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# Strategic Decision Support Systems for Short Supply Chain Development in the Agrifood Sector

**Abstract.** There has been an interest in short food supply chain recently which has stemed from the need of improving the flow both of products and information from suppliers to customers. Although, many tools have been developed in order to increase the performance of supply chain, they haven't succeeded in helping managers make strategic decisions concerning the operations of the short food supply one. In the agrifood sector, practitioners face short food supply chains as integrated systems that incorporate all the processes of traditional supply chains. Thus, Decision Support Systems (DSSs) are required to help managers handle these processes properly. Most of the existing studies focus on the improvement of individual firms or processes more than on the design of an entire food supply chain. So, the purpose of this paper is to propose such a strategic DSS model that based on the Strategic Information Systems Planning (SISP) process, could provide a holistic approach to effective decision making in short supply chain in the agrifood industry. This model supports product managers to improve the effectiveness of food supply operations.

**Keywords:** Strategic Information Systems Planning, Decision Support Systems, Short food supply chains, Logistics, Agrifood sector.

## Introduction

The importance of supply chain management is conceived as the core value of business model by those businesses which especially emphasize on customer service (Korpela and Tuominen, 1996). Due to the fact that the business environment is getting more and more turbulent an effective and timely decision making process is absolutely imperative that have to be implemented so that the objectives and business strategy would be opted (Alalwan, 2013). DSSs are Information Systems that help managers make decisions on the effective implementation of supply chain's processes taking into account firm's objectives and business strategy (Korpela and Tuominen, 1996).

In recent years, researchers have focused their attention on the supply chain performance in the agrifood sector. Despite the importance of agrifood industry for the development of any economy, researchers have ignored the field of food supply chains in the agrifood sector due to specific characteristics of food products (e.g. sustainability, quality, safety, integrity, and diversity). Food supply chains are complex and different sectors work together to bring products and services to the market and satisfy customers' requirements (Allaoui et al., 2018; Gunasekaran and Irani, 2014; Gunasekaran et al., 2014). Companies in food manufacturing always ignore the importance of combining new technologies with the existing operational process. Thus, there are only a few systems on the market that help managers to manage information and make decisions. A fast supply chain is required in food manufacturing because food products have unique characteristics such as a short expiry date and need real-time information when are stored. So, managers have to develop Information Systems that increase the efficiency and sustainability of supply chains (Lao et al., 2010).

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Short food supply chains are seamless of flow of information and products between suppliers and consumers. The importance of short food supply chains has increased as customers prefer consuming products produced by regional farmers. However, many operational problems stemming from supply chain requirements have emerged and the integration of food manufacturers, farmers, retailers, and consumers is limited. These problems stem from the fact that small farmers cannot focus their efforts on warehousing, transportation, logistics and marketing because these activities are invaluable for them (Craven, 2016; Pieter van Donk et al., 2008).

As a result, short food supply chains are not strategically designed and managers cannot implement policies that will support long-term and mutually beneficial relationships with their suppliers and customers. The strategic planning of DSSs can support managers to integrate Information Technology in short food supply chain's operations and help them to make more effective decisions. Thus, the purpose of this paper is to propose a strategic DSS model based on the Strategic Information Systems Planning process to provide a holistic approach to effective decision making in short supply chain in the agrifood industry.

The structure of this paper is the following: Section 2 presents the theoretical background regarding the contribution of short food supply chains and previous decision tools that have been developed. Section 3 analyzes the conceptual framework which is based on the literature review about strategic planning and DSS, as well as, DSS models in short food supply chains that are initially analyzed in Section 2. Finally, Section 4 provides recommendations for managers and suggestions for future research.

## Short Food Supply Chain

Researchers have been focusing their interest on short supply chains since 1990. Short food supply chains represent the flows of products and information between suppliers and customers. Furthermore, short food supply chains focus on the integration of product manufacturers, farmers, retailers and customers into a system and they do not only focus on the process of buying. Thus, short food supply chains are an alternative form of social organization which promotes the collaboration between different entities (Charatsari et al., 2018a; 2018b; Charatsari et al., 2017; Marsden et al., 2000; Sonnino and Marsden, 2006).

This collaboration could be achieved between one producer who directly sells food products and one buyer at a time. Also, in more complex short food supply chains groups of farmers collaboratively produce and distribute goods to consumers who do not belong to the same community (Charatsari et al., 2018). This collaboration aims to the improvement of performance and operations of short food supply chains. Customers demand environmentally friendly products and prefer to purchase food from regional farmers. They are aware of the production processes of food as well as food safety. As a result, farmers have to produce and sell products that meet local demand. On the other hand, retailers develop distribution systems that meet customers' requirements by delivering good quality products in appropriate quantities to the right place choosing the optimal path at the appropriate time with reduced costs (Aghazadeh, 2004; Craven, 2016; Validi et al., 2014). Food manufacturers, alongside with trends in markets and changes in consumer's preferences "force" them to adopt a production strategy which

meets customers' needs but allows them to produce at the lowest cost (Pieter van Donk et al., 2008).

Short food supply chains are characterized by many problems because local farmers produce and distribute products that sell in the urban area through short and local supply chains. Decision makers who are responsible for farming system design have to take factors such as the location of farms in urban areas, small available areas, high rents and high investments, high hiring costs and customers' demands into consideration when they plan models for farming system sizing or adapt existing farms with viable business models (Brulard et al., 2018). DSSs can be used to improve strategic or tactical actions of farmers or manage production systems. Furthermore, DSSs could improve distribution systems in order to increase logistics efficiency.The improvement of strategic or tactical actions, as well as the enhancement of production and distribution systems can be supported through information sharing between the users of DSSs. Information handling is important in food supply chains because food can easily deteriorate and have short expiry dates (Craven, 2016; Lao et al., 2010; Validi et al., 2014).

To conclude, many researchers have noticed the importance of Information Systems on supply chain performance but the developed systems do not provide holistic solutions to the above problems. These systems have not been designed using a strategic approach and they focus only on specific operations of food supply chains. Thus, decision makers should not ignore significant factors that affect the performance of supply chains such as changes in market conditions, changes in technology, market maturity, and product life cycle in order to produce innovative products (Childerhouse and Towill, 2002).

**Decision Making Models in Short Food Supply Chain**

A DSS is defined as "an interactive, flexible and adaptable Computer Based Information System which uses decision rules, models and model base as well as a database and the decision makers apply decisions in solving problems which would not be willing to manage visualization models per se" (Waxlax, 1993).

Another definition is based on the view that a DSS is "an interactive and adaptable Computer Based Information System which helps non-organized management problems" (Alyoubi, 2015; Moormann and Lochte-Holtgreven, 1993).

Previous surveys in supply chain management examined the significance of IT to support decision makers to achieve more efficient decisions and to increase the effectiveness of supply chains. Specifically, existing studies presented the benefits of using computer-based systems to support logistics management, especially in transportation and warehousing (Kengpol, 2008; Salam and Khan, 2016; Songbai et al., 2010). Limited surveys have been conducted in the areas of inventory and product forecasting (Accorsi et al., 2014; Moynihan et al., 1995).

Fanti et al. (2015) developed a DSS for operational and tactical decisions in the logistics sector. This system focuses on the evaluation of transportation performance. A database collects data related to products and services prices, resources and budget allocation, payroll costs, and cost per product. Then, simulation events such as demands, departures and arrivals of means of transportation at terminals as well as acquisitions

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and releases of resources by vehicles are repeated in order to evaluate the performance indices. Songbai et al. (2010) presented a DSS model for vehicle routing. In this model data related to demand, number of drivers, strength of vehicle, and mileage per vehicle are analyzed. Decision makers can use this model in order to make decisions regarding transportation personnel requirements, vehicle demands, and appropriate paths using optimization techniques. Kengpol (2008) developed a DSS for logistics distribution network. The system analyzes information such as GMS locations, and transportation costs of listed distribution centers and customers in order to generate alternative scenarios and evaluate them. The system estimates the delivery time, quality, and unexpected demand. It also calculates the transportation cost.

It is obvious that the developed DSSs ignore significant processes of strategic planning such as the identification of goals and objectives, the scanning of the external and internal environment, the execution and evaluation of supply chain's strategy. Likewise, the developed systems and models in short food supply chains have focused only on the technical aspect which gathers, optimizes and evaluates data, ignoring the strategic one. Validi et al. (2014) discussed a DSS for coordinated distribution systems. This system aims to improve logistics efficiency and reduce environmental impact. Location routing optimization techniques were used to reduce costs in the food distribution system. Other researchers have paid attention to crop production systems to help decision makers to manage production costs, uncertain labor supply or limited availability of land and water. Linear programming and network flows, have been used to generate and assess feasible crop rotations on a vegetable farm (Detlefsen and Jensen, 2007; Dogliotti et al., 2004). Lao et al. (2010) presented an integrative food handling system and a warehouse system but they also focused on the technical aspects. Allaoui et al. (2018) and Brulard et al. (2018) noticed that it is necessary to develop a holistic approach for strategic and tactical planning decisions taking into consideration specific goals and indices for performance evaluation of short food supply chains.

Table 1 summarizes different systems and models for short food supply chains as well as their functionalities.

[Insert Table 1 here]

Some common technical features are included in the previous systems. DSSs involve many basic components as follows. Firstly, the data component usually contains a Database Management System (DBMS). The DBMS involves modeling tools and general programming languages. Used data can either be internal or external, either cross-sectional data or time series. Organization's internal functions provide internal data as an input in the DBMS that concern resource allocation data, products and service prices, data related to costs such as payroll cost or cost per product and financial data. External data consider competition market share, government arrangements and anything that comes from external sources such as market research, government agencies, or the web. The data stored in the DSS database are used as input to the optimization processes associated with models. The DSS information is provided by other data files, which could be business' internal or external files. The next module is the model component, which includes a simulation model, a mathematical model as well as optimization algorithms to support the analysis of the impact of the selections on the system performances (Fanti et al., 2015; Yoo and Digman, 1987). Cyberphysical systems and service-oriented technology can be also used for data visualization in the

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logistics sector. These systems are useful because they provide real-time and multisource data (Illés et al., 2018; Zhang e al., 2010). Specifically, several methods, models, theories, and algorithms are implemented to develop and analyze the alternative decisions in DSS. Examples of these techniques are the intelligent analysis of data, the simulated and fuzzy modeling, the use of genetic algorithms and neural networks, the decision-making theory and the fuzzy theory (Kondratenko et al., 2014). As supply chain is characterized by a high level of automatization, interdisciplinarity and the need of flexible processes, companies have to integrate the heterogeneous systems and technologies in order to reach competitive production. This can be achieved with the use of smart technologies that integrate information level, material level and organization level with databases (Forkel and Schumann, 2017; Salmela and Ruohonen, 1992; Tu et al., 2018).

**Strategic DSS Model for Short Food Supply Chains**

In contrast to previous researchers, Yoo and Digman (1987) proposed a strategic DSS which includes four subsystems. In the first subsystem, named "Environmental Analysis Subsystem", decision makers gather information related to raw materials, inventory, economic conditions, production, industry, human resources, R & D, culture, marketing, technology, financial resources, market and government. This information is useful to forecast and analyze both the external and internal business environment. The staff, customers, managers, consultants as well as reports are the main sources of this information. In the second subsystem, named "Goal-setting Subsystem" a model base which generates alternatives models is included. One or more of them are selected according to identified goals and objectives as well as business's mission and purpose. The Goal-setting subsystem produces results that they should also be used as an input in the strategy operating subsystem. Additionally, the strategy operating subsystem uses the results of each phase of the strategic management process as an input for reparative actions and future effectiveness. The third subsystem named Decision Support Subsystem includes a DSS model base, application programs and a DSS database which maintain the flow of information within the system. This subsystem uses files on various transactions and files of historical, managerial and environmental data as an input for the DSS database. The DSS model base includes models which are useful for the solution of strategic problems. In the fourth subsystem named "Strategy Operating Subsystem", the decision maker identifies, evaluates and selects alternative strategies. Then, the selected strategy is implemented and evaluated based on information provided by the Decision Support Subsystem. This subsystem maintains each phase of strategic management process as it has been previously presented. Table 2 summarizes the functionalities of each subsystem.

[Insert Table 2 here]

The suggested model for short food supply chain that is based on the previous one includes four categories of subsystems, named; Situation Analysis Subsystem, Strategic Awareness Subsystem, Decision Support Subsystem and Strategic Implementation Planning Subsystem (Figure 1).

[Insert Figure 1 here]

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The first subsystem includes the identification of the problem in order to help managers to make the appropriate decisions. In order to maximize the efficiency of decisions, a situation analysis is conducted in order to analyze the existing business environment. Moreover, decision makers analyze the current external IT and business environment to determine new trends in IT. Regarding the internal environment, managers analyze strengths and weaknesses concerning production costs, level of demand, harvesting policies, prices, logistical structure and logistical costs, inventory management, transportation, warehousing, IS and materials handling.

The determination of threats and opportunities of the business environment is important for the sustainability of each supply chain. It becomes even more important in the agrifood sector because companies are highly interdependent. The awareness of developments in competitors, markets, business partners and products is considered a significant factor for the improvement of supply chain's performance. The analysis of this information requires a systematic scanning and a linkage with the needs of network companies (Fritz, 2009). In the agrifood sector, innovation increases the sustainability and performance of food supply chain. It is often driven by pressure from the external environment, and especially from resource scarcity, competition, customer demand, deregulation and isomorphism (Baregheh et al., 2012). So, decision makers should take these factors into consideration when they design DSSs that aim to improve supply chain's performance.

Furthermore, decision makers need information about distribution channels, economic situation of suppliers, relation demands to product characteristics, market segments where competitors are active and buy power, and quality of suppliers (Fritz, 2009; Manthou et al., 2004). Additionally, data as about the food production, rural economy, healthy eating and consumer values and the environment are also necessary (Volpentesta and Della Gala, 2013). However, decision makers should use the information sources of competition monitoring in the agrifood businesses through a focused, systematic and automated analysis of their content. Each company has to offer information about the results of the business and the analysis of its environment (Fritz, 2009).

In the second subsystem, managers have to identify important issues regarding the planning of short food supply chain, such as the determination of objectives and goals. These objectives are related to harvesting, food production, warehousing, customer service, inventory management, transportation and order processing.

In the third subsystem, Application programs, a Database and a Data Model are included. The results of the previous two subsystems can be used as an input to the DSS that interacts with the others. Therefore, managers can gather, store and reclaim the necessary information about external and internal environment and historical data, which will help them to create alternative scenarios. Then, managers will assess this information and they will select the best alternative, which will be developed in the next subsystem. The output of this subsystem includes alternative scenarios about material flow, costs, responsiveness and agility, food quality and sustainability, as well as cost and efficiency among other factors (Gold et al., 2017). Data can be stored for further working out and sensitivity analysis. The user interface helps decision maker with this process by providing a set of menus and question/ answer dialogues (Zviran, 1990). Alternative solutions are developed through mathematical models according to the

problem that has been determined. Furthermore, the models are created to analyze the alternatives. Next, the selection of the most suitable alternative follows. The analysis of alternative scenarios in DSS is based on several methods, models, theories and algorithms. Examples of these techniques are the intelligent analysis of data, the optimization techniques, the multicriteria methods and the fuzzy theory.

In the last subsystem, the identification of IT goals and objectives for the implementation of Information Systems in food supply chains are applied. Also, this subsystem includes the evaluation of goals and the execution of the technological strategy. Then, the definition of new IT architectures, processes, projects and the priorities over them are developed. Finally, activities concerning changes in management process, such as the implementation of supply chain's goals, the plans and the new processes, the action plan, and its evaluation are implemented (Brown, 2010; 2004; Dooley and O'Sullivan, 1999; Kamariotou and Kitsios, 2017a; 2017b; 2018; 2016; Kamariotou et al., 2017; Karthik et al., 2015; Kitsios and Kamariotou. 2018; 2016a; 2016b; Kitsios et al., 2018, Maharaj and Brown, 2015; Mentzas, 1997; Mirchandani and Lederer, 2014; Newkirk and Lederer, 2006; Newkirk et al., 2008). The output of this subsystem should give feedback into the Strategic Awareness Subsystem as well as into the other subsystems for corrective action and future effectiveness (Yoo and Digman, 1987). Table 3 summarizes the functionalities of each subsystem of the suggested model.

[Insert Table 3 here]

[Insert Figure 2 here]

The proposed model has few benefits in comparison with the previous ones which have been presented in Table 1. Current models have been implemented for specific functions such as transportation, vehicle routing and logistics distribution network. The proposed framework (Figure 2) is based on the strategic process of DSSs and it involves phases such as the identification of goals, the analysis of external and internal environment, and finally the formulation, execution and evaluation of IT strategy for short food supply chains. The identification of objectives, the analysis of business and IT environment, the organization of the planning team, the evaluation of opportunities, the improvement of business processes and the assessment of the process, are significant phases when managers formulate IT strategy for the development in DSSs. So, the proposed framework can be implemented by decision makers in each function of short supply chains in the agrifood sector.

The proposed model gives some benefits to managers in the agrifood sector. First, various strategic decision variables and steps can be considered comprehensively. Second, this model can be considered as an effective strategic management system which supports managers to make more effective and timely strategic and tactical decisions. Furthermore, the system provides updated information to managers as they can scan the business and IT environment. So, the environmental uncertainty is minimized as well as the risk under dynamic change. Another benefit is that the evaluation process is implemented in order to examine whether the strategy is being implemented and whether the goals are being achieved. If not, corrective action may be necessary to change the implementation activities or even to change the strategy itself.

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Finally, the system includes various levels of managers, so their participation enhances the increased use of the system and the effectiveness in decision making.

## Conclusions

The integration of strategic planning with decision making theory is an emerging research area especially for supply chain management. Short food supply chains are not strategically designed and managers cannot implement policies that will support long-term and mutually beneficial relationships with their suppliers and customers. The strategic planning of DSSs can support managers to integrate Information Technology in short food supply chain's operations and help them to make more effective decisions. The purpose of this paper was to propose a strategic DSS model based on the Strategic Information Systems Planning process to provide a holistic approach to effective decision making in short supply chain in the agrifood industry.

This model can significantly enhance the strategic decision making effectiveness. Careful planning is an important element to achieve the benefits of Strategic DSSs. The suggested model integrates the Strategic Information Systems Planning process and DSSs in short food supply chains and it contributes to the agrifood sector by increasing the communication among producers and consumers, supporting a redistribution of value for primary producers. Moreover, if producers in the agrifood sector use the DSS, the latter can give customers insight into sourcing and production methods enable producers to evaluate their customer base and increase the competitive advantage by achieving supply chain visibility and transparency (Volpentesta and Della Gala, 2013).

The contribution of this paper is twofold. Firstly, it helps academics as it bridges the literature gap regarding the integration between strategic planning processes and DSS. Secondly, it helps practitioners because it suggests a new model for decision makers with general applicability to various industries, including the agrifood sector. Planners and production managers in the agrifood sector are often aware of the described situation. However, the findings of this paper support general managers, and supply chain managers who can learn that there are obstacles in their endeavor to align supply chain's operations with customers' needs.

Implications for future research are suggested based on the identification of the phases that support managers' decision making. Academics and practitioners in the agrifood industry, as well as decision makers, should expand, optimize and test this model, to assess the efficiency of Strategic Information Systems Planning phases in the process of decision making. As the model has not been tested yet, the results of an exploratory study will be summed up in an expanded conceptual model for future research. Furthermore, future researchers could make interviews with farmers, retailers and product manufacturers in order to include specific indices for the evaluation of the IT strategy. Future studies in DSS research field and IS will urge new stimulations for successful Strategic DSSs development. The planning of DSSs depends on the needs for information of the existing organizational functions. In the future, DSSs will include tools based on environmental changes and business information needs, which will support decision makers so as to adapt their working practice for future demands.

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| **System/ model** | **Functionalities** | **Reference** |
|---|---|---|
| Coordinated distribution system | Location routing optimization techniques | Validi et al. (2014) |
| Warehouse system | Cost and time minimization<br>Real-time checking ability for visualizing the inventory status and for handling the food deterioration problems | Lao et al. (2010) |
| Integrative Food Handling System | RFID handles data such as forklift trucks, trolleys and pallets and static information<br>Sensors collect dynamic real-time data of the storage environment<br>Database storage | Lao et al. (2010) |
| Crop production system | Linear programming and network flows, have been used to generate and assess feasible crop rotations on a vegetable farm | Detlefsen and Jensen (2007)<br>Dogliotti et al. (2004) |

**Table 1:** Systems and models in Short Supply Chains

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| **Subsystems** | **Functionalities** |
|---|---|
| Environmental Analysis Subsystem | Gathering information related to raw materials, inventory, economic conditions, production, industry, human resources, R & D, culture, marketing, technology, financial resources, market and government. This information is useful to forecast and analyze both the external and internal business environment |
| | |
| Goal-setting Subsystem | Generating alternative models<br>Assessment of alternatives |
| | |
| Decision Support Subsystem | DSS model base, application programs and a DSS database |
| | |
| Strategy Operating Subsystem | Strategy execution |

**Table 2:** DSS model for strategic management

| **Subsystems** | **Functionalities** |
|---|---|
| Situation Analysis Subsystem | Identification of the problem<br>Analysis of Information Systems (IS) used in supply chain, logistical structure and logistical costs, the implementation of logistics functions such as inventory management, materials handling and transportation and the organizational structure<br>Analysis of distribution channels, economic situation of suppliers, relation demands to product characteristics, market segments where competitors are active and buying power, and quality of suppliers, food production, rural economy, healthy eating and consumer values and the environment |
| | |
| Strategic Awareness Subsystem | Identification of objectives related to customer service, transportation, order processing, inventory management and warehousing |
| | |
| Decision Support Subsystem | DSS model base, application programs and DSS database<br>Alternative decisions about drivers' and vehicle transportation, KPIs, cost rate, cost per unit of material flow, responsiveness and agility, cost and efficiency, food quality and sustainability |
| | |
| Strategic Implementation Planning Subsystem | Definition of new IT architectures, processes, projects and priorities<br>Strategy execution<br>Strategy evaluation |

**Table 3:** Strategic DSS functionalities for Short Food Supply Chain

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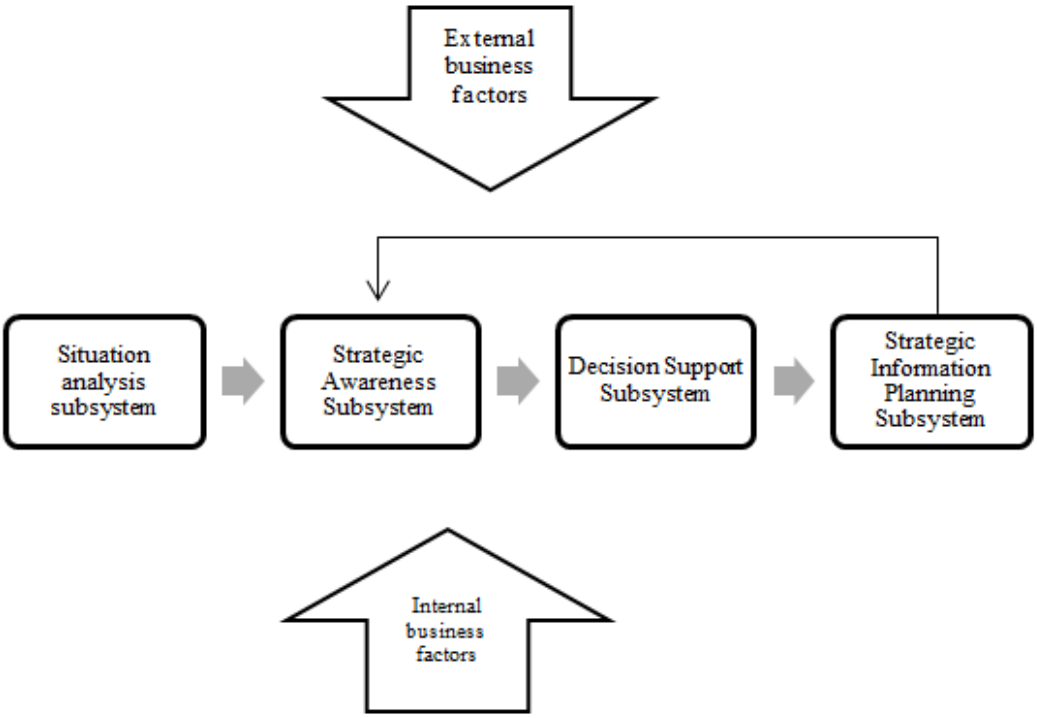


Figure 1. Strategic DSS Framework for Short Food Supply Chain

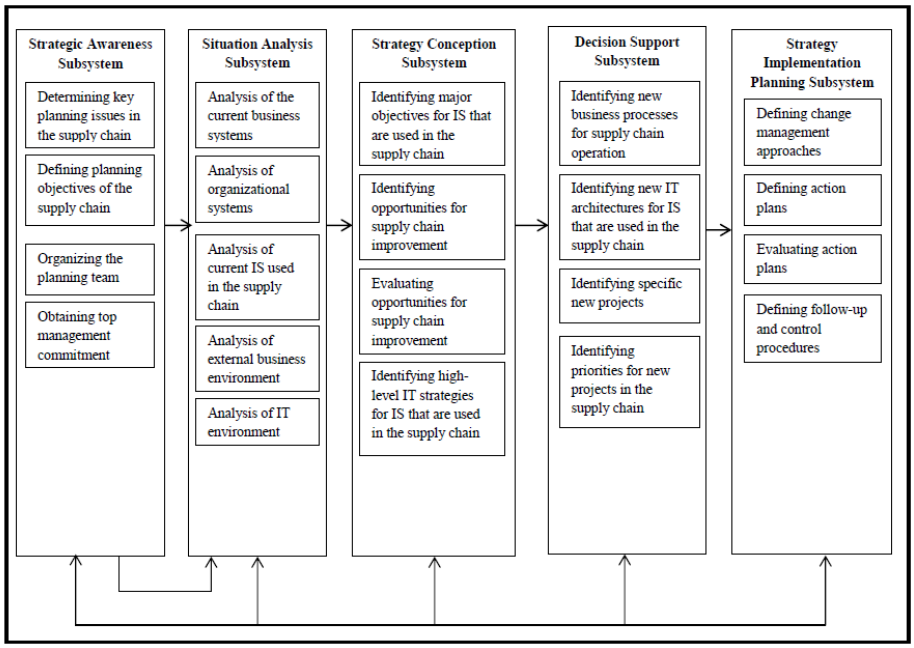


Figure 2. The functionalities of the proposed framework