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Market chain analysis of fish products in Cambodia

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Declaration

I hereby declare that the diploma thesis called "Market chain analysis of fish product in Cambodia" is my own work and effort. The data and results presented were obtained by me during the conduct of the research. Where other sources of information were used, they were appropriately acknowledge in the thesis and are found in the List of References.

In Prague on 22th April 2016 _____

Abstract

Food security is one of the sustainable development goals. The important part of food security is properly working value chain of food commodities to secure that food will come to consumer in adequate state for consummation. In Cambodia at least 82.1% of animal proteins are supplied by fish production and 86 % of Cambodian land is in the catchment area of the Mekong River which is 10th biggest river of the world. Fish production in Cambodia has a long history and is the fastest growing segment in this country. The study was analysing the value chain of fish products in Cambodia, specifically focusing on the following species: *Henicorhynchus/Cirrhinus siamensis, Henicorhynchus/Cirrhinus lobatus, Pangasius bocourti, Pangasius hypophthalmus, Oreochromis niloticus, Channa striata, Clarias batrachus and Anabas testudines.* The research focused on identification of all the segments of their value chain and analyzed their drawbacks and positives comparing added value and price levels between provinces and rainy and dry seasons. The primary data collection was based on six different questionnaires for each segment of value chain and interviews with 117 respondents from following groups: fishermen, fish farmers, intermediaries, processors, retailers and consumers. There have been found significant statistical differences in price levels of following species, Tilapia, Siamese Carp and Common Carp and also for fish paste in dependency on province. It was identified added value from each value chain segment; in Kampong Thom the average added value is 49.96%, in Kampong Chhnang 62.86% and in Phnom Penh 57.74% difference. The thesis also maps the geographical channels of supply chain for specified fish species and provides recommendations for improvements.

Key words: Value chain, fish products, fish storage, fish processing, added value, province comparison

Summary

List of Abbreviations'

Value Chain Analysis	VCA
Small Scale Fisheries	SSF
Exclusive Economic Zone	EEZ
Other Aquatic Animals	OAA
Fishery Administery in Cambodia	FiA

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1 Introduction

Fish production in Cambodia is one of the main pillars of national economy; fishes provide food for the poorest and directly provide employment for around 420,000 people. More than 2 million people are thought to derive some type of livelihood benefit from in involvement in the sector for example as to deliver meal on family table (FAO, 2016). This is due to Cambodian specific location, because around 22% of Mekong River goes through the Cambodia where is also located Tonle Sap Lake which is the biggest lake in South East Asia. In the Mekong is large abundance of fishes, the number of freshwater species is estimated from 758 to 1,500 and should be sustained not only for the animals, but prior for the people. Cambodia has more fish families than any other river system in the world (Baran and Borin, 2012). The ecosystem around Mekong is very sensitive and because many people's livelihood depends on it, we should choose very careful approach in dealing with this natural resources, because possible natural disaster would greatly affect all the people living around Mekong not only in Cambodia. It has to be protected from inadequate behaviour from fishers like usage of inappropriate fishing gears, fishing in the closed seasons, when fish needs space and time for breeding and growing (FAO, 2005). These problems may be tackled by good management of fish production in this area. Through the value chain analysis we may find any constraints on different segments of supply chain and propose action for improvement.

2   Literature review

2.1   Overview Cambodia

Cambodia is situated in Southeast Asia and share borders with Thailand on the east, Lao People's Democratic Republic on the north and Viet Nam on the west, on the north in Coastal area is Gulf of Thailand. Cambodia together with their neighbours mentioned above, China and Myanmar share Mekong river basin. The total area of Cambodia is 18,104,000 ha and 2.2 % is covered by water surface. Cambodia is for administrative purposes divided into 23 provinces and these provinces are divided into districts and communes (FAO, 2016).

	2010	2011	2012	2013	2014
Total population (1000)	14,365	14,606	14,865	15,135	15,328
GDP (market prices 1000 $)	11,242,275	12,829,541	14,038,383	15,449,630	16,777,820
GDP growth (annual %)	6	7.1	7.3	7.5	7.1
Agriculture (added value % of GDP)	36	36.7	35.6	33.5	30.4
Labour force participation rate (% 15+)	82.5	82.5	82.5	82.5	82.5
		2007		2009	2012
HDI (2012)					0.543 (ranking 138)
Per capita cultivated land (ha)	0.29			-	0.29

Agriculture labour force (% of total labour force)	67.1	66.3	65	
Global hunger index				16.8 (serious)

Table 1: Cambodia indicators (The World Bank Groups, 2016)**;** (FAO - Food and Agriculture Organization, 2014)**.**

2.2   Value chain

Value chain may be defined as a list of all process, which are required to bring the product or service from a conception through the different stages of production with combination of physical transformation and input of various producer services to deliver the final product to customer (Kaplinsky and Morris, 2002). Value chain is focusing on creation of added value typically through innovation in products and processes as well as marketing and also on allocation of the sequential value. On the other hand supply chain is focusing on logistical and procedural activities and does not count with added value because the primary focus of supply chain is on efficiency and smooth transportation of the goods to lower transaction cost, reduce outages or overstocks and improve fulfilment and customer satisfaction (Webber and Labaste, 2010).

The value chain concept can easily describe processes in fish production and aquaculture production. In fish production the simple value chain has around seven steps as we can see in figure 1, but the value chain may differ in dependence on type of fish. Fishing vessels are fisherman, who catches the fishes and bring them to landing sites for primary processing such a sorting and freezing. From landing sites the fishes are transported straight to the regional market or for secondary processing like filleting, drying, freezing, packaging, or making final product for example a fish paste. The product is transported to the wholesaler who send it to the retailer where is sold to the consumer.
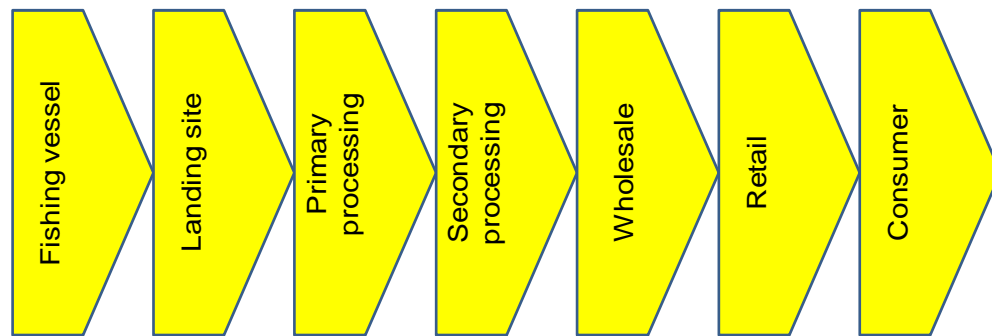
Figure 1: Basic value chain of fish production (Hempel, 2010)

In the value chain there are also activities within an each link of the chain often depicted as a vertical chain, intra-chain linkages, which does not have to go in only one way (Kaplinsky and Morris, 2002).

The value chain is not only a straight line of the specific product, but there are also external activities, which influence the product like in the aquaculture it would be buying the feeding for fishes or small fingerling, these activities we may call external parts of upstream and downstream activities of value chain. For simplification we may call the activities from simple value chain of fish production the core activities and upstream, downstream activities. Upstream activities provide inputs like for example: buying feeding for fish or gas for the motorboats and downstream activities are connected to the outputs like filleting fishes or drying.

The value chain analysis (VCA) is segmented along the supply chain and identifies added value on each stage of value chain, detailing both structural and dynamic factors that affecting contribution of each stakeholder of the value chain of specific product.

Structural factors include:

- The characteristics of food commodity (e.g. price, quality, quantity…)

- The enabling environment (laws, regulations, policies, norms, infrastructure) or factors which may enhance or hinder the market functioning, hence the movement or service along its value chain.

- Relationships between the chain actors at different level of value chain.

- Along the value chain, there are supporting markets (financial services, telecommunications etc.). This factor is critical for the further development of value chain.

Dynamic factors influencing value chain performance characterize how actors in the market system respond to the opportunities and constraints (World Food Programme, 2010).

To create a VCA we need to know relations between the stakeholders of the specific value chain, how the relations are evolving, what keeps them together, what information are shared.

Understanding the relevance of the value chain in food security problem we need to know three information:

- Location: where the specific activities are carried out? Each location has their own specifications.

- Value: what value is inserted by the specific activities?

- Power: some actors in the chain have domination over the other actors.
  (World Food Programme, 2010)

2.3   Fisheries in Cambodia

Fisheries in Cambodia have a great importance thanks to the fact that about 86% of the land area is within Mekong Catchment area. The Mekong has created vast wetland area and flooded forests through the rainy seasons, which has great species diversity and create opportunity for high fish productivity. Fisheries in Cambodia supply at least 82.1% of animal proteins in households (Nam, 2009) and Cambodian inland fisheries is one of the world most productive and with the fastest grow. In 2008 marine fisheries production was about 65,000 tones and inland fisheries production was around 422,000 tonnes (Nam, 2009) which is 86% of the total fish productivity in Cambodia. According to FAO (2016) in 2009 the fisheries sector directly employed around 420,000 people and more than 2 million people are thought to derive some type of livelihood benefit from in involvement in the sector for example as to deliver meal on family table (FAO, 2016).

Marine Fisheries

Cambodia has around 435 km long coastline which is pretty small if we compare it with other countries in South East Asia which have access to sea. The marine fisheries can be characterized into two different groups the coastal fisheries which have characteristics that it is mostly done by small scale fisherman and family-scale fishing which goes from coast to 20 meters depth and as a gear are used boats without engines or boats with engines up to 50 hp.

The commercial fisheries are characterized by large scale fishing boats and goes from 20 meters depth to EEZ. Boats fishing in Cambodia can be classified as purse seiners, shrimp trawlers and gillnetters (FAO, 2016).

The growth of marine fishing sector is placing the nature under high pressure through exploiting natural resources with degradation of habitat brought by destructive fishing practices like dynamiting, cyanide fishing, electricity fishing, mangrove forest destruction (for firewood, shrimp aquaculture), siltation and the pollution from industrialization and urbanization in coastal areas also the increase of tourism is taking toll on natural resources.

Aquaculture

In 2009 the Cambodian aquaculture contributes of the total inland fisheries sector less than 10% and is said to have great potential in increasing their production (FAO, 2016). The aquaculture is consist from cage culture which is practiced in Cambodia exactly in Mekong basin for hundred years and has roots around Tonle Sap lake, Pond Culture and Fish culture in rice fields.

Normally the small scale and medium scale fisherman are contributing in aquaculture by selling their captured small fishes as a feed to aquaculture which consist mainly from *Pangasianodon hypophthalmus*, *Clarias batrachus* and *Oreochromis niloticus* and in recent years there has been a lot of interest in the culture of *Macrobrachium rosenbergii* and numerous hatcheries have become established to produce post larvae (FAO, 2007). In 1990 the aquaculture began to rise so rapidly that the poor Cambodians whose meals were consisted mainly from small fishes which were now fed it to snakehead loos their food security. In 1995 was introduced ban on snakehead culture and 2005 was fully banned. In 2007 Cambodia and Vietnam joined forces to develop sustainable feeding

strategies to reduce dependence on SSF (small scale fisheries) and lay the groundwork for a hatchery program in Cambodia (Nam, 2011).

Cage culture

As we said earlier the cage culture has a long history in Cambodia. It was originated around a Tonle Sap lake. The original idea could have been evolved from the tradition to put fishes into a wooden basket under water to hold them alive until the time to sell them on the market or eat them when the time comes.

Cages are made either of split bamboo supported by a wooden frame or wood. Most cages are constructed in the shape of a boat, elongated with a tapering bow and truncated stern. This is to permit the cage to be towed by a motorized boat to market. Moreover, cages used to culture snakehead species tend to be smaller than those used for other species, and they are rectangular or box shape.

Most cage culture involves the culture of indigenous species, the major groups of which by species are Carps and Catfish. In terms of production from aquaculture, the major species are *Pangasius Catfish*, in particular *Pangasius Sutchi*, and the Giant Snakehead *Chana Micropeltes* (FAO, 2011).

Pond and Rice-Fish culture

The pond and rice culture are mainly practiced by households to ensure household consumption and to generate a bit more income.

The pond and rice-fish culture is in fact often overlooked by the rural development experts. Small aquatic animals such as fish, frogs, crabs, snakes as well as a number of plant species are the product from the rice fields, and there is a great potential for intensification of their production in Cambodia (FAO, 2011).

2.4 Fish products

Prahoc

Prahoc is fermented fish paste which is made from low value fishes such as trey riel. The fishes are thoroughly washed, the scale and heads are removed and the fish are than salted and dried for few days. During fermentation, bacteria hydrolyze protein into its constituent amino acids, at the same time producing lactic acid which prevents further decomposition. The protein in prahoc is more digestible than in fresh fish, so prahoc is

excellent food for the elderly or small children (Horte et. al., 2004). Prahoc is often made with mix of two or more fishes the variety of fish is also seen on the prize at which is prahoc sold.

As a side product of prahoc processing is fish fat which is collected and sold, the guts are used as a feed for fishes in fish farms or fertilizers.

Fish paste

Fish paste is made from smaller fish and parts of the fish, which are not suitable for other types of processing. The process of making a fish paste is done by gradual fermentation of smashed or minced parts of fish. Fish paste is used in cooking as a seasoning or poor people use it as a compensation for fish.

Dried fish

It is form of processing at which are fishes salted and whole or cut on half put on direct sun and gradually dried. The dried fishes are after wards sorted on semi dried, dried and fully dried. In Cambodia dry fishes are very popular, because this process is also mean of conservation.

Smoked fish

It is form of processing at which fish meat is exposed to the smoke from burning or smouldering of wood. Smoking is a mean of preservation only in combination with other preservation techniques like drying or salting.

2.5   Fish species

This chapter is focused on fish species at which our value chain analysis is oriented. These fish species were selected due to their market abundance and are most preferred for consumers.

Climbing Perch

Anabas testudineus

Anabas testudines in English known as a Climbing Perch we may recognize, because of this biological features: number of dorsal spines may differ between: 16–20, dorsal soft rays: 7-10; anal spines: 9-11; anal soft rays: 8-11. In life it has dark to pale greenish colour and it has very pale colour below, back is coloured dusky to olive colour, head

has longitudinal stripes ventrally. Climbing Perch has scaled head with 4-5 rows between eye and rear margin of preoperculum (Froese, 2015).

Climbing Perch is mostly found in canals, lakes, ponds, swamps and estuaries (Vidthayanon, 2002), It occurs in medium to large rivers, brooks, flooded fields and stagnant water which are often found in areas with dense vegetation. Climbing Perch has a big tolerance in means of water condition, to overcome dry seasons, it may bury himself in mud. Climbing Perch feeds on macrophytic vegetation, shrimps and small fishes. Usually is sold still alive in markets where it may be kept alive for several days if kept small amount of water (Rainboth, 1996). Climbing Perch is economic food fish in the Southeast Asia because his low cost on the market and big accessibility.

Walking Catfish

Clarias batrachus

Khmer names: trey andaing roueng; trey andeng; trey andèng

English name: Walking Catfish

Clarias batrachus has elongated body, which is broader at the head. Catfish is easily recognizable because of their four pairs of barbells and papillated lips. The teeth of catfish are villiform (small and bristle). Their pectoral spines are large, robust and finely serrate along the margins. Walking Catfish does not have dorsal spine. The dorsal fin is continuous and extends along the back 2/3 of the length of the body. The dorsal, caudal, and anal fins together form a near-continuous margin; the caudal fin is rounded and not eel-like though it is occasionally fused with the other fins (Talwar, 1991).

Chana

To genus Chana we may count 6 species (*Ophicephalus lucius, Oph. marulius, Oph. melanosomus, Oph. micropeltes, Oph. orientalis, Oph. striatus)* which may be found in Cambodia and we may characterize them by 5 biological features: the top and sides of a head is covered with scales, dorsal fin is longer than anal fin and starts above pectoral fin, head is broad and flattened, mouth is large and eyes are situated in anterior part of head.

For this work we need to target just 2 species which may be seen in Cambodian market *Ophicephalus striatius* (*Chana striata*), *Ophicephalus lucius (Channa lucius),* and these two species are most commonly seen on the Cambodian market. Specie *Oph. micropeltes* which goes by FAO name as a Giant snakehead is well seen on the market also, but because of his specialize market behaviour it is excluded from this paper.

Channa Striata

English name: Striped snakehead

Local name: Trey Ros

Walking snakehead is broadly adapted specie found in rivers, lakes, ponds, mountain stream and even brackish waters. Walking snakehead is a predator and feeds on small fishes, or prawns, shrimps and other invertebrates. Walking snakehead is caught with seines gill nets and entangling nets strung across dry land between rice paddies.

Chana lucius

Local name: Trey kahn chorn chey

English name: Does not have English name issued by FAO.

Chana lucius inhabits slowly moving streams and rivers as well as lakes, ponds, reservoirs. Found in areas with lot of aquatic vegetation, as well as submerged woody plants. Chana lucius feeds on small fishes, prawns, and crabs. Caught with seines, gill nets, and entangling nets strung across dry land between rice paddies.

Chana used to be growth in aquaculture but because of the impact on poor population of Cambodian people, Cambodian government had to impose a ban on this growing business, as is said above walking snakehead is predator and aquacultures which were farming it bought for feeding all small fishes from the market and fisherman which used to be daily food for the poor population which cannot afford to pay for pricey fishes

Tilapia

Oreochromis niloticus

Tilapia has a compressed body. Caudal peduncle length is equal to depth. Scales are cycloid. Their lower pharyngeal bones are fused into a single tooth bearing structure. Their mouths are protrusible usually bordered with wide and often swollen lips. Tilapias have a long dorsal fin with 16 to 17 spines and 11-15 soft rays. Tilapia has lateral line interrupted, which starts again two or three rows of scale below. Tilapias color in spawning season is pectoral and dorsal and caudal fins are going reddish, caudal fin have also numerous black bars (FAO, 2015).

Production system

Tilapia are asynchronous, their spawning does not need hormones to induce spawning. Tilapia spawns throughout the year in the tropical climate and during the warm season in the subtropical climate. Commercial tilapias production requires male monosex population because of the disparity in the growth between male and female, the male tilapias grow approximately 2 times faster than female more over the presence of female tilapia leads to uncontrollable reproduction. Therefore thank to a tilapia special trait that sex organs are developing after several days of yolk sac absorption, the female may be fed by male sex hormone which will cause that the spawn will develop as a phenotypic male. The sex reversal process takes around 4 weeks and needs more activities, but in the end the average efficiency is around 95-100 % in Thailand (FAO, 2015).

After sex reversal period the fingerlings are generally nursed to advanced sized before they are moved to grow-out facilities. Sex reversed fingerlings are stocked at approximately 20-25 fish/m^2 in small ponds and cultured usually 2-3 months to weight of 30-40 g. These fingerlings are afterwards ready to move to other aquacultures for example: ponds, cages, recirculation systems, tanks and raceways.

Prepared feeds for tilapias are easily found in developed countries and have high efficiency. In the developing countries the artificial feed is usually too expensive for domestic market so is used only by exporters. The farmers mostly rely only on manures and other agriculture by product for the feeding of tilapia aquaculture (FAO, 2015).

Pangasius

Pangasius hypophthalmus/bocourti

FAO name: Striped catfish/Basa Catfish

Local name: Pra, Trey Pra and Trey Pra Kchaov.

Biological features

Body is long, latterly flattened with no scales. Head is relatively small, mouth broad with small sharp teeth on jaw, vornerine and palatal bones. Eyes relatively large, two pairs of barbells, upper barbells are shorter than the lower, fins dark grey or black. Six branched dorsal-fin rays. Gill rakers are normally developed. Young fish have black stripe along lateral line and another long black stripe below lateral line; large adults uniformly grey but sometimes with greenish tint and sides silvery. Dark stripe on middle of anal fin; dark stripe in each caudal lobe; small gills regularly interspersed with larger ones (FAO, 2015).

Production system

In Cambodia is still used production system based on wild catchment of juveniles as a seed for aquaculture (pond, cage) but in some cases we may meet special hatcheries.

In hatchery mature brood mothers are induced to spawn using HCG (Choriogonadotropin) and HCG with pituitary gland extract. Females are given 2-4 injections of hormones and males are given injection of hormones just once when the female resolving dose is given. The eggs are incubated in jars with up-welling water flow and in 22-24 hours, depending on water temperature the eggs hatch.

Nursing is done in two phases, In the first phase larvae are stocked at 400-500/m^2 just prior to yolk sac absorption and to avoid cannibalism the ponds are filled with Moina

(20-30 kg/ha). After 4 weeks the larvae change to fry 0.3-1.0 g and harvested to transfer to another pre-prepared pond 150-200/m^2 without moina where is growing for 2 months. After seeding phases the fingerling may be transferred to aquaculture (pond, cage or net pens) and it takes at least 6 months to achieve 1.0 1.5 kg of life weight (FAO, 2015).

Siamiese Carp

Scientific name: *Henicorhynchus/Cirrhinus Siamensis*

English name: Siamese Mud Carp

Cambodian name: Trey Riel Tob

Biological features

Dorsal and anal fins has both, sharp, serrated spine, Carp has 4 barbells around mouth, long dorsal fin with 18 or more rays (Rainboth, 1996).

Adults inhabit warm, deep, slow-flowing and still waters such as lowland rivers and large, well vegetated lakes (Kottelat and Freyhof, 2007). Carp is tolerant to wide variety of conditions but prefer slow moving and standing water with soft bottom sediments. Adults and juveniles feed on plant material and benthic organisms. Carp is spawning along shores and in backwaters. East Asian congeners and their hybrids have caused continuous decline of wild populations (Kottelat and Freyhof, 2007).

In Cambodia we can see on the market also Lesser Silver Mud Carp *(Henicorhynchus/Cirrhinus Lobatus)* and because of their great biological similarity with Siamese carp (as be seen in the appendix), same market behaviour as a Siamese Carp, for this study these two different species will be called as a Siamese Carp.

Common Carp

Scientific name: *Ciprinus Carpio*

Khmer name: Trey Carp Sahman

FAO English name: Common Carp

Biological features

Common Carp has a dorsal and anal fin in sharp shape, separated from spine, around mouth has 4 barbells, Dorsal fin is long and has 18 or more rays.

Habitat, Biology and fishery around Mekong

Common Carp is a widely introduced species native to temperate latitudes which is now starting to show up more and more often on the market in Cambodia. Common Carp is capable to reproduce in cooler waters in Mekong basin. In cool waters Common Carp seems to be extremely tolerant of turbidity and stream contamination. Common Carp is a omnivorous specie consuming a wide variety of plants and animal matte often uprooting aquatic plants and muddying the water transparency. In the developed countries of western hemisphere they ingest all matter of industrial waste and made them self inedible. Together with their destructive feeding activities they were marked as a trash fish and there was millions of dollars unsuccessfully spent to eradicate or at least control them. They are fished usually with gill nets, hook and line, seines. On the market they are sold fresh.

2.6   Value chain actors in fish production

Fishers

The fishers are differentiated according to size of catch potential, gear used for fishing on small scale medium and large scale. Small scale or family scale is usually comprised from 1-3 persons, who fish primarily for family needs and income. The number of family fishers is every year bigger and bigger as the population in Cambodia grows. Medium scale fishers are extended families and village level partnerships and are consisted from 3–6 persons who catch fishes also for family income and sell their catch to fish collectors or directly to consumers (Rab et al., 2005).

Fish collectors

Fish collectors are collecting fishes from small and medium scale fishers directly at the fishing grounds. Normally they have a few collecting boats with ice boxes on them for

fish storage during the fish collection. They set prices of fishes in the dependence on actual catch, fish quality, daily fish market and actual supply situation. Fish collectors usually provide payment in cash from money what they have at their disposal but they also often provide payment in credit or in the form of fishing gear. In practice some collectors get loans from wholesalers, middle persons and exporters to whom they sell the fishes at the landing sites (Rab et al., 2005).

Wholesalers / Traders

Wholesalers and traders are representing important part in supply chain in fish production in Cambodia. Through wholesalers and traders are major quantities of fish products channelled. They act as a distributors which have permanent stall at the landing sites, floating villages or distribution centre. They buy fishes from fishers, lot owners, fish collectors and distributing them to restaurants, retailers and exporters. The business of wholesalers is very much specified in the dependence on locality whether is based in provincial town or Phnom Penh area (Rab et al., 2005).

Semi-wholesalers

Semi-wholesalers are those fish trades which have permanent fish store inside or outside of the market whereby are the fishes brought by middlepersons or other lower participant in the supply chain, than they act by them self as a retailers or sell the fishes to other retailers who sell fishers to consumers or processors. Usually semi-wholesalers act as retailers, but sometimes they act as a distributers and sending their commodities to provinces which have a deficit (Rab et al., 2005).

Retailers

Retailers are those people who sell directly to consumers and have permanent stall outside or inside the market. Generally in each market there are many retailers who sell fishes everyday like on provincial level or local levels. The selling is mostly done by female parts of the family, but is normal that on the right functioning of business are participating others from the family, for example buy fishes from the landing sites and distribution centres.

There is also a special category of retailers, itinerant traders, they do not have permanent stall but sell from a container by moving from one place to another (Rab et al., 2005).

Fish processors

Fish processors are usually fish raisers, fishers or business persons. The processors usually produce fish paste, salted dry fish, fermented fish, smoked fish etc. The processors generally sell on domestic markets some also sell on international market with specific species and product (Rab et al., 2005).

3 Objectives

The general objective of this study was to analyze value chain of fish production of selected fish species such as Climbing Perch (*Anabius testudines*), Walking Catfish (*Clarias batrachus*), Tilapia (*Oreochromis niloticus*), Channa (*Ophicephalus striatius/lucius*), Pangasius (*Pangasius hypophthalmus/bocourti)*, Siamese Carp (*Henicorhynchus/Cirrhinus Siamensis*) and Common Carp (*Cyprinus carpio*) in Cambodia. Value chain analysis (VCA) is important for all the competitors in the specific market on each segment of value chain to identify problems and inconsistency. This identification helps later on in improving the value derived from fish production resources and for policy makers to improve food security.

The specific objectives were:

- To describe of supply chain of fish products and its links between different levels of supply chain.
- To analyze of marketing channels of specific fish products.
- To analyze of different price level in dependence on species and locality.
- To provide recommendations for improvements.

Hypothesis:

H1: There is no significant difference in price levels between provinces of selected fish species and its products.

H2: There is no significant difference in price levels between dry and rainy season in selected fish species and its products.

4   Methodology

The primary data research was conducted in a form of questionnaire which is based on market analysis tool published by the World Food Programme (2010) and is modified on research held in Cambodia. The methodology follows step by step tool mentioned above, specifically in provinces Kampong Chhnang, Kampong Thom provinces and Phnom Penh city and was aimed on fish products, specifically species: Climbing Perch (*Anabius testudines*), Walking Catfish (*Clarias batrachus*), Tilapia (*Oreochromis niloticus*), Channa (*Ophicephalus striatius/lucius*), Pangasius (*Pangasius hypophthalmus/bocourti)*, Siamese Carp (*Henicorhynchus/Cirrhinus Siamensis*) and Common Carp (*Cyprinus carpio*).

The literature review and discussion was based on secondary data that have been gathered from available literature in the scientific articles focusing on the topics: fish production, fish species in Cambodia, added value, value chain analysis and South East Asia.

4.1   Data collection

The primary data collection was based on six different questionnaires for each segment of value chain and has been interview together 123 respondents but due to inconsistent data 6 respondents had to be removed from this study and the final number of respondents is 117 from following groups:

- o Questionnaires for primary producers was set of seven questions including two tables, in total filled by 21 respondents (7 respondents from each province)
- o Questionnaires for aquaculture producers was set of fifteen questions, in total filled by 15 respondents, 5 respondents from each province
- o Questionnaires for intermediaries was set of eleven questions which included three tables in total, filled by 9 respondents, 3 respondents from each province
- o Questionnaires for processors was set of twenty questions which includes three tables in total, filled by 9 respondents, 3 respondents from each province

- o Questionnaires for retailers was set of seven questions including three tables in total, filled by 30 respondents 10 respondents from each province

- o Questionnaire for consumers was set of 7 questions and 3 tables in total, filled by 30 respondents, 10 respondents from each province.

All the questionnaires are available in the Annex II.
In all the provinces the interviews were held on the base of previous recommendations from local people who we asked and were living in local areas where we guessed on the base of geographical situation would be communities engaged in fish production in combination with fishery administer office, where we introduced ourselves and explained our research and asked for information.

The research was done in the three provinces: Kampong Thom, Kampong Chhnang and Phnom Penh (Kandal province). (Figure 2)

Figure 2: Provinces researched

4.2   Identification and mapping value chain

This research is aimed on value chain of fish production in Cambodia in provinces: Kampong Chhnang, Kampong Thom and Phnom Penh city with the aim on fish

products species Climbing Perch, Walking Catfish, Tilapia, Pangasius, Common Carp and Siamese Carp. How the commodities are divided from one segment of value chain to other. For example how many percent of production from fisherman is going to intermediaries, processors, retailers or consumers. Also how the commodities are transported between provinces on geographical level. Functional and institutional analysis is used for constructing a preliminary mapping of fish production value chain This includes elaboration of refined map by quantifying key variables for example: added value (Grote and Winter, 2009).
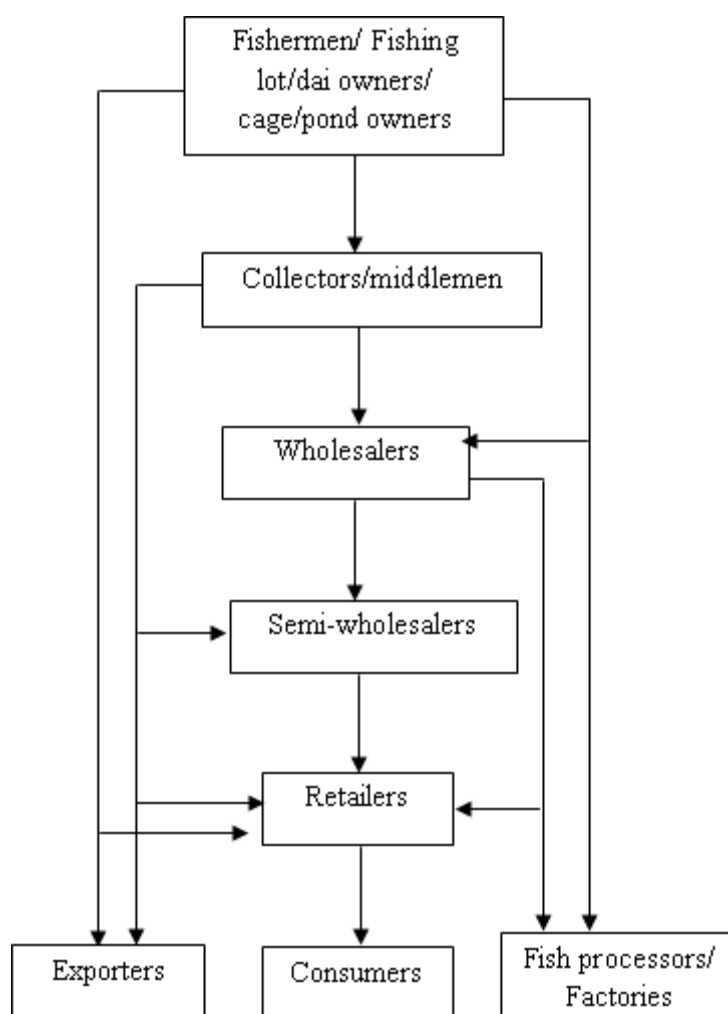
Figure 3: value chain of fish production in Cambodia (Rab et al., 2006)

4.3 Financial Value Chain Analysis

Financial analysis is done from perspective of individual stakeholder is based on the concept of value added to derive findings according to the chain performance and impact on agents.

Calculation of value added (VA)

$$VA_{ij}=Y_{ij}-II_{ij}$$

II: stands for value of intermediate inputs

Y: stands for value of the output product

$_i$:product

$_j$:agent

The VA represents value added of specific agent in the chain, but to measure which stage of value chain contributes to the value added the most or the less we have to calculate the overall value added.

$$VA_{chain}=Y_{chain}-II_{chain}=\sum VA_{agents}$$

Value chain actor	Costs			Revenues	Profits		Margins
	Unit total cost	Added unit cost	% Added Cost	Unit price	Unit profit	% Total Profits	Unit Margin
Fisherman	A	-	A/F	G	G-A	(G-A)/(K-F)	G
Intermediaries	G	B	B/F	H	H-B-G	(H-B-G)/(K-F)	H-G

Processors	H+C	C	C/F	I	I-C-H	(I-C-H)/(K-F)	I-H
Traders	I+D	D	D/F	J	J-D-I	(J-D-I)/(K-F)	J-I
Retailers	J+E	E	E/F	K	K-E-J	(K-E-J)/(K-F)	K-J
Total		F= A+ B+ C+ D+ E	100		K-F	100	K

Table 2: Calculating of marketing margins - formula for calculating ratio (M4P, 2008)

4.4   Comparison tests

For the comparison tests were used MS Office Excel®, Statistica 64 - StatSoft, Inc. statistical program and Factorial ANOVA and one way ANOVA test to confirm or to disprove null hypothesis, when the null hypothesis from Anova test were rejected than was used Sheffes test, lesser square means test to identify the differences between samples.

<u>**Hypothesis:**</u>

There is no significant difference in price levels between provinces of selected fish species and its products.
There is no significant difference in price levels between dry and rainy season in selected fish species and its products.

4.5   Research limitations

One of the main limitations encountered during the data collection was definitely the language barrier which made interviewing sometimes difficult because of small understanding of the problem and cultural differences as some interviewed people did not fully understand what we were researching but even so from most of the interviewed persons we engaged friendly attitude towards us. Other limitation is that there was not possible to properly follow value chain and we could not meet following

segments for interview because of missing contacts, that also relate with the number of respondents from intermediaries and processors, as there was not known any mean of contacting them before interview. We were left to find them by ourselves and asking of local people for providing of further information to help localize them. During the data collection there were missing detailed socio economic questions such as years of schooling and whole family income. Even thought that the data research was not aimed on the family budget it would be important indicator in the means of livelihood and if the family is living only from fish production. Details of limitations are also mentioned in the part of Discussion of the thesis.

5   Results

5.1   Overview of supply chains in Cambodia

According to our findings based on the collected questionnaires, the marketing and distribution lines of fish production are mostly managed in hand to hand exchange between each level of supply chain but despite that the actors in 50% does not have closed relationship. The first steps of supply chains in fish production are fish farms, or local fishermen in that dependence there is a difference in product, the local fisherman are going daily mostly two times per day to fish and afterwards immediately sell their products to fish collector which is mostly coming to their places. The fishermen are selling their catch in the dependence on locality for example in Kampong Thom fisherman sells their catch as a whole mostly with no relevance on fish species (mix), the revenue of fisherman are based on the weight of captured fish the revenues are 1,000 – 2,000 KHR per kilogram, in Kampong Chhnang fisherman were catching Siamese Carp and Channa and in Phnom Penh fisherman where specialized in catching of Tilapia Common Carp and Siamese Carp. The fish farms produce once per year per cultivation large amount of fish species. The intermediaries (fish collector) come to fish farm to collect fishes and then transport them to processors or appropriate market where they resale them to retailers. The retailers than have their place on the market and sell the products to consumers. Retailers differ in the products they sell. Retailers specialize in selling either processed fishes: smoked, dried, fermented or sell fresh/alive fishes. Retailers rarely sell both fresh and processed fish altogether. Consumers come to market every day or every two days to buy fresh fishes and once per week to buy processed fish.

Socio-economic data

In total, there were researched 117 respondents. In each province there were 39 respondents divided into different segment of supply chain methodology and can be seen in the Figure 4: Distribution of respondents
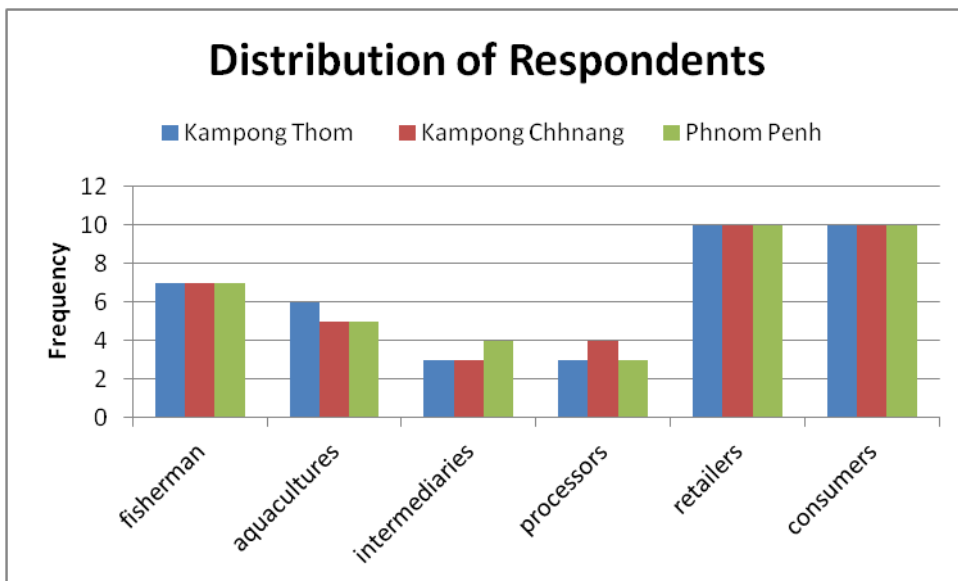
Figure 4: Distribution of respondents according to their position in the value chain

Segments of fishermen, aquacultures and consumers were asked on size of their household where was identified that household size is at least 4 or more people.

In Kampong Thom the respondents answered most frequently that they live in household of 4 people on the other hand in Kampong Chhnang the most frequent size of family was 6 persons. In Phnom Penh have not been recorded any maximum values but still the biggest numbers of respondents are in the boundary of 4 and 6 members of household.
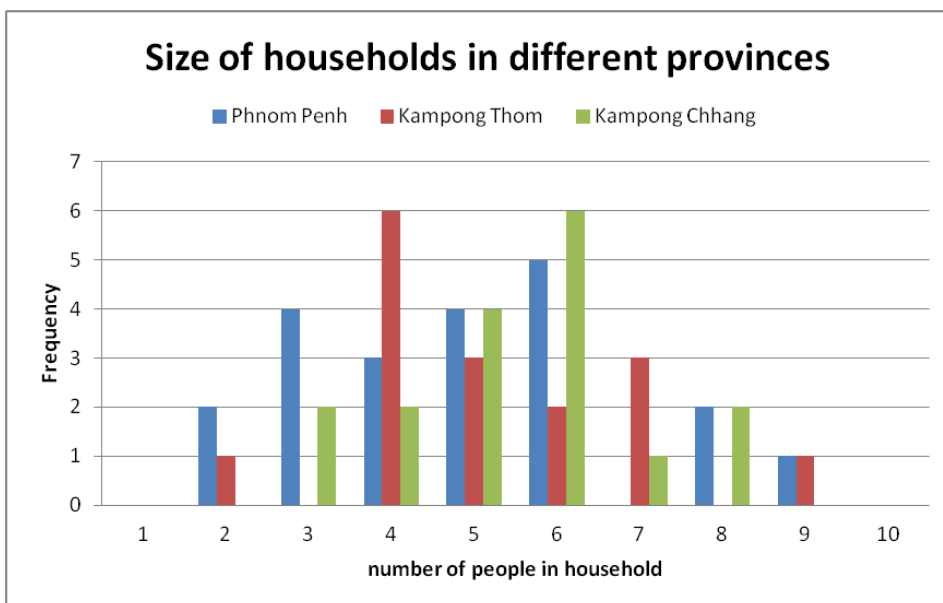
Figure 5: Household size of respondents in different provinces

Storage

Along the supply chain the very important factor is the way how the product is stored in Cambodia. The fishes are mostly selling the same day or the next day as they are caught. The fishes are sold mostly alive in case of Channa and Walking catfish. If the retailers are in holding of water barrels the other species may be bought by consumer alive too but that strictly depends on how the retailer is equipped. In case of quality, the fishes are sold fresh but unfortunately the low number of conservation methods does not give wide possibilities of keeping the unsold fishes fresh for long time and retailers have to decrease the price of fish to even sell them or they have to process them either by themselves or through other processors. As we can see in the Figure 6. the usage of freezers and ice is occasional and have been discovered only in Kampong Thom and Kampong Chhnang. On the other hand in Phnom Penh has been found that they do not use any means of storage mostly. The reason behind not using any storage may be a big density of population. The fish come from other provinces or from intermediaries in water barrels still alive and are promptly resold on the market with enough customers to buy all the products. As has been said above high importance in prolonging the shelf life is done by processing, even that it cannot be seen very well in Figure 9, the products are very abundant on the markets, from our observation we can say that for every retailer with products (dried, smoked, fermented fish) there are 3 retailers with fresh fishes.
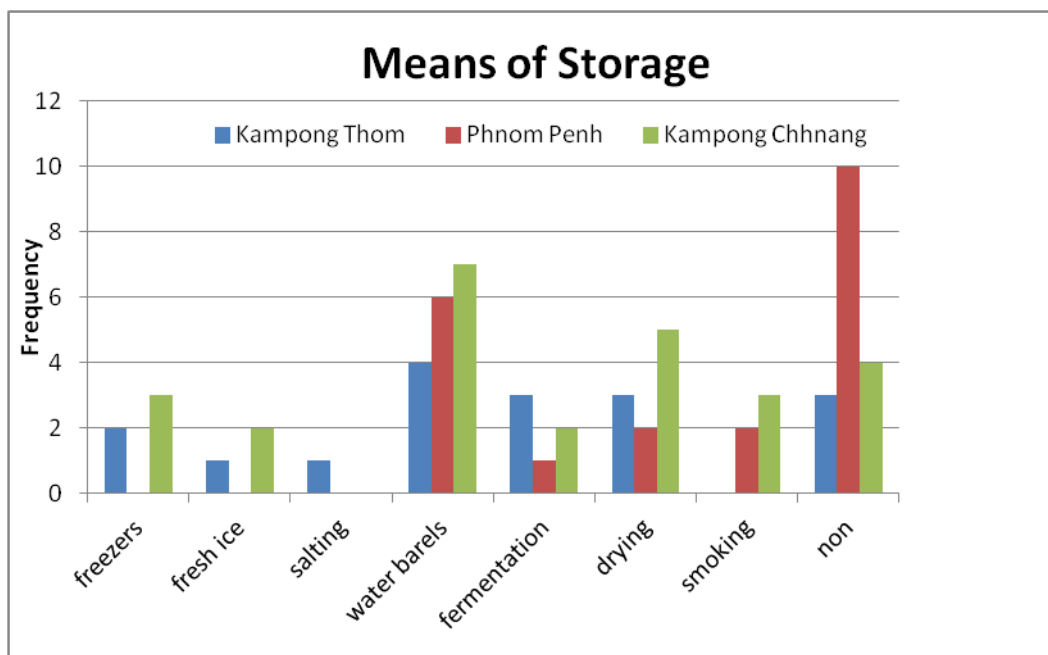
Figure 6: Means of storage

Fish consumption

As have been said above in Cambodia fishes are important source of income and nutrients and are part of dish every day. In questionnaires for consumers we asked on how frequently they eat fish. In Kampong Thom and Kampong Chhnang most households have fish as a part of their dish 2 times per day and in Phnom Penh 1 time per day. This may be a result of the different specification of provinces. Kampong Thom and Kampong Chhnang as rural provinces with the aims on fish have harder access to other products such as cattle or pork. On the other hand Phnom Penh as a capital and urban area has more possibilities in changing of diet.
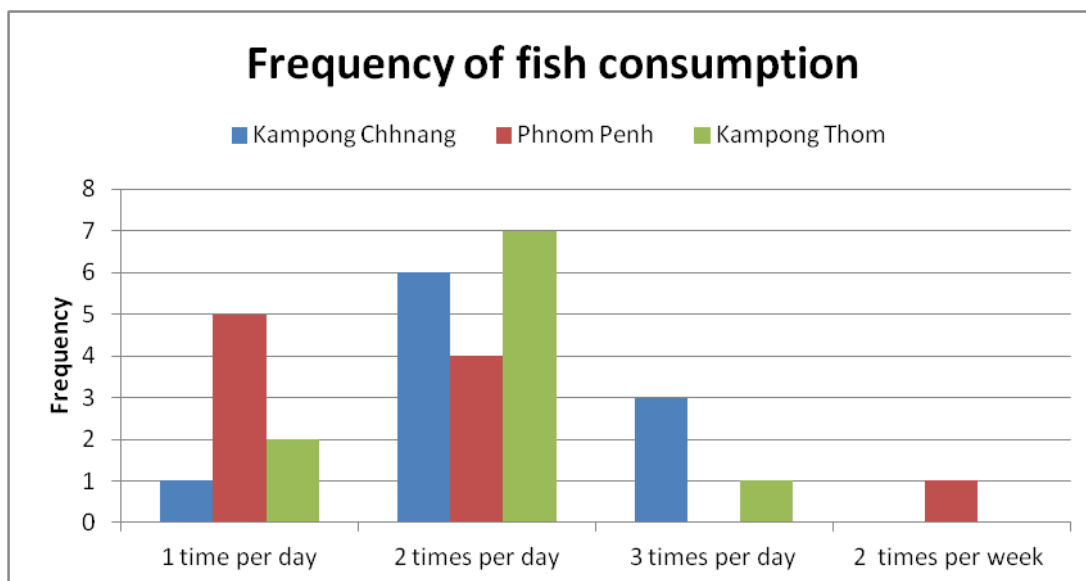
Figure 7: Fish consumption frequency

Fish product consumption

Other good indicators of importance of fish production in Cambodian livelihood are products which fulfil two important roles. In one way they carry out role of preservation of fish and on the other they are important from cultural point of view, as said before in the case of prahoc as a nutrient food for children and elderly people. Fish products like a dried or smoked fishes are also taken as a more luxurious food for the poorer population and are bought once a month or less frequently. In the tables 3-5 we can see a difference between Kampong Thom, Kampong Chhnang and Phnom Penh in total mean consumption of fish products per capita.

Phnom Penh							
Product	mean consumption per capita/kg	Mod us	Medi an	standard deviation	Disper sion	Mi n.	Ma x.
Prahoc kg/month	0.776	-	0.09	1.51	2.3	0	5
Fish paste kg/month	0.173	0	0.08	0.22	0.04	0	0.6 7
Dry fish kg/month	2.186	3	1.87	2.03	4.12	0	6
smoked fish	0.076	0	0	0.15	0.02	0	0.5
Total	3.213						

Table 3: Phnom Penh product consumption

The table 3 shows, that in Phnom Penh are consumed 3.2 kg of fish products per month, however in Kampong Thom and Kampong Chhnang is the consumption only 0.9 kg. This can be caused because of higher income and higher standard of living in capital city than in the other two provincial cities where the consumer cannot afford to buy products with higher added value and more often prefer to dry or to ferment the fish by themselves at home. In provinces they have area which they can utilize for drying or fermenting on the other hand Phnom Penh with higher density of population cannot provide for people space where they could process their own products.

Kampong Thom							
Product	mean consumption per capita/kg	Modus	Median	standard deviation	Dispersion	Min.	Max.
Prahoc kg/month	0.367	0.2	0.2	0.4	0.16	0	1.14
Fish paste kg/month	0.184	0	0.03	0.26	0.07	0	0.83
Dry fish kg/month	0.37	0.5	0.5	0.26	0.06	0	0.8
smoked fish	0	0	0	0	0	0	0
Total	0.922						

Table 4: Kampong Thom product consumption

The most commonly consumed products are dried fish and prahoc. These two products have the highest consumption in all provinces. In Phnom Penh the mean consumption per capita of dry fish is 2.18 kg/month, on the other hand in Kampong Thom the mean consumption is only 0.37 kg/month and in Kampong Chhnang only 0.29 kg/month. There may have been a number of reasons for this big difference. The main reason is the difference in density of population. The other reasons are different size of salary, abundance of variety of dry fish, and sample of respondents.

Kampong Chhnang							
Product	mean consumption per capita/kg	Modus	Median	standard deviation	Dispersion	Min.	Max.
Prahoc kg/month	0.38	0.25	0.26	0.35	0.12	0.71	1.33
Fish paste kg/month	0.2	0	0.13	0.23	0.05	0	0.8
Dry fish	0.29	0	0.14	0.38	0.15	0	1.3

kg/month							3
smoked fish	0.01	0	0	0.05	0.002	0	0.16
Total	0.905						

Table 5: Kampong Chhnang product consumption

5.2   Possibilities of business increase

During data collection we asked intermediaries and processors if there is a space for bussiness increase in next years. 58 % of respondents answered that there is space for incresing their bussiness if they get into a contact with more clients. In the case of one processor the answer was that he is in need to hire more workers, but is rather a problematic case, because new people does not have the necessary skills or working habits in his close area of business. Other respondents answered that they want to enlarge their sortiment.

The resons why several respondets answerred that the are not interested in incresing their bussiness are age issue „they are too old to solve problems which goes togather with further increase of their production and lack of capital. In Kampong Thom one intermediarie answered that there is not enough fish for him to increase his bussines beause the law prohibits fishing in rainy season so for him is possible to do business only during the dry season.

5.3   Means of transport of commodities

For the intermediaries and retailers, is also very important how they transfer their commodities to the market for sell. In Figure 8 we can see the transports used by intermediaries and retailers.

Intermediaries, because of higher amount of commodity and longer distance to overcome are using cars, trucks, boats or combination of two. Some of the intermediaries does not own the vehicles and only rent them, or if they use combination of two vehicles the own only one and the other rent. Intermediary from Kampong Thom told us, that he shares the costs for hiring the vehicles and also the cost for the commodity with other partners.

The most used vehicle by retailers is motorbike, as it is used to transport smaller amount of commodity and for retailers it is convenient as they can move to closer range of their stall because of the small size of the vehicle.
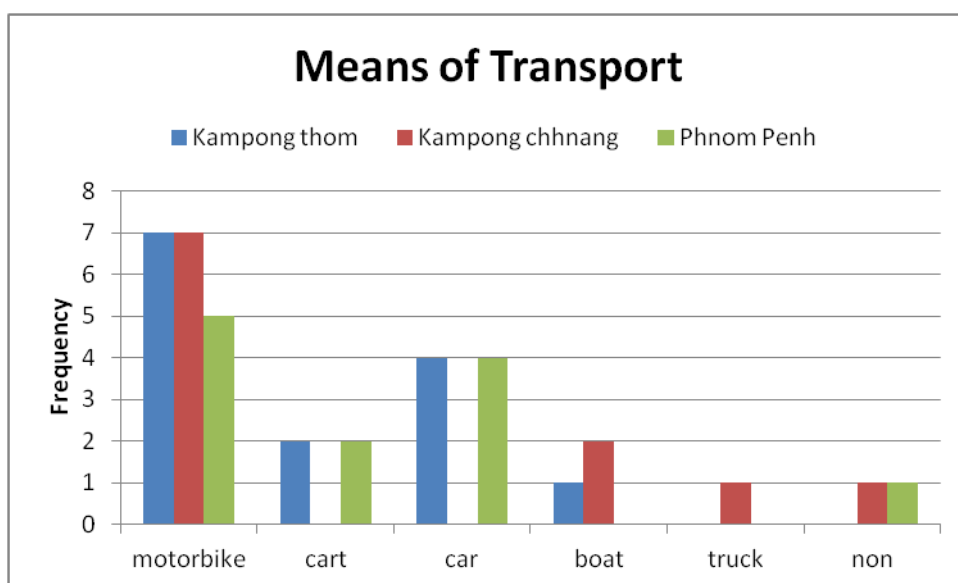
Figure 8: Means of transport

5.4   Comparison of retailers

The questionnaire for retailers was aimed on fish species and their prices, to specify what species the retailer is buying, reselling and for how much. From the tables 6 and 7

we can see the difference in average prices in the dependence of season and provinces and also what is the abundance of species, how many retailers sell specific species. We can say that in Kampong Chhnang only two from ten interviewed retailers sell Tilapia, Climbing Perch and Carp sells independently one retailer, three sell Walking catfish, four sell Pangasius during dry season and three during rainy season, Siamese Carp and Channa is sold by two retailers.

	Rainy Season								
	Phnom Penh			Kampong Chnang			Kampong Thom		
	Mean KHR[1]	SD	N	Mean KHR[1]	SD	N	Mean KHR[1]	SD	N
Tilapia	9,777	415	9	9,500	500	2	10,750	829	4
Climbing Perch	9,750	250	2	8,000	0	1	8,666	942	3
Walking Catfish	7,200	509	5	7,166	623	3	7,750	829	4
Pangasius	6,740	332	5	6,900	787	3	6,600	860	5
Carp	13,333	471	3	8,000	816	3	8,333	471	3
Siamese Carp	13,000	816	3	9,750	3,250	2	5,500	1,500	2
Chana	11,250	901	6	11,000	0	2	11,000	632	5

Table 6: Average prices province/specie (Rainy season)

During the comparison of prices and provinces there were not found statistically significant data which would neglect null hypothesis: "there is no statistically significant change in price level with correlation on rainy and dry season".

	Dry season								
	Phnom Penh			Kampong Chhnang			Kampong Thom		
	Mean KHR[1]	SD	N	Mean KHR[1]	SD	N	Mean KHR[1]	SD	N
Tilapia	9,888	314	9	10,000	0	2	10,750	829	4
Climbing Perch	9,750	250	2	8,000	0	1	8,666	942	3
Walking Catfish	7,300	400	5	7,500	408	3	7,750	829	4

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[1] 4100 KHR = 1 $

Pangasius	6,940	233	5	7,925	1,310	4	6,875	739	4
Carp	13,000	816	3	9,000	0.00	1	8,333	471	3
Siamese Carp	13,333	471	3	10,250	2,750	2	5,500	1,500	2
Chana	10,916	931	6	11,000	0	2	11,000	632	5

Table 7: Average prices province/specie (Dry season)

In the comparison of price level on the correlation with province there were not found statistical significance in fish species Walking Catfish, Channa, Pangasius or Climbing Perch so we can confirm first hypothesis: "There is no statistical significance in price level on the dependence of province in which were they sold" on these four species. In the case of Tilapia, Common Carp and Siamese carp were monitored statistically significant changes (Table 8).

	Tilapia	Common Carp	Siamese Carp
Phnom Penh (KHR)[2]	9,833	13,166	13,000
Kampong Chhnang (KHR)[2]	9,750	8,333	10,000
Kampong Thom (KHR)[2]	10,750	8,333	5,500
p - value	0.002	0.00	0.004
Std. error	284.63	304.29	1232.16
Degr. of freedom	(2, 27)	(2, 12)	(2, 8)

Table 8: difference in price levels[3]

In the comparison of price levels for fish products were used same test as in comparison of fish species, in the case of products there were not found statistically significant differences in dependence of season. In the dependence on province there was found with statistically significant difference in price for fish paste, in the case of other products there was found also difference in prices but we cannot say with certainty that the change of price is in correlation with the province in which were bought in other words there is no statistical evidence that the price has not change because of other

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[2] 4100 KHR = 1 $
[3] Note: significance level 0.95.

factors for example, not consistent sample group, size of sample group, place of interviews different quality of product.

	Fish paste	Prahoc	Dry fish	Smoked fish
Phnom Penh (KHR)[4]	24,142	10,444	22,000	15,000
Kampong Chhnang (KHR)[4]	17,833	7,150	28,500	28,500
Kampong Thom (KHR)[4]	46,000	10,300	26,500	22,500
p - value	0.000	0.11	0.17	0.13
Std. Err.	3115	1196	2522	3341

Table 9: Comparison of fish product province/prices[5]

5.5   Comparison of added value

In the table 10 we can see the comparison of percentage in difference of proportional distribution of added value in different provinces and on different level of value chain. The values are derived from all products and founded results monitored during the data research divided into provinces and segment of value chain. From this table we cannot say that these numbers will refer to any other example in future research as they are valid only for this particular data collection and would be same only if further research would be exactly the same with same number and identity of respondents, even though we can say: "because of particularity of each province, the added value in each segment may differ in dependence of province".

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[4] 4,100 KHR = 1 $
[5] Note: significance level 0.95.

Province	Primary producer	Intermediaries	Processors	Retailers	Mean Total added value (riel)	Added value from final price	Final price (riel)
Kampong Thom	19.01%	26.83%	9.06%	45.10%	5684	49.96%	12118
Kampong Chhnang	34.17%	32.45%	15.81%	17.56%	7560	62.86%	11786
Phnom Penh	30.54%	38.29%	11.26%	19.94%	7858	57.74%	13357
P - value	0.19	0.65	0.88	0.09	0.45	0.28	0.85
Std. error	0.058777	0.08693	0.0961	0.09	1295	0.05	2103.6

Table 10: added value comparison[6]

In the Figure 9. is graphically illustrated how the added value is distributed into different segment of value chain.
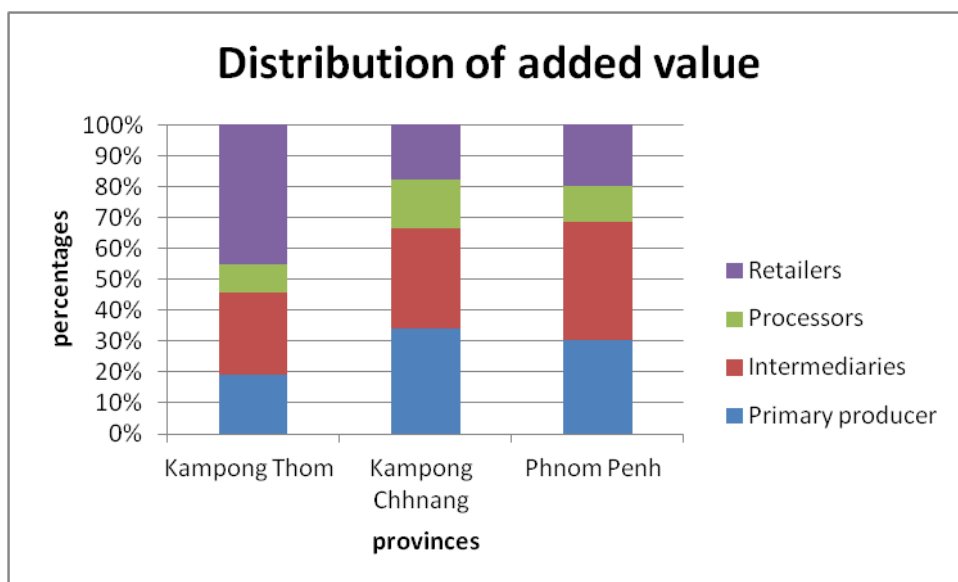
Figure 9: distribution of added value

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[6] Note: significance level 0.95.

5.6   Mapping the travel roads of products

As we can see in Figure 10 the geographical exchange of products on different level of supply chain between provinces are abundant but there can also be seen the slight tendency to target the markets in Phnom Penh, what is understandable as the market in Phnom Penh is also with the highest demand as the capital city with good geographical position on Mekong river which provides possibility as a supply mean.
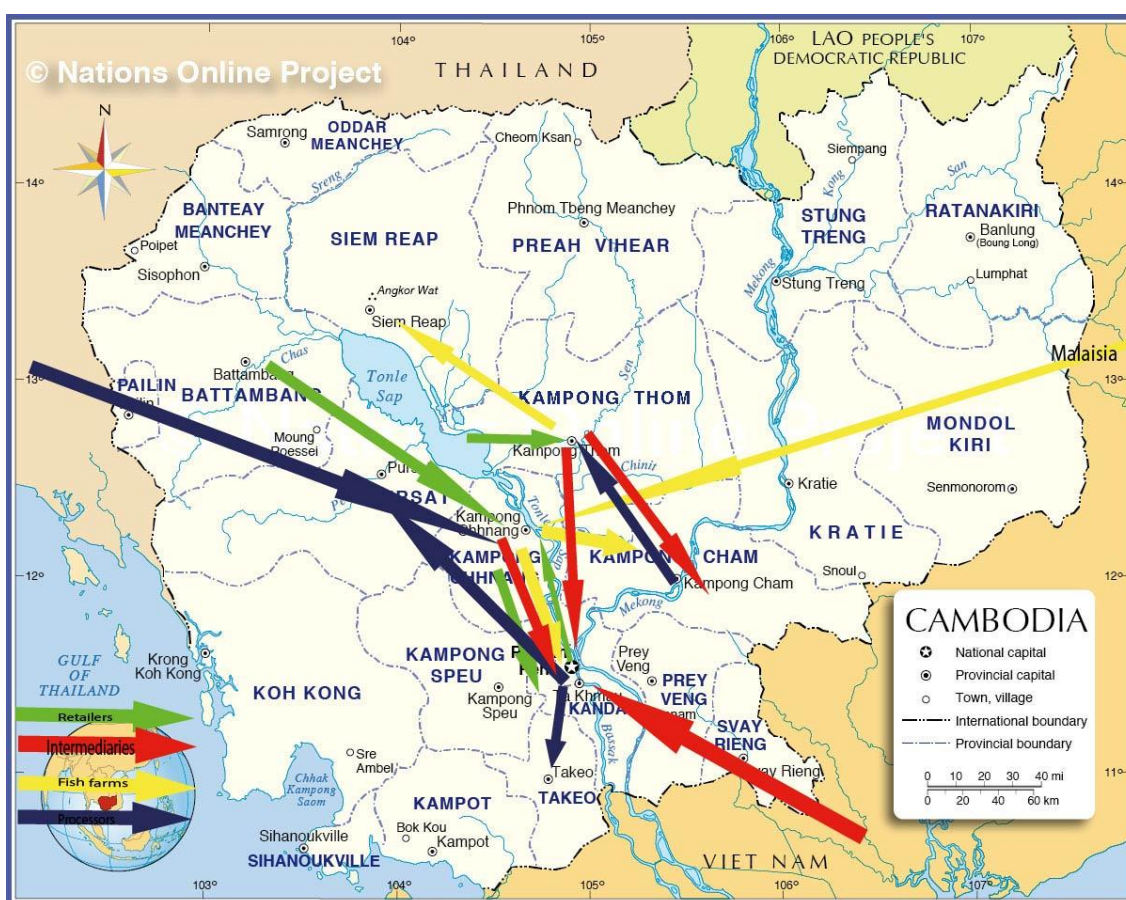
Figure 10: Mapped travel roads of fish production

From the map there is also noticeable that the exchange is not only between provinces but also between countries for example processors from Kampong Chhnang acquire fishes from Thailand fish farmers acquire their fingerlings in Malaysia and intermediaries situated in Phnom Penh buy their fishes in Vietnam and if the research would be more wide there would be other findings of export and import as for example with Vietnam the exchange works on daily basis in both directions, thanks to the Mekong river. In the diagrams of supply chain for each province, figures 10 and 11, we

can visualize how many percents of commodities are transferred from lower segment to higher segment and which of the segments it is. These results are based on data collection and can function as a guide and an example that the value chain in Cambodia is not strictly following in linear continuity.
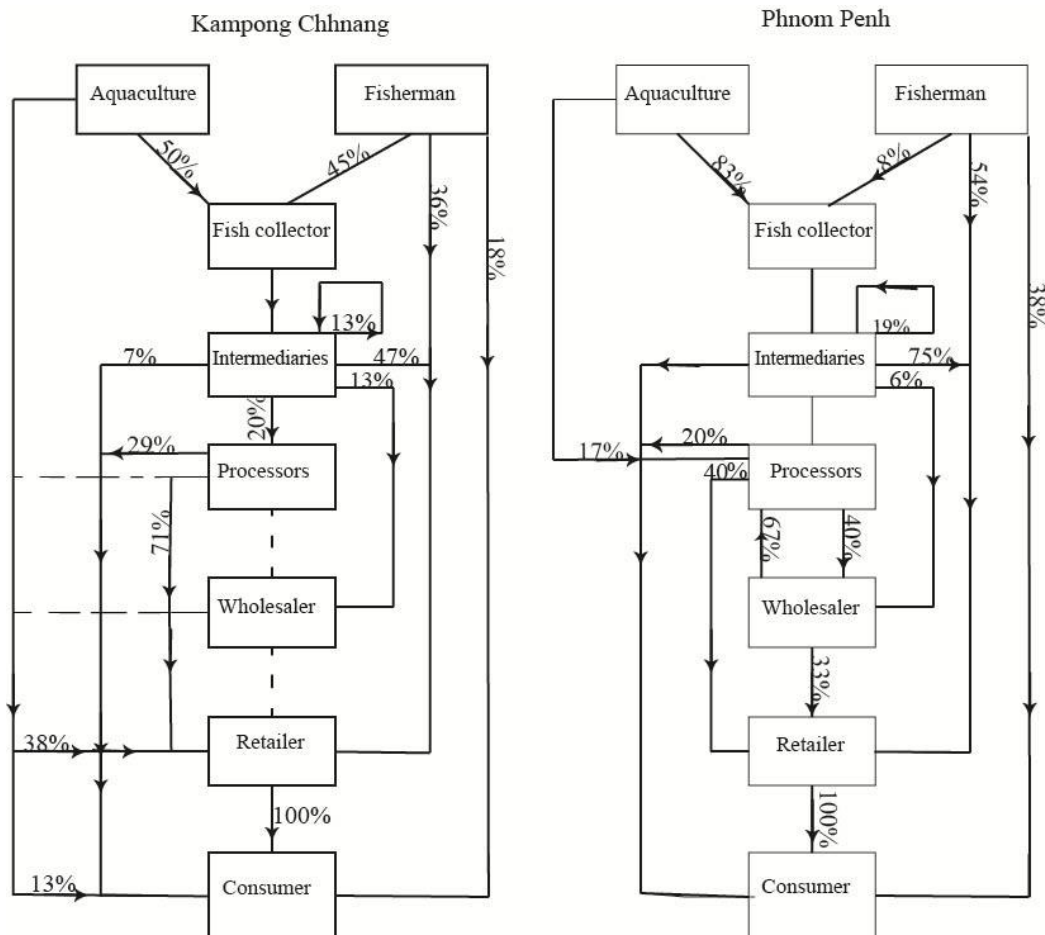
Figure 11: Phnom Penh and Kampong Chhnang supply chain

Fisherman does not sell all his production to the fish collector, but some of the fisherman are selling it by them self or by someone from their family, or they can sell it directly to the processor. This goes with the fish farmers similarly but, because of the high amount they produce, they are not selling it to the consumers except to their relatives or close friends. In the segment of intermediaries there can be seen that some of the intermediaries are selling the commodity to other intermediaries this is due to problems with the transport or if they are exporting it, they transport the commodity to the place where other intermediary will buy it from them and then the second intermediary is transporting it further and resale part of the commodity to the specific segment which is in need.
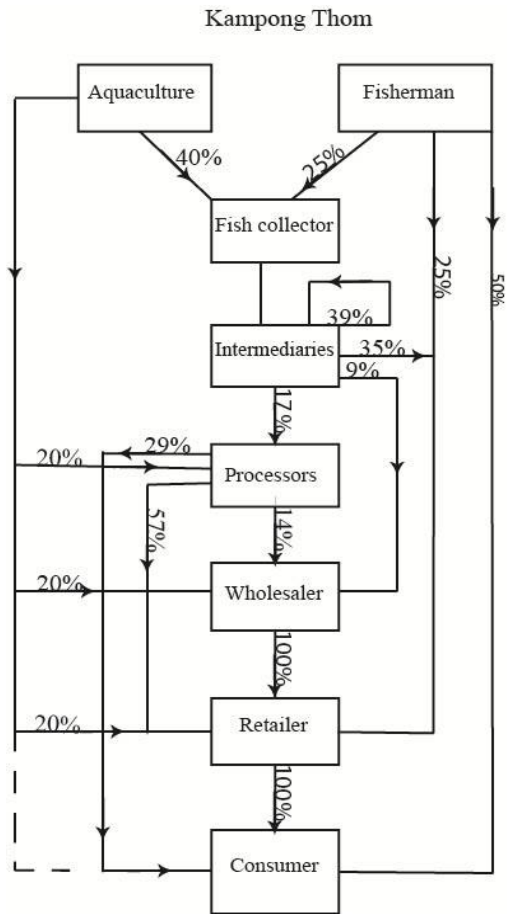
Figure 121: Kampong Thom supply chain

6   Discussion

The differences between the published articles and this research outputs are mentioned in this chapter. The results are divided according to each segment of the value chain. The following chapters follow step by step each segment separately to describe in detail positive and negative aspects of specific segments.

6.1   Primary producers

According to Rab et al. (2005) the value chain starts with fisherman, fish farmers or lot owners (medium or large scale fishermen, sometimes formed to companies), Rab et al. classify them in one segment. In our case it is not divided in the same way, due to the fact that their way of business is too different. For example fish farmers are selling their products once per year, per culture, their revenues are intermittent and they sell all of their production to middleman. On the other hand fisherman, especially small scale farmers, are fishing every day. In most of the cases they keep something for their own consumption (0.5-1 kg.), some part they sell by themselves or by their relatives, mostly female as they could obtain that way better prices. If they do not sell everything the same day or if they cannot afford to go to the market due to time or distance than they sell it to the middleman. The lot owners are categorized as a large scale fisherman. They sell all their catch to the middleman but their activity is strictly controlled and in some places or seasons they are prohibited to fish or have been closed due to law empowerment because overfishing. During data collection there have not been any interviews with lot owners so they are not included in this research.

Aquaculture

The aquaculture in Cambodia is one of the fastest growing sector in fish production. The reason is that with increasing population there is also a need of increasing production and wildlife fishery would not be able to sustain the demand according to plan 2000 to 2020 SO and Nao, (1999). In 2020 Cambodia will be in need of 300,000 tons of fishes from aquaculture to supply the demand of annual consumption 30 kg per capita. According to this report Cambodian government begin to encourage aquaculture in rural areas of the country by promoting a range of aquaculture approaches. The

number of aquacultures increased from 3,455 pond to 56,234 pond in 2009 (FAO, 2016). During the data collections it occurs that most of the fish farmers have owned more than one aquaculture, 10 % had more than that and they planned to further increase volumes. It is profitable if we compare the costs of 500 to 1,000 riel per kg which includes buying of fingerlings and costs for feeding. The basic problem is that the fish farmers have a very small economical knowledge and when they sell their fishes they have to save 50% of revenues for another year to pay for the cost of fingerlings and other costs associated with starting new aquaculture, (repairing, cleaning). The fish collectors always come to the fish farmer and put the goods to the truck or boat, pay per kg so the fish farmers does not have to take care about the transportation and its cost.

Fishermen

The fisherman people are the poorest in the process as they earn around 20,000 to 40,000 KHR per day depends on the province, species they fish and if they are selling it by themselves or to fish collector. It is their only means of income, they also fish to catch fingerlings for aquaculture around 26% of fingerlings comes from capture fisheries (Joffre et al., 2010). They mostly left 0.5 to 1 kg of their catch for their families and their revenues are spend for repairing of boats, fuel, net, clothes and meals on the basis of informal interviews. They told us they are able to save around 1,000 KHR per day. The fishermen in our research were all small scale fisherman and we could not find any medium or lot owners. The small scale fishermen are a job that is done by anyone mostly by the poorest people In Cambodia. According to the law, anybody can fish whenever wants. Small scale fishermen are controlled only by the gear they use as there is prohibited to use electricity and certain fish traps (depends mainly on the sizes of eyes in net) which kills also the fingerlings. The most fishermen used boats with engines, only two interviewed fishermen where using boats without engine as the most used gear was special fish trap called *loap* in Khmer language. *Loap* is a fish trap which comes in two varieties: one is made from net and it looks like long tube with knotted end and the other one is made from wood and look like a basket. The trap is mainly used for catching Siamese carp and mix. Fishing rod was use by 3 questioned respondents.

6.2   Processors

"*Cambodia has centuries of old tradition of processing freshwater fish. Products include: fish paste, fermented fish, dry salted fish, smoked fish, fish sauce, and dried fish for animal feed*" (FAO, 2011). This statement summarizes the whole processing business, they learn those procedures from their ancestors, mostly processing the goods at home or any storage facility in their close vicinity, in the case of drying, they use any place which is on the sun, for example: roof, road, specially made tables for drying. On the question; what is the most problematic thing in the processing of drying? They obviously mentioned rain. According to our data collection there was no respondent which would use any other drying device like solar dryer or other more sophisticated equipment like ovens. If it would start raining they would cover the commodity by plastic cover. In the case of smoking they need special equipment for smoking and mostly it is located inside their house. The device is similar to a closable grill. The most problematic thing in the process of smoking is a fire as the wood cannot be in fire but should only glow to produce heat and smoke. If it caught fire the processing goods will be damaged (burned). The smoking process has to be checked periodically. All the interviewed processors had the knowledge from their parents or other ancestors and were based as family businesses. In addition to the processing earning they can sell the waste and leftovers from processing to other stakeholders and earn additional money.

6.3   Intermediaries and Distribution Channels

The trade channels in Cambodia fish productions can be divided according to Hap et al., (2011) into 11 groups.

- Channel 1: Fishers → Retailers → Consumers
- Channel 2: Fishers → Retailers → Restaurant → Consumers
- Channel 3: Fishers → Wholesalers → Retailers → Consumers
- Channel 4: Fishers → Wholesalers → Retailers → Restaurant → Consumers
- Channel 5: Fishers → Wholesalers → Processors → Retailers → Consumers
- Channel 6: Fishers → Wholesalers → Processors → Retailers → Restaurant → Consumers
- Channel 7: Fishers → Wholesalers → Processors → Consumers
- Channel 8: Fishers → Wholesalers → Processors → Restaurant → Consumers

- Channel 9: Fishers → Wholesalers → Processors → Phnom Penh city
- Channel 10: Fishers → Wholesalers → Wholesalers in Phnom Penh city
- Channel 11: Fishers → Wholesalers → Restaurant → Consumers

For the fish farmers the channels are the same, the difference is only in the starting point.

The intermediaries are working as a connection between primary producers, processors, wholesalers and retailers. They vary from person on motorbike which for small fee transfers few kilograms of commodity from wholesaler to retailer, to intermediary which transports the commodity between provinces or across the border in the amount of tonnes. The intermediaries were using transportation depending on the geographical location, for example in Kampong Chhnang they were using boats in Kampong Thom and Phnom Penh trucks with combination of boats. During the transportation huge amount of fish died because of bad transportation methods (Nobuyuki et al,. 2012). During the data collection we encountered segments only from channels: 1, 3, 5, 7, 9. There have not been reported any connection to restaurants but there is a possibility that the segments which we were interviewing have not been aware that their commodity is going to restaurants. When we were asking the respondents the question who is buying the goods from them, they were able to answer from which province they come and if they are wholesalers or intermediaries after we carefully explained them the difference but they did not have any knowledge what is happening with their commodity afterwards.

The earnings of fish collectors and intermediaries are according to Kula and Turner (2015) depending on variety of fish species from 500 to 1,000 KHR per kg they collect and resell. The challenge of their business is that their work is extremely seasonal, because they cannot operate during some period. These data are in consent with our data collection.

6.4   Retailers

The fish retailers in Cambodia are situated at the town markets which sometimes also serve as a gathering place for local people this mostly apply for provincial markets and markets in the rural areas. The retailers are mostly poorly equipped and sell from the ground or tables. These conditions apply for all the retailers not only in fish production.

The hygienic conditions are poorly managed as they kill, gut and fillet all the fish in one place, mostly there is no any outlet for blood and in some places the commodities were infested by flies. The itinerant traders does not have their stall and move from place to place, they mostly sell already processed products and their offer is more limited in the comparison with stall retailers.

For the comparison of the different price level between the provinces and seasons we chose the final price for which the retailers sell to consumers. In case of other segments the commodity could have been sold in other province and for the purpose of comparing price levels between the provinces it would not be a suitable process. The results show us that there was not statistically significant difference in price levels between the seasons. During the interviews the respondents mostly answered that the prices were the same, but some of the respondents said that the price change in the amount of 1,000 KHR but in the overall results these changes were not evaluated as a significant and the same changes were monitored even between the retailers for the same season. In case of different price level and their correlation on province there were found 3 species Tilapia, Common Carp and Siamese Carp which proved the changes statistically significant. These changes of price levels between provinces may have been caused because of different abundance of these species on the market in concrete provinces.

6.5   Fish consumption

FAO (2011) reported that fish consumption on the household level is one of the highest in the country. (Ahmed et al., 1998) reported that annual consumption per capita is 75 kg of fish fresh and processed. Mogensen (2001) found that daily consumption of fish and other aquatic animals in Cambodian diet is 79 g per capita per day or 492 g for household per day (at the rate 109 g per adult unit). In our research we prioritized the daily consumption of fish product (prahoc, fish paste, dried fish, and smoked fish). We compared the results depending on provinces as there may be seen the big difference between the capital and urban provinces. In the rural provinces (Kampong Thom, Kampong Chhnang) has been monitored average consumption per month around 900 g and in Phnom Penh the average consumption was 3,213 g per capita, but these numbers were calculated by the weighted mean and the inconsistent data could have adjust the

results. As we can see in the results the dispersion is 4,129 g for dry fish and for prahoc is the dispersion 2,308 g in Phnom Penh. Even though that the research sample was inconsistent the modus for dry fish is still few times higher than at the other provinces which shows us that the difference is still significant.

6.6   Constraints

Rab et al., (2005) and FAO (2011) identified in their work number of constraints, concerning infrastructure of supply chain of fish production in Cambodia.

- Rudimentary or no permanent structures at landing sites.
- Lack of equipment for proper storing and preservation of freshness.
- Minimum quality control.
- Lack of proper processing equipment.
- Inadequate retailers facilities
- Poor access to information
- Inadequate facilities for hygienically storing, transporting, processing, weighing, packing along whole   supply chain.

The data collection has found that these constraints are still preserving and actual. Until these constraints will still be in place there will be no possibility of upgrading value chain for exporting purposes as there will be no possibility to empower certificate of quality control which are required for other countries, one of the most well-known HACCP.

The demand on fish production in Cambodia is increasing with the same speed as population, the demand for amount need to be filled with aquaculture as natural resources will not be able to provide such a production.

6.7   Résumé of value chain of fish production

Fishery and fish production in Cambodia is part of livelihood for most Cambodians, they are inevitable band together because of natural resources and cultural habits, the interconnection can be seen almost everywhere. The main subject of this thesis was to map value chain in Cambodia as developing country. The value chain is in many ways different from the value chain in developed countries from the view of processing goods, storage and transportation means. In developed countries the processing starts immediately after harvest or catch, in the form of packaging or filleting. In Cambodia the processing part is missing and most of the fishes are sold fresh or alive if we are not talking about processed goods like for example: prahoc, fish paste, dried fish or smoked fishes, but even so, these processions are done only to prolonged shelf life or use unwanted parts and low value fish. When the retailer does not sell everything through the day he may use unwanted parts of commodity as a feed for aquaculture or to make low quality prahoc or low quality fish which are bought by the poorest of Cambodians.

The value chain of fish production in Cambodia is well managed despite the fact of poor country infrastructure and bad or no conservation methods which leads during the transportation to unnecessary deaths of fish or loosing weights (FAO, 2011) or it may lead to health problems for consumer.

7   Conclusion and recommendation

The value chain of fish production in Cambodia works sufficiently enough for domestic purposes in 2015, the connections between different segments of value chain are on the level of fluent transfer between the actors. On the other hand the demand on fish production grows fast, the value chain needs to be upgraded on all levels in the means of storage, processing and transporting to ensure that the commodities are in their best quality. Also with the growing population there will be a higher need of aquaculture as the wild life fisheries will not satisfy growing demands for food consumption and Cambodia might deplete their natural resources. This may lead to the state where it will be impossible to recover. In the means of export they may in the future occur problems with the unhygienic handling of commodity along whole value chain, therefore it will be a problem to adopt certifications which - as has been said above - are mandatory for developed countries to import products from abroad.

For the upgrading of value chain of fish production there are few suggestions for actions which may be done.

1. Better managing of wildlife fishing to put a bigger pressure on preventing illegal fishing by employing more people to fishery administration or to appoint guards from local people with good knowledge and responsibility to improve environmental controlling system.

2. Increase the amount of aquacultures to increase production from fish farms and decrease the burden of environment, government may continue to utilize programs to augment and adopt technologies for raising various fishes on fish farm.

3. Using pellet feed at affordable price for fish farmers as an alternative to low value fish. Start to culture fish for fish farming to avoid fishing of fingerlings and thus decrease fish prices.

4. Increase amount and transparency of information about fish prices to increase marketing power of smaller merchants or intermediaries.

5. Increase the quality of fish by introducing better conservation methods for transportation and selling to induce more hygienic conditions on market, also to decrease amount of deaths during the fish transportation.

6. Secure proper environment for establishing financial organizations which tend to offer more loans with low interest rates.

7. Provide possibilities to induce certification of quality for increasing market opportunities.

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Appendix I:

1   Maps
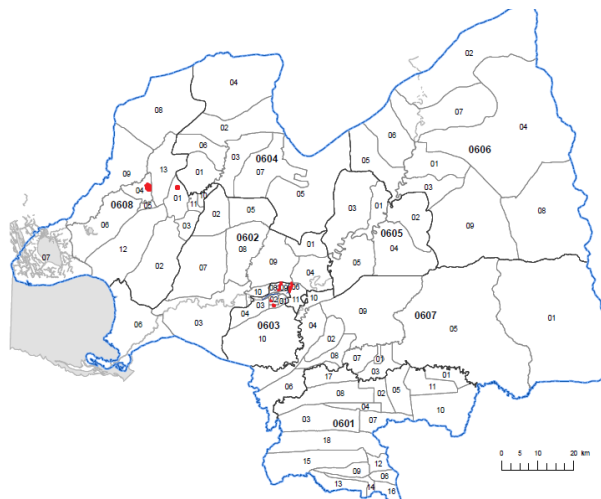
Annex 1: Kampong thom places of data collection
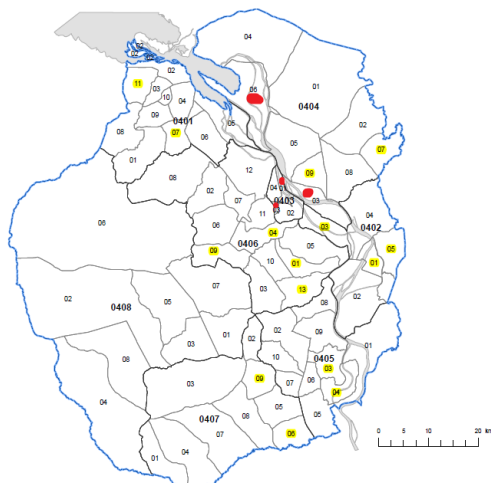
Annex 2: Kampong Chhnang places of data collection
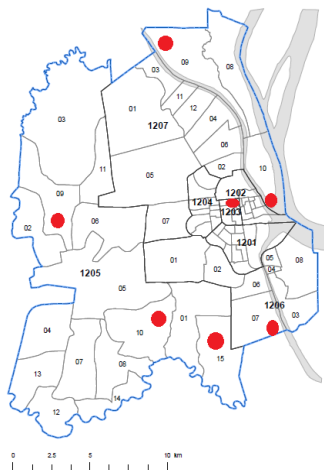
Annex 3: Phnom Penh municipal area places of data collection

Appendix II : Questionnaires

Primary producers Questionnaire:

1. What kind of equipment do you use to fish?

   Fishing rode   boat   fishing net   Other____

   If boat: what type?   Boat with engine   without engine

2. Do you own or rent your fishing gear?

   Own   rent

   If rent: what is the cost?

3. How much do you catch per day at the dry season?

   Rainy season?

4. Do you sell all your catch?

   If not: how much of your catch you leave for yourself?

5. What do you sell?

Specie	Sell kg/day (dry)	sell kg/day (rainy)	Price/kg rainy season	Price/kg dry season
Tilapia				
Climbing Perch				
Walking Catfish				
Pangasius				
Carp				
Chana				

6. How do you process products you catch?

   Filleting   drying   freezing   fermenting
   Other_____
   no processing

7. To whom do you sell?

   Fish collector   wholesalers   retailers   consumer
           Other_____

8. Did the price at which you sell your commodities changed in last 5 years?

   Yes   No
   If yes how much? _____

9. How many members does you have your family?
10. Nationality: Cambodian   Vietnamese   Thai   Laos
            Other_____
11. How big is your household? Number_____

Processors

1. What do you sell??

Specie	buy kg/day (dry)	buy kg/day (rainy)	price/kg rainy season	Price/kg dry season	sell kg/day (dry)	sell kg/day (rainy)
Tilapia						
Climbing Perch						
Walking Catfish						
Pangasius						
Carp						
Chana						

2. How do you process following species?

Specie	Drying Cost/kg	Filleting Cost/kg	Freezing Cost/kg	Packaging Cost/kg	Making paste Cost/kg	Fermenting Cost/kg	Other Cost/kg
Tilapia							
Climbing Perch							
Walking Catfish							
Pangasi							

us						
Carp						
Chana						

3. From whom do you buy the fishes?

   Fisher   fish collector   wholesaler   retailer   other

4. How many people do you hire?

   1-5   6-10   11-20   21-50   more than 50

5. Do you rate quality of the fishes you buy?   Yes   No

   If yes how?

6. Where do you store it?

   Special storage house   freezers   fresh Ice

   water storage   cage in water   other_____

7. What is the form of payment?   Cash   credit   Other____

8. Can you please show me where do you process it?

9. By who is the product bought?

   wholesalers   retailers   consumer   Other____

10. What is the major problem in the processing?

11. Do you measure the quality of your product? Yes   No

If yes: how?

12. What type of arrangement do you have with your business counterpart?

13. Is your business expanding or decreasing?

14. Has it expanded or decreased over the last five years?

15. Have you invested in new machineries in last 1 year? Yes No
    If yes: what type of machinery?

16. Have you hired new people? Yes   No

    If Yes: how many, eventually gender?

17. Over the next five years, is there space for business increase?

18. Nationality: Cambodian   Vietnamese   Thai   Laos
            Other____

Intermediaries

1. What kind of fish/product are you buying?

2. From whom do you buy fishes?

Fisher   fish collector   wholesaler   other

3.

Specie	buy kg/day (dry)	buy kg/day (rainy)	price/kg rainy season	Price/kg dry season	How is it processed
Tilapia					
Climbing Perch					
Walking Catfish					
Pangasius					
Carp					
Chana					

Specie	Sell kg/day (dry)	sell kg/day (rainy)	price/kg rainy season	Price/kg dry season
Tilapia				
Climbing Perch				

Walking Catfish				
Pangasius				
Carp				
Chana				

4. How do you transport your commodities?

by boat   by car   by motorbike   by tuk tuk   other____

5. How much you pay for the fuel necessary to transport these commodities per day? per week?

6. Which is the form of payment, credit or cash?

7. From whom do you buy the fishes?

Fisher   fish collector   wholesaler   retailer   other

8. To whom do you sell your commodities?

wholesaler   retailer   consumer   other

9. Did you sell these commodities at the same price throughout the past 5 years? Yes No

If no: How the price has changed?

10. Over the next year is there space for business increase of your product? YesNo

If yes: how?

11. Have you noticed any other changes in your commodities sales? Yes   No

If yes: what type of changes?

12. Nationality: Cambodian   Vietnamese   Thai   Laos

Other____

Retailers

1. Which type of fish do you buy or sell?

Walking Catfish   Pangasius   Carp   Channa   Tilapia
Climbing Perch

2.

Specie	buy kg/day (dry)	buy kg/day (rainy)	price/kg rainy season	Price/kg dry season	How is it processed
Tilapia					
Climbing Perch					
Walking Catfish					
Pangasius					
Carp					
Chana					

3. Method of conservation:

   Ice box   Vacuum   Bags   Water barrels
   Other____

4. How do you transport your commodity to market?
   Car   Boat   Motorbike   Truck   Other____

5. What is the form of payment?

   Credit   Cash   Other____

6. Selling

Specie	Sell kg/day (dry)	sell kg/day (rainy)	price/kg rainy season	Price/kg dry season	How is it processed
Tilapia					
Climbing Perch					
Walking Catfish					
Pangasius					
Carp					
Chana					

7. Nationality: Cambodian   Vietnamese   Thai   Laos

   Other____

Consumers

1. What type of fish you prefer/consume more?

   Tilapia   Climbing perch   Walking Catfish

     Pangasius Carp

2. How often do you eat fish?

   2 times per day   1 time per day   weekly____ times

3. At what price do you buy fishes?

Specie	buy kg/day (dry)	buy kg/day (rainy)	price/kg rainy season	Price/kg dry season	How is it processed
Tilapia					
Climbing Perch					
Walking Catfish					
Pangasius					
Carp					
Chana					

4. What type of fish product do you buy?

Product	How often	Price per unit

Prahoc		
Fish paste		
Dry fish		
Fish fillets		
Whole Fish		
Other_____		

5. Do you fish? Yes no

If yes: for food   for sell   as a hobby

6. Nationality: Cambodian   Vietnamese   Thai   Laos

   Other____

7. How big is your household? Number____

Fish farmers

1. What kind of aquaculture do you do?

Cage   pond   other

2. What specie do you grow?

3. Do you buy small fishes?

No   yes

if yes: what is their cost?

how many?

cost per kg?

4. How much does cost you the feeding?

5. What is the mortality of your aquaculture?

6. How much do you sell per year?

7. What month do you sell your commodity?

Price/kg

8. From whom do you buy the small fishes?

9. To whom do you sell?

fish collector   wholesaler   retailer   consumer

comment….

10. How many aquacultures do you have?

What is their size?

12. Did the price at which you sell your commodities change in last 5 years?

if yes how?

13. Nationality: Cambodian   Vietnamese   Thai   Laos
        Other____

13. How big is your household?

Appendix III: photo documentation

Annex 4: Kampong Chhnang data collection

Annex 5: Kampong Thom data collection

Annex 6: Phnom Penh photo documentation

Appendix IV: Fish species

Scientific name: *Anabas testudienus*

English name: Climbing Perch

Scientific name: *Clarias batrachus*

English name: Walking Catfish

Khmer names: trey andaing roueng; trey andeng; trey andèng

Scientific Name: *Channa Striata*

English Name: Common Snakehead

Khmer Name: Trey Ros

Scientific name: *Oreochromis niloticus*

English name: Nile Tilapia

Khmer name: Trey tilapia chhnoht

Scientific name: *Pangasius hypophthalmus*

English name: Striped Catfish

Khmer name: Pra, Trey Pra

Scientific Name: *Pangasius Bocourti*

English Name: Basa Catfish

Khmer Name : Trey Pra Kchaov

Scientific Name: *Henicorhynchus/Cirrhinus Lobatus*

English Name: Lesser Silver Mud Carp

Khmer Name : Trey Riel Ongkarm

Scientific Name: *Henicorhynchus/Cirrhinus Siamensis*

English Name: Siamensis Mud Carp

Khmer Name : Trey Riel Tob

I. Statistics

Tilapia

Effect	Univariate Tests of Significance for Tilapia (Spreadsheet1) Sigma-restricted parameterization Effective hypothesis decomposition				
	SS	Degr. of Freedom	MS	F	p
Intercept	2.137032E+09	1	2.137032E+09	6073.671	0.000000
season	2.168459E+05	1	2.168459E+05	0.616	0.440107
province	5.116667E+06	2	2.558333E+06	7.271	0.003399
season*province	1.722222E+05	2	8.611111E+04	0.245	0.784841
Error	8.444444E+06	24	3.518519E+05		

Cell No.	Scheffe test; variable Tilapia (Spreadsheet1) Probabilities for Post Hoc Tests Error: Between MS = 3519E2, df = 24.000			
	province	{1} 9833.3	{2} 9750.0	{3} 10750.
1	1		0.968261	0.005156
2	2	0.968261		0.037133
3	3	0.005156	0.037133	

	province; LS Means (Spreadsheet1) Current effect: F(2, 24)=7.2711, p=.00340

Cell No.	Effective hypothesis decomposition					
	province	Tilapia Mean	Tilapia Std.Err.	Tilapia -95.00%	Tilapia +95.00%	N
1	1	9833.33	139.8117	9544.78	10121.89	18
2	2	9750.00	296.5855	9137.88	10362.12	4
3	3	10750.00	209.7176	10317.16	11182.84	8

Climbing Perch

Effect	Univariate Tests of Significance for Climbing perch (Spreadsheet1) Sigma-restricted parameterization Effective hypothesis decomposition				
	SS	Degr. of Freedom	MS	F	p
Intercept	761280303	1	761280303	818.0923	0.000000
season	0	1	0	0.0000	1.000000
province	4833333	2	2416667	2.5970	0.153991
season*province	0	2	0	0.0000	1.000000
Error	5583333	6	930556		

Walking Catfish

Effect	Univariate Tests of Significance for Walking Catfish (Spreadsheet1) Sigma-restricted parameterization Effective hypothesis decomposition				
	SS	Degr. of Freedom	MS	F	p
Intercept	1.273475E+09	1	1.273475E+09	2473.657	0.000000
season	1.198582E+05	1	1.198582E+05	0.233	0.635258
province	1.197917E+06	2	5.989583E+05	1.163	0.334822
season*p	9.791667E+04	2	4.895833E+04	0.095	0.909737

rovince					
Error	9.266667E+06	18	5.148148E+05		

Pangasius

Effect	Univariate Tests of Significance for pangasius (Spreadsheet1) Sigma-restricted parameterization Effective hypothesis decomposition				
	SS	Degr. of Freedom	MS	F	p
Intercept	1.229526E+09	1	1.229526E+09	1592.753	0.000000
season	1.569767E+06	1	1.569767E+06	2.034	0.169288
province	1.987880E+06	2	9.939402E+05	1.288	0.297848
season*province	7.909679E+05	2	3.954840E+05	0.512	0.606757
Error	1.543900E+07	20	7.719500E+05		

Common Carp

Effect	Univariate Tests of Significance for common carp (Spreadsheet1) Sigma-restricted parameterization Effective hypothesis decomposition				
	SS	Degr. of Freedom	MS	F	p
Intercept	1.780056E+09	1	1.780056E+09	3204.100	0.000000
season	5.555556E+04	1	5.555556E+04	0.100	0.757263
province	9.344444E+07	2	4.672222E+07	84.100	0.000000
season*province	7.777778E+05	2	3.888889E+05	0.700	0.515773
Error	6.666667E+06	12	5.555556E+05		

	Scheffe test; variable common carp (Spreadsheet1) Probabilities for Post Hoc

Cell No.	Tests Error: Between MS = 5556E2, df = 12.000			
	province	{1} 13167.	{2} 8333.3	{3} 8333.3
1	1		0.000000	0.000000
2	2	0.000000		1.000000
3	3	0.000000	1.000000	

Cell No.	province; LS Means (Spreadsheet1) Current effect: F(2, 12)=84.100, p=.00000 Effective hypothesis decomposition				
	province	common carp Mean	common carp Std.Err.	common carp -95.00%	common carp +95.00%	N
1	1	13166.67	304.2903	12503.68	13829.66	6
2	2	8333.33	304.2903	7670.34	8996.32	6
3	3	8333.33	304.2903	7670.34	8996.32	6

Siamese Carp

Effect	Univariate Tests of Significance for siamese carp (Spreadsheet1) Sigma-restricted parameterization Effective hypothesis decomposition				
	SS	Degr. of Freedom	MS	F	p
Intercept	1.218375E+09	1	1.218375E+09	200.6244	0.000001
season	5.104167E+05	1	5.104167E+05	0.0840	0.779257
province	1.350000E+08	2	6.750000E+07	11.1149	0.004905
season*province	2.738095E+05	2	1.369048E+05	0.0225	0.977771
Error	4.858333E+07	8	6.072917E+06		

Cell No.	Scheffe test; variable siamese carp (Spreadsheet1) Probabilities for Post Hoc Tests Error: Between MS = 6073E3, df = 8.0000			
	province	{1} 13000.	{2} 10000.	{3} 5500.0
1	1		0.229622	0.004905
2	2	0.229622		0.088463
3	3	0.004905	0.088463	

Cell No.	province; LS Means (Spreadsheet1) Current effect: F(2, 8)=11.115, p=.00490 Effective hypothesis decomposition				
	province	siamese carp Mean	siamese carp Std.Err.	siamese carp -95.00%	siamese carp +95.00%	N
1	1	13000.00	1006.058	10680.03	15319.97	6
2	2	10000.00	1232.164	7158.62	12841.38	4
3	3	5500.00	1232.164	2658.62	8341.38	4

Prahoc

Effect	Univariate Tests of Significance for prahoc (Spreadsheet19) Sigma-restricted parameterization Effective hypothesis decomposition				
	SS	Degr. of Freedom	MS	F	p
Intercept	2.501036E+09	1	2.501036E+09	174.6406	0.000000
province	6.796312E+07	2	3.398156E+07	2.3728	0.113099
Error	3.723472E+08	26	1.432105E+07		

Fish paste

	Univariate Tests of Significance for fish paste (Spreadsheet19) Sigma-restricted

Effect	parameterization Effective hypothesis decomposition				
	SS	Degr. of Freedom	MS	F	p
Intercept	1.519028E+10	1	1.519028E+10	260.7951	0.000000
province	2.344087E+09	2	1.172044E+09	20.1223	0.000057
Error	8.736905E+08	15	5.824603E+07		

	Scheffe test; variable fish paste (Spreadsheet19) Probabilities for Post Hoc Tests Error: Between MS = 5825E4, df = 15.000			
Cell No.	province	{1} 24143.	{2} 17833.	{3} 46000.
1	1		0.357005	0.000784
2	2	0.357005		0.000087
3	3	0.000784	0.000087	

	province; LS Means (Spreadsheet19) Current effect: F(2, 15)=20.122, p=.00006 Effective hypothesis decomposition					
Cell No.	province	fish paste Mean	fish paste Std.Err.	fish paste -95.00%	fish paste +95.00%	N
1	1	24142.86	2884.590	17994.50	30291.22	7
2	2	17833.33	3115.714	11192.35	24474.32	6
3	3	46000.00	3413.093	38725.16	53274.84	5

Dry fish

	Univariate Tests of Significance for dry fish (Spreadsheet19) Sigma-restricted

Effect	parameterization Effective hypothesis decomposition				
	SS	Degr. of Freedom	MS	F	p
Intercept	1.641877E+10	1	1.641877E+10	322.5115	0.000000
province	1.902400E+08	2	9.512000E+07	1.8684	0.178049
Error	1.120000E+09	22	5.090909E+07		

Smoked fish

Effect	Univariate Tests of Significance for smoked fish (Spreadsheet19) Sigma-restricted parameterization Effective hypothesis decomposition				
	SS	Degr. of Freedom	MS	F	p
Intercept	2.904000E+09	1	2.904000E+09	130.0299	0.001447
province	1.830000E+08	2	9.150000E+07	4.0970	0.138740
Error	6.700000E+07	3	2.233333E+07		