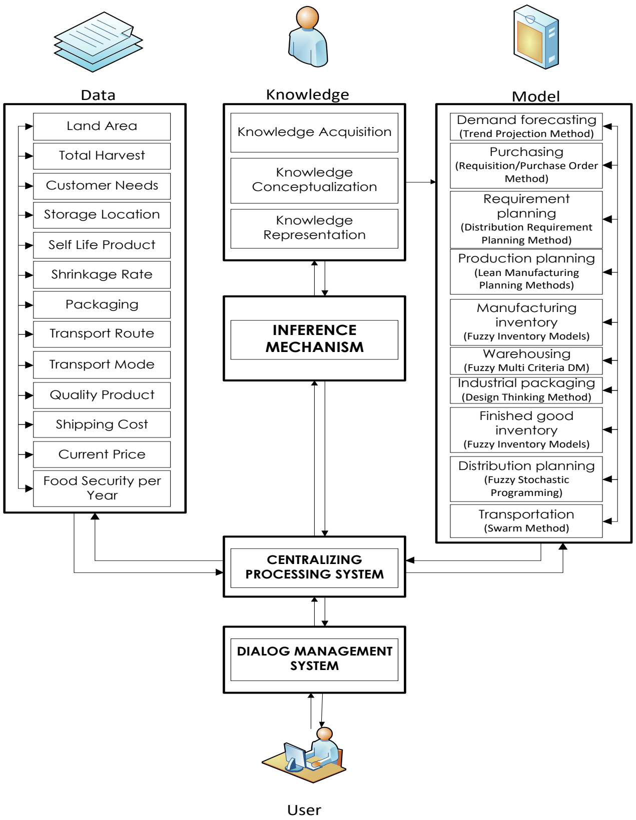

Figure 10. ISL-DSS configuration

7 Conclusions and recommendations

Horticultural commodities are perishable products. Post-harvesting quality decreases rapidly. So that post-harvest handling, distribution and delivery of products must be on time so that customer satisfaction increases. In the previous discussion, we can know that the logistic approach in food horticulture industrial product consists of smart logistics, spatial logistics and traceability logistics. Mishandling causes a decrease in product quality and product damage. Therefore, to minimize postharvest damage, a smart logistics system that is developed with a new framework can estimate from harvest time, select the right warehouse and distribution center, and choose the optimal shipping route

Articles reviewed are categorized into sensor RF, GPS systems for location and navigation, IoT and mobile applications. Most of the previous authors have applied the agricultural product approach. The dominant topic that we found in the literature is IoT, and tracking systems with RFID. Most of the literature focuses on agricultural logistics and there is a lack of discussion about food horticulture industrial product. We have designed and developed a new framework based on smart logistics for food horticulture industrial products. ISL-DSS is the name we use to refer to the new framework. ISL-DSS was developed using RFID and GPS navigation systems for tracking and tracing in real time. With this system, tracking horticulture food can be known quickly, precisely and accurately. The position of the truck at the time of distribution can be known with certainty. Regarding spatial logistics, we have set up a system that can automatically display surplus areas and other areas that are lacking, so that decision makers can easily determine the delivery of their products. The balance of supply and demand and disruption at several nodes in the supply chain is expected to facilitate the achievement of fair prices for food horticulture industrial product farmers.

The contribution of this paper is a new smart logistics framework that can map geospatial-based food security areas and real-time tracking systems using RFID and GPS tracking so that there is an increase in customer satisfaction. For the future agenda, we propose the development of smart logistics that are integrated with the agro-industrial institutional system.

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