Supply chain design for agriculture product in Viet Nam: A case study of Sturgeon in Kon Tum province

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Abstract. Emerged as a new branch for Vietnam aquaculture industry, sturgeon farming in Kon Plong district, Kon Tum province with advantages coming from cool weather condition all year round, hydropower reservoirs for water resources is expected to exploit the potential and diversify tourism products of the district. Meanwhile, there is no effective supply chain for this kind of fish causing by the uncertainties in supply sources, no stable logistics and consumption market, which is easily harmed by illegal sturgeon import. This study, then, try to propose some improvements for the current status by applying techniques in value chain and demand analysis, products, process, supply chain, transportation system design, facilities planning. The paper can be a reference for local authorizes implement to develop policies in sturgeon aquaculture.

Keywords: maximum five keywords should be included

1. INTRODUCTION

The sturgeon, listed in the top of ancient and valuable world fish, has been emerged as a potential branch for Vietnam aquaculture industry lately. The demand for sturgeon products worldwide exceeds the supply capacity bringing lots of opportunities for new players. The quantity of wild sturgeon fisheries, however, tends to be reduced and strictly controlled due to risk of extinction caused by overfishing, habitant loss, water pollution and other environmental issues. Sturgeon farming, then, is expected to be an effective way to restock and create new market sectors.

There are two main types of sturgeon products having been purchased in the global markets. Sturgeon meat is firm, white and boneless, which can be consumed in fresh (whole fish, bullet and fillet) or processed (smoked, frozen or marinated) forms. Ho Chi Minh and some other big cities in Vietnam require 1,000 tons of this kind of fish with high prices (retail price: 300,000 VND/kg, price ordered by restaurants, hotels: 270,000 VND/kg). Caviar, or sturgeon roe known as "Black Gold", is one of the world's most luxury foods due to its precious, rare and nutritional characteristics. While the annual caviar demand is 3,000 tons globally, the total output is only 100 tons (3%). As a result, the cost of one kilogram caviar can reach to 2,000-10,000 USD/kg.

Located in the Vietnam's central highlands, Kon Plong plateau with cool weather all the year round and clean water resources from hydropower reservoirs has been proved to have good conditions for developing sturgeon aquaculture. Being farmed in cool temperature instead of cold one (average 26^{o}C), the sturgeon growth rate is nearly three times faster than in Russia. It takes more than ten years of farming before harvesting sturgeon eggs in cold countries. In Vietnam, this specie's caviar can be collected after only 2-5 years. The more time being saved for sturgeon aquaculture, the more cost being reduced and the more competitive the market creates.

The contribution of this paper includes the value chain analysis for stating the current problem of sturgeon production the Kon Plong district. The paper also proposes the value chain and supply chain network including facility location for factory and hub along with existing farms and markets. The product design and factory planning, then, are covered in this paper to exploit the resources and approach to potential markets.

2. LITERATURE REVIEW

As one of the most ancient and valuable fish, sturgeon requires many aquaculture standards in terms of food, water resources, and temperature, especially in tropical climates. Different growing stages ask for different technical requirements. Mims et al. (2002) covered some technological aspects in farming and producing sturgeon. The paper includes indices and parameters for controlling each of the sturgeon growing phases from milt and egg to grow-out stage. Water requirements and diseases are studied for providing technological farming information. A market study in US of sturgeon meat and caviar is also conducted in the paper.

Providing a global overview of the world sturgeon caviar market, Bronzi and Rosenthal (2014) showed in their work the changes in the fish production scenario. Due to the CITES regulation, there is a reduction in figures of sturgeon fisheries along with the increase in farmed sturgeon. The aquaculture industry, therefore, is expected to restock the market. Caviar production forecasting was involved for the year 2016 to conduct a future look the markets.

Being a leader in field of producing sturgeon Vietnam, Vietnam Sturgeon Group provides models and information for farming, processing the fish and studying the market. Six key success factors are listed in the website for facilitating the sturgeon farms. Basing on product ranges offered by "Caviar de Duc", the most brands in the sturgeon product in Vietnam, the ranges of sturgeon product in local and export markets can be observed. The Vietnam market, therefore, mainly consumed fresh forms of sturgeon (whole fish). Other product ranges (caviar, fillet, and smoked fillet) with value added are potential for both markets.

The relationship between components in a supply chain are best described by value creation in value chain (Martel & Klibi, 2016). Sausman et al. (2015) stated that all components of the value chain effect adversely on the value creation of the supply chain. This work also mentioned the importance of all actors' involvement in whole value chain analysis rather than any single one. In the paper of Macfadyen et al. (2012), an aquaculture value chain analysis is obtained by drawing more attentions to the percentage of sectors' contribution than the cost or revenues created in the supply chain.

The decisions of facility locations have a huge impact on a supply chain's performance due to their relative costs for shutting down or moving a plant, transportation, and inventory. Good location decisions will improve the efficiency of a supply chain by reducing those excessive costs (Chopra & Meindl, 2007; Daskin, Snyder, & Berger, 2005). The location, therefore, is crucial for any supply chain to have stable development.

Russell and Taylor-Iii (2008) discussed the effect of new products and services into business in their work. Product design, then, is needed to be managed due to its market influence. Technology, moreover, is mentioned to be a key factor for controlling the cost, speed, quality, operations' flexibility, and plant's capacity. To make a good decision, the manager must cover all factors before further drawing the best choice.

The "Facilities planning" book written by Tompkins et al. (2010) stated the importance of facilities planning for factory strategies. The concept of facility planning is defined based on facility system, layout and material handling. Designing an effective facility for manufacture reduces the operation and improves the production.

2. PROBLEM STATEMENT

To study about the current status of sturgeon supply chain in Kon Plong district, field trips were taken with observations and interviewing the local government and famers. The records of current value chain and production are used for stating problems in the existing supply chain.

2.1 Current Kon Plong Value Chain Analysis

There are two main actors involved in the current value chain, farmer and government. The farmer, then, contributes the majority percent of the whole chain. In Kon Plong, only two sturgeon farms left recently due to the market's pressure. Those farms take part in all processes of the chain from input to distribution and consumption. Government, on the other hand, enrolls only in the input of the chain, accounting for about 20 percent.

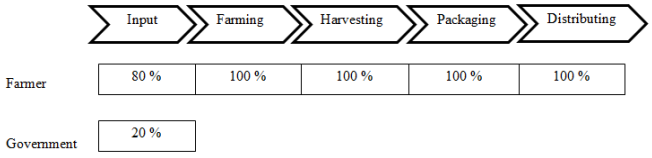

Figure 1: The current sturgeon value chain in Kon Plong.

2.1.1 Input

A project of cold-water fish nourishment in the Kon Plong district, Kon Tum province has been launched for supporting the farmer. By giving the investment, building roads, doing land, water resources investigations, tax reduction and technologies transfer, the government aims to help and encourage the locals to do their business.

The farmer, then, pay their own investment on buying input material and constructing infrastructure for the

sturgeon production

- Breed: imported from Ukraine
- Food: fish meal transported from Binh Duong province. Another additional source is worms purchased from the local cooperative namely Lan Rung. To achieve 1 kilogram of sturgeon weight, the fish has to consume 1.5 kilograms of food (ratio 1:1.5).
- Medicine
- Machine and equipment: installing some tool for the farming process such as water filter, pump and nets

2.1.2 Farming

This process depends mainly on the farmer's experience. The survival rate of sturgeon is about 80%. Different growing period gives different requirements of treatment in terms of food amount, feeding times and percentage of protein.

2.1.3 Harvesting

The harvesting method is manual one. When there is a large demand, water will be discharged from the ponds and nets are used for catching in batches. Otherwise, single catching with small nets is applied.

2.1.3 Packaging

Before being transported to the restaurant, the fish is put in Styrofoam boxes along with oxygen bags for preservation purposes during the trips. This method is applied for maximum eight to ten hours of transporting.

2.1.3 Distributing

To utilizing the water resources, the farm is located in the mountain area with slopes (about 10 kilometers away from the hub of the district), which causes difficulties for transportation. The sturgeon, then, is transported and consumed by three following types:

- Purchased by tourists: tourists come to the farm for buying the fish
- Local restaurant: boxes of sturgeon are shipped by motorbikes to the local demand in restaurants
- Personal restaurant: one out of two farm's owners has opened his own restaurant in Da Nang city. The sturgeon, then, is mainly distributed to that restaurant for consumption.

2.2 Sturgeon production in Kon Plong district

Started in 2010, sturgeon aquaculture in Kon Plong district harvested the first yield in 2012. The Kon Plong sturgeon production figures until 2015 recorded by Kon Plong Ministry of Agriculture and Rural Development offices are given in figure 2.

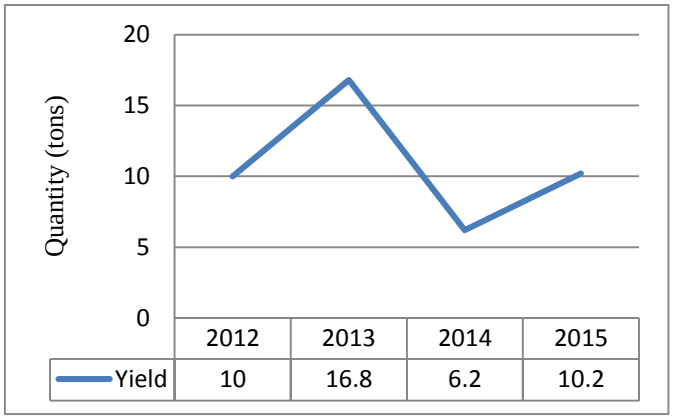

Figure 2: Kon Plong sturgeon aquaculture yield from 2012 to 2015.

Due to the uncertainties in demand, the district sturgeon production yield is unstable. In recent years, the limitations in markets and effects of illegal imports forced the farms' owners to narrow or even shut down their business. Consequently, the number of sturgeon farms in Kon Plong has been reduced from four initially to only two recently. There are, however, 89 potential locations for cold-water aquaculture with around 94.7 hectares in total water surface area. One owner, then, opened his own restaurant as a new market for tackling this output problem.

The sturgeon, on the other hand, has gone through no any processes for adding value. All the fish, after being harvested, is transported and sold directly to the customers as fresh and whole one. It, therefore, limits the potential markets in both domestic and export domains.

2.3 Problem Statement

Designed to exploit the natural and human resources of the district, Kon Plong sturgeon aquaculture industry, however, has to struggle with lots of challenges coming from local markets and farming technologies.

The weak and limited market, especially domestic one, has been raised to be the most concern in the industry. Lots of local farmers have to cope with the pressures coming from illegal import. The Vietnam Sturgeon Corporation estimated that up to 15 tons of this specie is delivered daily to the country (5,000 tons/year) without any Government permission. The local supplies, meanwhile, can provide only 1,000 tons annually (meeting about 20% of the country demand). The price of one kilogram of local fresh

sturgeon produced nearly triples those figures imported from China (70,000-80,000 VND/kg). Moreover, the potential of caviar, the highest commercial product can be obtained from this fish, has not yet been exploited well, especially in domestic market. In Kon Plong district, sturgeon roe has just been discovered then not yet been commercialized. Both domestic and export markets, therefore, are promising for farmers, investors to conquer.

Technological bottleneck is the second issue for scientists, farmers to tackle. Sturgeon production requires large inland spaces for cage system, natural water resources from hydropower reservoirs or hydroelectric lakes, strict nutrition control and preservation method to obtain high quality standards and help the fish to adapt to the Vietnam tropical climate. This kind of fish need lots of cares in crucial breeding stages such as hibernation, hatching and technologies in processing, preserving its products.

The third problem needed to be considered is lacking of effective supply chain (uncertainties in supply sources, no stable logistics and consumption market), which is easily harmed by illegal sturgeon import. For the case of Kon Plong district, there are only two sturgeon farms left in the district after the domestic market dominance from Chinese suppliers. In 2015, the yield and total value of the whole district were 10.2 tons and 3,060 million respectively. Therefore, laboratory, breeding farms, cold storage and manufacturing plants for sturgeon products (caviar, meat and others) with advanced technologies are needed to be facilitated as a chain to guarantee, maintain the quality and satisfy the customer's requirements.

3. PROPOSED VALUE CHAIN AND SUPPLY CHAIN NETWORK

3.1 Proposed Value Chain

After studying the value chain and stating problems of the current aquaculture in the district, a new value chain is proposed with more actors involved.

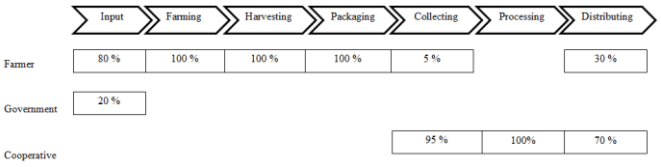

Figure 3: The proposed value chain.

The cooperative actor is suggested to join the value chain and responsible for processing the fish to create value added. 30% of the total quantity will be kept for supplying traditional markets in Kon Tum, Gia Lai, Da Nang, Quang Ngai, Binh Dinh provinces. The other 70% will be shipped to hub before delivering to plant run by a cooperative for producing other product ranges and thus aim for potential markets (Ha Noi, Ho Chi Minh City and export).

3.2 Proposed Supply Chain Network

To overcome the problems in the current supply chain network, a proposed one is constructed by finding locations of facilities along with minimizing the distances between each pairs. The network general framework, then, is proposed as given in figure 4.

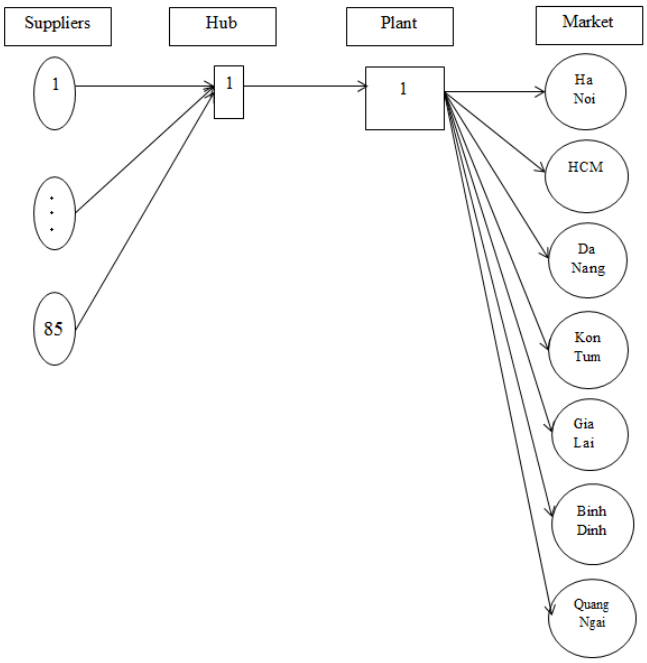

Figure 4: General framework of the sturgeon supply chain network for Kon Plong district.

The cold-water fish nourishment project launched by Kon Plong Ministry of Agriculture and Rural Development offices has estimated that there are 85 nourishment positions located in 6 communes, of which 84 positions in the form of flowing water and others in the water surface of reservoir. The total water surface area for nourishing fish is 87.69 hectares. When the resource have exploited well, 85 potential positions will become the sturgeon supplier.

Kon Plong district has many mountains and hills with slopes causing obstacles in transporting especially in hard weather conditions. A hub, thus, is needed to be constructed for gathering and storing sturgeon before being delivered to the factory for processing. The output goods from the factory, then, are distributed into the markets.

There are five traditional markets located in provinces nearby, namely Da Nang, Kon Tum, Gia Lai, Binh Dinh,

and Quang Ngai. Besides, two big cities, Ha Noi and Ho Chi Minh, with large population and demand become potential markets for the output.

3.3 Location model and Results

To find out the location of the hub and plant (new facilities) with minimized distance travelled from stated suppliers and markets (existing facilities), Multi-facility Euclidean Minisum location model (Tompkins et al., 2010) is chosen. The parameters, variables and objective function of the model are identified for solving the problem. The network conformation problem relates to input data, including:

- Input variables:

n number of new facility

m number of existing facility

$P_i = (a_i, b_i)$ location of new facility i

w_{ji} "weight" associated with travel between new facility j and existing facility i

v_{jk} "weight" associated with travel between new facility j and new facility k

- Decision variables:

$X_j = (x_j, y_j)$ location of the new facility j

The model is derived to minimize the weighted sum of travel between pairs of new and existing facilities with the assumptions that the "weight" associated with travel between each pair of facility is proportional to the quantity transported among them.

$$Minimize \ f\big((x_1, y_1), \dots, (x_n, y_n)\big) = \sum_{1 \le j < k \le n} v_{jk} \sqrt{(x_j - x_k)^2 + (y_j - y_k)^2} + \sum_{j=1}^{n} \sum_{i=1}^{m} w_{ji} \sqrt{(x_j - a_i)^2 + (y_j - b_i)^2}$$

The first term of the two objective functions aims to minimize the distance between the new facilities. The other term is to minimize the distance between new and existing facilities.

After identifying longitude and latitude of the 92 existing facilities (85 points for suppliers and 7 for market), all the points are converted into decimal values by the help of a utility [1] developed by Federal Communications Commission of United States. The origin (x=0, y=0) is located in the Gulf of Guinea in the Atlantic Ocean.

The farmed sturgeon after being harvested and packaged is moved to the hub from each supplier points. The shipped quantity of sturgeon from each supplier assumed to be the production yield of each farm.

From the hub to the plant, the quantity transferred equals to 6138.3 tons annually. After being processed, the fish are distributed into markets with different quantity.

Based on the capacity of the transportation means, the number of travelling trips from each pair of facilities is calculated by dividing the quantity moved with the minimum capacity of each trip.

Due to the difficulties in transporting activities of Kon Plong district and large number of points, the hub and the plant should be located closer the supplier and the customer than near together. The priority of travelling distance from the existing facilities (45% each) should be higher than between the new ones (10%). The weight of each travelling distance is calculated by multiplying the number of trips with priority index.

The result of the model, then, is given in table 1.

Table 1: Location results for hub and plant.

	Location
Hub	Mang Canh, Kon Plong, Kon Tum, Viet Nam (14.6924081, 108.2942) Latitude: 14°41'33.7", Longitude: 108°17'39.1"
Plant	Dak Koi, Kon Ray, Kon Tum Viet Nam (14.69551, 108.20079) Latitude: 14°41'43.8", Longitude: 108°12'02.9"

3. STURGEON PRODUCT DESIGN AND FACILITIES PLANNING

3.1 Sturgeon Product Design

According to Vietnam Sturgeon Group, there are two main sturgeon products – caviar and meat has consumed both globally and locally. The caviar, highest achieved value of sturgeon product, has a huge demand. Kon Plong district, however, have not produce this kind of product due to the time and cost consuming (more than 2 years of farming taken for a mature female fish yields eggs). Those consuming may lead to loses when the demand is unstable.

[1] http://transition.fcc.gov/mb/audio/bickel/DDDMMSS-decimal.html

The only product has been purchased is live fish with nearly no value added for processing.

Potential markets in and outside Vietnam, however, prefer processed sturgeon. Russia demand, for instance, is recorded to be 200 million tons, ten times more than total official imports plus domestic production according to a GAIN report. Mims et al. (2002) showed that in U.S. market, sturgeon meat is presented into two forms – bullet and fillet.

Basing on the market research in Sturgeon Vietnam Group and "Caviar de Duc" company, three products are proposed for conducting the plant along with live fish:

- Caviar
- Fillet
- Smoked fillet

Applying the Hazard Analysis Critical Control Point (HACCP) standards and procedure in fish processing for three selected products, the plant will obtain high product quality. The obstacles in transportation and inventory pressure will be reduced due to the increasing in life span. Some wastes from processing the fish such as head, bones, and viscera can be utilized or sold for fish meal, gelatins or fertilizer production.

3.2 Facility Planning

After studying the process of each sturgeon product range and the resources of the district, the capacity of the plant is calculated. With 94.7 hectares of total water surface area for farming cold-fish water, the annual sturgeon yield figures are derived to estimate the input and output of each process in the plant. List of required machines (dimension and capacity) and flows between each stage, then, are conducted for designing layout of the factory.

With strict requirements in preservation, live sturgeon needs a high equipped warehouse for storing before being shipped into factories or customers. Some techniques and methods for both transporting and stocking the aquaculture products such as deep freeze are considered.

4. CONCLUSION

Listed in the top ten countries of caviar production, Vietnam and its sturgeon aquaculture industry is expected to not only exploit the natural and human resources but also open a new branch for the country economy. Kon Plong district, with the advantages of the weather and water conditions, launched the project on nourishment cold-water fish, especially sturgeon, to create jobs, raise incomes and improve living standards of the locals. The limited market with small demand, however, puts sturgeon farmers into challenges for finding the output of production. The lack of product variety, on the other hand, prevents them from reaching potential markets.

Providing a better look of the current supply chain in Kon Plong district, value chain analysis has been applied for problem statement. The proposed value chain, then, expects more actor involvement to create more values along the chain. Three products are suggested in this paper for increasing the variety, value and the competition of the Kon Plong sturgeon brands in both traditional and potential markets. Hub and factory are mentioned in terms of location and planning to build the linkages among the components in the supply chain.

Further work is welcomed for studying on topics of sturgeon and its products market research to understand scenarios and forecast the demand. More studies on implementing the stochastic model with demand uncertainties are highly recommended to have another approach to tackle the issue.

The work from this paper is highly recommended for implementation in the district. The local authority should consider for applying the suggestions stated in the paper. Other aquaculture products meetings the similar problems with the sturgeon farming can refer to this paper for references.

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