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SUPPLY CHAINS IN AGRICULTURE AND FOOD PRODUCTION

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Abstract

The role of production and supply chain is increasing worldwide due of the growing consumer concerns over food safety and quality together with retailer demands for large volumes of consistent and reliable product. In developed countries, product losses (post harvest losses) are generally small during processing, storage and handling because of the efficiency of the equipment, better storage facilities, and control of critical variables by a skilled and trained staff. Recently, the concept of Agricultural and Food production has been under development as more effective and efficient management system is required for the food production planning, physical collection of primary produce from fields and homesteads, processing and storage at various levels, handling, packaging, and distribution of final product.

Key words**:** *agriculture, competitive farmers, food productions, logistical activity, supply chains*

INTRODUCTION

During the recent two decades, goods flow has been tremendously increased, even though the amount of goods remains at the steady state. Increased variety of goods, the just-in-time delivery system, low load rate, specialization and centralization of production systems globalization of marketing and seasonal variations are among the main challenges of logistics system which may lead to the necessity of developing effective logistics in the sector. Effective logistics and technologies are a critical success factors for both manufacturers and retailers.

Effective logistics requires delivering the right product, in the right quantity, in the right condition, to the right place, at the right time, for the right cost (and it has a positive impact on the success of the partners in the supply chain [13].

Food chain logistics is a significant component within logistics system as a whole. The food sector plays a significant role in economy being one of the main contributors to the GNP of many countries, particularly in developing countries. According to the European Commission (2010), the food and drink industry is one of Europe's most important and dynamic industrial sectors consisting of more than 300.000 companies which provide jobs for more than 4 million people.

The current trend in food value chain is characterized by three overriding features:

-greater concentration of farms, food industries, and wholesalers into smaller number with large sizes;

-the evolution of integrated supply chains linking producers and other stakeholders;

-ever increasing consumers demand for food quality and safety (food that is fresh, palatable, nutritious and safe) and animal welfare.

However, to date, the linking between logistics systems of the stakeholders in the agriculture and food supply chain is rather loose and fragmented. Even within individual firms, the vertical and internal integration as related to freight and logistics is loose, and therefore they are both economically and environmentally inefficient and not sustainable. In this regard effective and efficient logistics will be a critical success factor for both producers and retailers.

In addition to the increase in transport of agricultural and related goods in the recent decades, empty haulage is common in agricultural sector and the load capacity utilization level of vehicles is very low (it varies between 10 and 95%) [11]. Therefore, efficient use of vehicles could be among the

methods to reduce transport work and attenuate negative environmental impact.

The aforementioned constraints in the Agri-food chain necessitate the development of innovative logistics system taking into consideration, road and traffic conditions, climate, transport time and distance, and queuing at delivery points to:

-strengthen the economic competitiveness of stakeholders in the food supply chain;

-maintain quality or adding value of food and improve animal welfare;

-attenuate environmental impact.

In local food systems, the distribution infrastructure is partial, fragmented [5] and often inefficient, as in non-centralized distribution, the share of the transportation cost per unit of the product is relatively high. This is an area that offers great potential for improvement with potential benefits both to supplies and outlets. The studies focused on local food systems, were carried and these studies confirmed that coordination and logistics network integration in food supply chain promote positive improvements in logistics efficiency, environmental impacts, traceability of food quality, and the potential market for local food producers. Such improvement is important as developing food product traceability systems has been a major challenge both technically and economically [7; 9].

MATERIALS AND METHODS

In order to achieve a comprehensive analysis of the studied problem, the following research methods were used, such as: analysis of the specialization literatures, methods of comparative analysis, quantitative and qualitative methods and etc.

RESULTS AND DISCUSSIONS

The role of production and supply chain management is increasing worldwide due to the growing consumer concerns over food safety and quality together with retailer demands for large volumes of consistent and reliable product. In developed countries, product losses (post harvest losses) are generally small during processing, storage and handling because of the efficiency of the equipment, better storage facilities, and control of critical variables by a skilled and trained staff. Recently, the concept of Agricultural and Food Logistics has been under development as more effective and efficient management system is required for the food production planning, physical collection of primary produce from fields and homesteads, processing and storage at various levels, handling, packaging, and distribution of final product. In the food supply chain many stakeholders such as farmers, vendors/agents, wholesalers, rural retailers and suppliers and transporters are involved. At all levels, information flow and management of produce is essential to maintain the food quality throughout the chain (see Figure 1). The flow of input resources from farms to consumers needs to be described in detail and the constraints in each sub-process needs to be identified to develop appropriate solutions for logistics related problems.

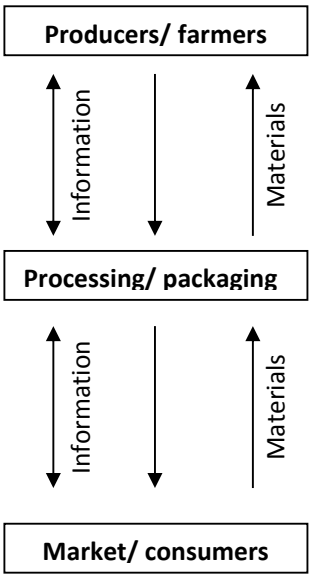

Fig. 1. Material, capital and information flow between producers (farmers) and consumers

It is important to note that lack of packaging facilities may be one of the constraints in the logistics system of small-scale farmers during the transition from subsistence to commercial farming. Significant post-harvest losses occur when especially vulnerable crops and fruits are subjected to mechanical damage.

Therefore management of packaging should be taken into consideration in the development of agricultural logistic systems.

The development of smallholder agriculture in developing countries is very sensitive to transport strategies. Many isolated farmers have little opportunity to escape poverty, as their potential marketing activities are hampered by inadequate or poor transport facilities. The rural transport planning must address the needs of people, as much as possible at the household level. Such well planed transport system enables smallholders make the transition from subsistence to small-scale commercial farming. This helps them to harvest and market crops more efficiently, reduces drudgery and, by facilitating communication, helps stimulate social integration and improve quality of life. Availability of road infrastructure (that includes feeder roads, tracks, and paths), storage facilities and transport services increases mobility and encourages production [10].

In agricultural systems of developing countries, animal power is used to replace human power and facilitate transport tasks. Animals are used to pull carts or sledges and as pack animals. At least ten species have been so domesticated, and their (absolute) capabilities depend primarily on body size. In relative terms, pack animals can carry 12 to 30 % of their body weight and can pull horizontally 40 to 60% of their body weight. These values depend on species, but field observations have returned higher values, probably at some cost of animals' well being.

In rural agricultural transport, in developing countries, special emphasis should be on collection, packaging, storage and distribution of agricultural primary products. Among the urgent tasks that formulated by the 8th plenary meeting of General Assembly of United Nation in June 1986, regarding transport and related infrastructure in developing countries, were improving and expanding the storage capacity, distribution and the marketing system; and development of transport and communications. Training of farmers (producers) may reduce loss due to harvest and temporarily storage, while other stake holders (for examples service providers) should take the responsibility to minimize loss. Loss in processing, storage and handling is high because of poor facilities and frequently inadequate knowledge of methods to care for the produce. Post-harvest losses run up to 40% varying from 15 to 25% on farm and 10 to 15% in trade. The high losses in developing countries represent not only a severe economic loss for the regions but also a major loss of nutrients to already malnourished populations [16].

The basic concept described in Figure 1 is also applicable for small-scale farmers in developing countries. However, the challenges of rural transport may be promoting the application of the concept of rural logistics; developing rural infrastructure (storage and packaging facilities, collection points and centers); developing efficient and effective management of product and information flow; developing strategies to promote best transport services. Some of the main issues that require immediate attention are: encouragement of private entrepreneurs to take the responsibility of service provider in storage, packaging and transport services; development of collection centre systems to promote marketing possibilities by facilitating coordinated transport services. Constraints associated with the flow and storage of produce and services in food and agribusiness exist in developing countries include lack of adequate storage facilities and knowledge of handling; poor processing, management and transport services.

In the absence of coordinated product delivery system, farmers themselves transport most of the produce, either as head loading or using pack animals, to both nearby and long distance markets. There are many constraints of such transport conditions: Amount of produce that can be transported by head loading or pack animals is limited; Transport time and distance is long; Drudgery on farmers; and Spoilage of produce during transport, etc. These constraints may result in reducing production and marketing opportunities for farmers, and consequently shortage of food for consumers. The reduction of spoilage and damages that could improve

the marketing value of the produce may necessitate the availability of adequate processing, packaging and storage facilities and management for each varieties of produce [10].

Logistics in abattoir chains: Animal supply and meat distribution

From effective logistics management point of view, an integrated approach from farm-to-table is required for effective control of food hazards which is a shared responsibility of producers, packers, processors, distributors, retailers, food service operators and consumers. This is important issue, because the increase in world population and improvement of living standard increase the meat consumption and, especially in developed countries, consumers prefer food with no additives or chemical residues; food exposed to minimal processing; safe and economic food.

The increasing interest in transparency of food supply chain leads food industries to develop, implement and maintain traceability systems that improve food supply management with positive implications for food safety and quality [15]. As animals stressing may damage meat quality, and lead to more contamination with pathogens, humane treatment of animals is getting more attention. Tracking slaughter animals from birth to finished products and tracking food shipments are becoming area of focus recently [15]. This helps to control the risk of animal disease, to reduce risk of tampering, to generate detail information on country of origin and animal welfare in the global food supply systems .

Animal identification and traceability as well as meat processing and distribution are some of the issues related to meat safety challenges. In the process of establishment of animal identification and tracking systems, countries should take the following into consideration: Selection of appropriate technology and precision requirements, maintenance of confidentiality, payment of costs, premises number and animal identification number, livestock feed and meat safety.

Meat spoilage may occur during processing, transportation and storage in market. An important aspect of fresh meat distribution and consumption is effective monitoring of time/ temperature conditions that affect both safety and overall meat quality. Appropriate packaging, transporting and storage of meat products are important, since meat products spoil in a relatively short time. Scientific attention on meat spoilage increased when shipment of large amounts of meat products started [7]. The EU legislation requires a maximum final meat temperature of 7°C before transport and the vehicle for meat transport must be provided with a good refrigerated system. The meat transport from cold storage to retail outlet and then to the consumer refrigerator are critical points for meat quality and safety. Animal collection from many farms and transporting to abattoirs requires a dynamic planning process taking into consideration stress inducing factors such as road conditions, climate and traffic conditions transport distance and time, queuing at the gate of abattoir for unloading [3].

Coordination and optimization in food distribution is a potential strategy to promote economically effective and environmentally sustainable food distribution. Some of the major possibilities for improved coordination and transport planning of agricultural goods transport are: possible coordination of meat and dairy product distribution through combined loading; possible coordination of fodder transport and grain transport through back-haulage; and partial or total optimization of vehicle fleet [11].

Uncoordinated and non optimum food transport systems are not energy efficient in local food systems, although there is considerable potential to increase the efficiency of energy use by organizing the food delivery system in new ways [2], using more energy efficient vehicles and/or introducing the production of biofuel in the region, increasing the utilization level of vehicles' capacity [11] and planning optimum routes for food collection and distribution systems.

Logistics in milk supply and dairy product distribution

Milk is an important agricultural produce that livestock keepers use for both consumption and market. The marketing of milk, surplus to family and farm needs, improves farm income, creates employment in processing, marketing and distribution and contributes to food security in rural and urban communities [10].

From transport services point of view, marketing of milk is difficult for producers who are living in scattered and isolated areas. These farmers can only sell butter to the urban areas and the remaining milk products are for home consumption. Delivery of fresh milk from long distance to urban by small-scale farmers is difficult for two main reasons. Firstly, the daily milk produce is relatively small to deliver to urban area and transporting perishable commodity over long distance is difficult. Secondly, milk quality deteriorates as it is transported over longer time without processing. The only available traditional processing is fermentation. To promote marketing of milk for small-scale farmers, it is necessary to develop strategies for on-farming chilling and collection of milk.

In developed nations, transport companies collect the milk from farms to collection points and thereafter transport to dairy plants [7]. The dairy industry provides a special milk container in which the farmers store the milk before the transporters collect the milk. Usually tank Lorries and tank trailers are used for collecting milk from farms and deliver to the nearest dairy. The milk supplied to dairy companies is processed and distributed to consumers. The dairy products such as milk, powder, edible fat and cheese are distributed by dairy product distributors. In such a process, the tank Lorries collect milk up to their full capacity and pump to the tank trailer which is usually placed in the best place as illustrated in Figure 2.

Optimizing the routes of milk collection enables to improve the transport distance and time.

The European Union (EU) limits the maximum level of milk production of member countries [11; 4]. The domestic consumption of dairy products in EU is as high as 90% of its milk production. And still, EU is a major player on the world dairy market and the EU dairy sector is expected to be market oriented in the future [4].

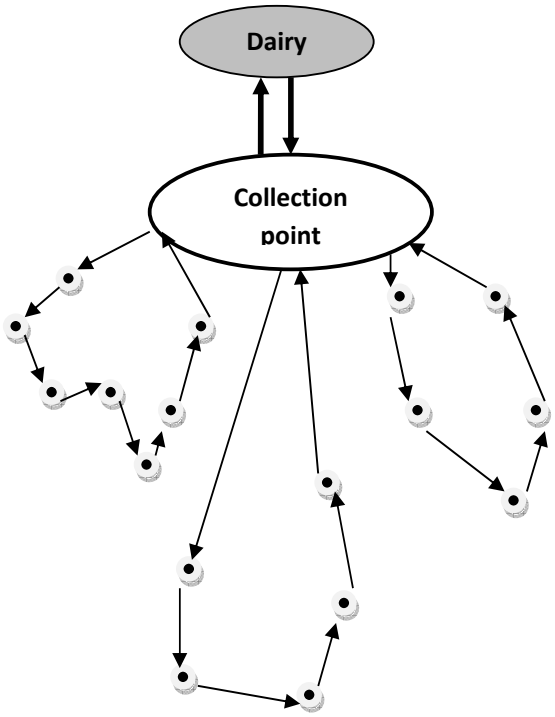

Fig. 2. Schematic presentation of possible way of milk collection from farms and delivery to the dairy industry

In developing countries individual traders or small scale agencies collect milk from producers and supply to collection centers. Milk may be carried to the collection points as shoulder slings, on bicycles, animal carts or small boats [10]. Advanced milk collection process found in developing countries begins with the producer delivering milk to a collection point where the volume is measured, or the milk weighed, recorded, and sometimes it is sampled and checked for quality. The milk is later transported, to a larger collection centre where, if possible, it is chilled. The collected milk is subsequently sent in bulk to a processing plant by truck. The time-delay from milking to delivery at the processing plant often exceeds five hours and is negatively affecting the quality of non-refrigerated milk, which is often rejected by dairy processing plants and is also not acceptable by consumers [10].

Logistics in grain supply chain

During the recent 20 years, goods flow has been tremendously increased, mainly not due

to the increase in the amount of goods, but due to other factors such as specialization and centralization of production systems and globalization of marketing [11]. Agricultural goods transport is a significant component within such increasing goods transport. For example about 13% of the international sea-borne trade is grain transport. Grain transport is the main component in agricultural transport in general and it includes grain transports from farm to depot/terminals, between farms, between terminals, from farms and terminals to fodder industries and mills and from terminals to ports for export.

Due to the legal limit of total weight of a lorry, the drivers have to estimate the load weight and it is not unusual that the actual loads exceed the legal maximum loads due to overloading.

In grain transport systems, back-hauling can be used for the delivery of fodder to farms [11]. Although the grain transport from farms is concentrated during the harvesting season, there is a possibility to coordinate the delivery of fertilizers and other means of production with grain transport i.e. the farmers can dry their grain and keep it at the farm till the time of delivery of means of production. The intensity of grain delivery at the harvest season causes capacity problems for vehicle resources and transport planning. Planning of production and orders at farm level, to minimize the seasonal effects, would improve the conditions for transport planning and coordination. In developing countries, grain collectors are responsible for commercializing the grain within the country and exporting surplus. Even though, these grain collectors are considered as informal by the government body in some countries, they served an important role in the grain supply chain. For commercializing grain, it can be collected from individual farmers to a critical size that can be transported cheaply for retail locally, and the surpluses can be exported at premium prices elsewhere [10].

Logistics in local food supply chain

In the agriculture sector, globalization of food production has considerably influenced the food supply system by increasing distance the food has to be transported to reach consumers. This situation not only has increased emissions of greenhouse gases but also has reduced the relationship between local food producers and consumers, affecting local food producers, their environment and culture. In terms of distance, locally produced food can be characterized by the proximity of production place to the consumers and usually there is a limit. In addition to geographical distance, locally produced food is also considered as food which meets a number of criteria such as animal welfare, employment, fair trading relations, producer profitability, health, cultural and environmental issues [3]. Currently it is observed that customers have been motivated (to purchase the local food) by contributing positively to the ecosystem (a more altruistic reason) and by food quality and pleasure (a more hedonistic reason) [6;3].

Coordination and network integration in local food supply chain increases logistics efficiency, potential market, access to information and reduces environmental impact [3;11]. In the food distribution system of local food producers, logistics is fragmented and inefficient compromising the sustainability of localized systems and this requires improvement. Therefore forming the best collection and distribution centers for locally produced food is very important. Such location decisions should be supported technically since the location decisions have the dynamic implication over time [7]. Therefore, in the process of developing improved logistics systems in the local food supply chain, detailed location analysis (mapping and clustering producers and determining optimum location of collection and/or distribution centers) and route analysis (creating optimized routes for product collection and distribution, simulating route distance and delivery time) are very essential [3].

Potential producers of local food want to expand their sales area. However, increasing sales of locally produced food, on small scale bases, needs to overcome the main problems such as low size of production and more volatility of market price and high seasonality of food products on market, inadequate packing and storage facilities, limited or no

means of transport and limited knowledge of potential market. These problems can be overcome mainly if the local food systems can be embraced by dominant food supermarket and superstore chains and this can be facilitated by integrating the local food system into large scale food distribution channels.

Such integration in local food systems plays a key role in sharing information and scarce/expensive resources as it enables the stake holders get access to the right information at the right time. Well organized information concerning local food is important to satisfy the increasing demand of consumers to have good knowledge and information of the food origin and how it is handled and transported. The logistics network integration is also helpful in creating favorable situation for interested researchers. For example, well established data management might come into existence which in turn helps to conduct more detail studies on the logistics activities enabling further improvements that increase the sustainability of local food systems [3]. The integration also facilitates improved traceability system which depends on information connectivity and provides an added layer of food security which might be established more easily within integrated systems [9;1]. One apparent advantage of such a co-ordination and logistics network integration is that each stakeholder in the network concentrates on its specialty and improves its productivity in both quality and quantity [2].

Studies [3] indicate that in local food systems, producers of local food run mostly their own vehicles and about half of the vehicle capacity is unutilized. Therefore, the coordination and logistics network integration in local food system leads towards positive environmental impact by: (I) Reducing number of vehicles to be deployed for produce collection and distribution of local food products; (II) Increasing the utilization level of vehicle loading capacity; (III) Reducing travel distance, time and fuel by following optimized routes where possible; (IV) Reducing green house gas emissions (as the consequence of the facts mentioned above).

CONCLUSIONS

From effective logistics management point of view, an integrated approach from farm-to-table is required for effective control of food hazards which is a shared responsibility of producers, packers, processors, distributors, retailers, food service operators and consumers. Therefore, tracking slaughter animals from birth to finished products and tracking food shipments are becoming area of focus recently. Studies indicated that, in the food and agriculture supply chains, there are potential area of logistics related improvements in terms of reducing transport routes, distance and time; reducing emission from vehicles; improving the packaging of food products and improving transport services. This can be implemented in collecting, storing and transporting slaughter animals, meat products, milk and dairy products, grain and related products.

Agriculture and food supply chain is specific and complex area with important responsibilities. There are two main demands:

a. Maintaining food quality and safety including animal welfare along the supply chain, and

b. Reducing logistics cost.

The concept of *Agricultural and Food Logistics* is slowly emerging as one of the important types of logistics to reach the requirements for maintaining quality of raw materials for food and food products or even to perform value adding activities in the food supply chain. The questions related to post harvest loss, which ranges up to 70% in developing countries, animal welfare during transport, and the concern of origin of food staffs and how they are produced and processed are societal questions.

In relation to globalization of marketing system, it is a vital for all stakeholders to reduce logistics cost in order to increase their economic competitiveness. Therefore, development of effective and efficient *Agricultural and Food Logistics* is necessary and essential.

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