The role of low value fish in aquaculture in Cambodia after ban on the cultivation of Giant Snakehead- *Socio-economic impact assessment*

by

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Abstract

Cambodia is among the poorest countries in the world. A majority of the population depends heavily upon natural resources for their livelihood, and sustainable management of the ecosystems providing these is therefore utterly important i.e. a matter of life and death. One of Cambodia's most important natural resources is the Tonle Sap Lake. The majority of the Cambodian population lives within the central floodplain of the Tonle Sap Lake and Mekong River. People living in provinces bordering the lake and Mekong River depend on fisheries and other ecosystem services that the area provides for food, income and livelihood. Fish is one of the most important food sources for Cambodian inhabitants and constitute 75 % of the animal protein intake for the population. Besides the use of low value fish for human consumption, the fish is increasingly of great importance in aquaculture of carnivorous and omnivorous fish species. Aquaculture is an important employment, food and income provider in many developing countries and has therefore been encouraged. Trey chdor, Giant snakehead (*Channa micropeltes*) was the most popular cage cultured fish species in Cambodia. Giant snakehead is a strict carnivore and culture mainly depends on low value fish for feed. In order to sustain future supplies of low value fish, the government in Cambodia banned snakehead culture in 2004. The aim of this study is to describe the effectiveness of the ban and present role of low value fish in Cambodian aquaculture located in the Tonle Sap area. The analysis of this report was based on interviews from a field study and literature reviews. The study showed that pond and cage aquaculture in Cambodia is still depending on low value fish and 60 % of the farmers included in this study use low value fish as fish feed. The study also showed that the cost of both rice bran and low value fish have increased considerably the past five years. This study could not show any general trend of change in household economy for pond and cage farmers after the ban. And despite the ban a majority (54 %) of the farmers experienced a decreased availability of low value fish after the ban. Giant Snakehead is still farmed after the ban by 14 % of the farmers. The observance of the ban is not complete and the control system in place seems subject to manipulation and bribery.

Contents

1. Introduction

1.1 A fishing-depended country

Cambodia covers an area of 181 000 km^2, has 13,9 million inhabitants and is among the poorest countries in the world (CIA 2008). A majority of the population depends heavily upon natural resources for their livelihood, and sustainable management of the ecosystems providing these is therefore utterly important i.e. a matter of life and death (Bonheur and Lane 2002). Agriculture (includes fisheries) constitutes 31 % of the national gross domestic product (GDP) (CIA 2008) and has together with the fisheries sector the highest incidence of poverty of all sectors (46 %) (CFDO-IMM 2005). In Cambodia 35 % of the population lives below poverty line and the median age is only 21,3 years and many people living in the countryside lack both basic infrastructure and education (CIA 2008). The population in Cambodia is growing at a rate of 1,752 % per year (CIA 2008) with increasing pressure on the natural resources as result (Bonheur and Lane 2002). The population suffers of poor health and malnutrition, the diet do not often give them enough micronutrients such as vitamin A, iron and zinc, low intake of these nutrients causes retarded growth and mental development in children (Roos et al. 2007).

One of Cambodia's most important ecosystems is the Tonle Sap Lake providing large amounts of natural resources (Fig. 1) (Bonheur and Lane 2002). The majority of the Cambodian population lives within the central floodplain of the Tonle Sap Lake and Mekong River (Bonheur and Lane 2002) and 1,25 million of Cambodia's inhabitants live in the five provinces bordering the Tonle Sap Lake (i.e. Po Sat, Kompong Chnang, Battambang, Siem Reap and Kampong Thom) (Navy et al. 2006) (Fig. 1). These people depend on fisheries and other ecosystem services that the area provides for food, income and livelihood (Navy et al. 2006). Fish is one of the most important food sources for Cambodian inhabitants (Rab et al. 2006) and constitute 75 % of the animal protein intake for the population (MAFF 2007). A study made by Ahmed et al. (1998) estimated the average annual per capita consumption of fresh fish to 43,5 kg. Cambodia has the highest catch/inhabitant (kg/capita/year) in the world[1] (Baran 2004). Communities remote from Tonle Sap Lake area are also very dependent on fish for food security (CFDO-IMM 2005).

[1] The catch/inhabitant in year 2000 was 20,09 kg/capita in Cambodia, 0,97 kg/capita in China, 0,41 kg/capita in India and 4,58 kg/capita in Bangladesh (Baran 2004).

The unique biodiversity of the Tonle Sap Lake make it a key element in the ecology of the lower Mekong River system and the economy and culture of Cambodia (Bonheur and Lane 2002). The lake's aquatic ecosystem is thought to be the most productive inland fisheries of the world (Rab et al. 2006) and estimated annual fish catch is between 289,000 and 431,000 tonnes (Bonheur and Lane 2002). Of the total inland fisheries production, it is estimated that 60 % originates from the Tonle Sap Lake, the value is approximated about US$ 150-250 million (Navy et al. 2006). The total GDP of Cambodia is US$ 2 800 million with the total fisheries sector contributing between 8-10 % (MAFF 2007). It is, however, important to be aware about that many reports on fish consumption, fish catches and the monetary value of fish catches presents different data and there is a strong mismatch between official and scientific assessments (Baran et al. 2007). Official statistics are often under-reported (Baran et al. 2007).

Fig. 1 Map of Cambodia. Modified from: CIA 2008

1.2 Low value fish and inland fisheries

Small fish species generally have a lower market value than larger ones and is therefore more accessible to poor people particularly in seasons of high production (Roos et al. 2007). Low value fish has been defined as: "Fish that have a low commercial value by virtue of their low quality, small size or low consumer preference. They are either used for human consumption (often processed or preserved) or used for livestock/fish, either directly or through reduction to fish meal/oil" (Funge-Smith et al. 2005). Although there are differences in the use of the

term, e.g. in China is fish of low value destined for human consumption named “low value fish” but if it is utilized as animal feed it is named “trash fish” (FAO 2005). Some fish become of low value after harvest due to poor handling, a problem that many fish producing countries, e.g. India, seek solution to (Funge-Smith et al. 2005). Juveniles of commercially important fish species are also being caught and used as low value fish (FAO 2005). Despite their low economic value, low value fish species have multiple uses through-out the Asian-Pacific region e.g. consumption, animal feeds, fish meal production and for value-added products (FAO 2005). Species that make up low value fish can also be of high ecological value despite their low economic value, and intensive fishing of these species can therefore have negative impact on the aquatic ecosystem (e.g. catches of juvenile large species can result in changes in food-web structures and loss of larger fish species) (Funge-Smith et al. 2005).

Inland fisheries of Cambodia is composed of three different levels of fishing operation and gear types: 1) family/small-scale (subsistence) fishing, 2) middle-scale (artisanal) fishing and 3) large-scale (industrial/commercial) fishing (Rab et al. 2006). There are different regulations depending on what type of fishing that is performed. Family-scale fisheries are permitted to fish all year round, middle-scale and large-scale gears are only permitted during the open season (October-May) (Rab et al. 2006). Family-scale fishing is very common around the Tonle Sap Lake and its basin areas. About all households in the area practice this type of fishing (Navy et al. 2006) and family members usually use small gears such as gill nets (must be smaller than 10 meters long) and bamboo fence traps (Nam S. and Roitana B. 2005). As mentioned above, this type of fishing can be conducted all year round and does not require license and the majority of the catches is used for subsistence consumption (Navy et al. 2006). Of all the households actively involved in fishing about 90 % are small-scale operators, in 1995 about 85 000 households in the area were engaged in family fishing (Navy et al. 2006). Middle-scale fishing is for commercial purpose and is only allowed to fish during October-May when the water level in the Tonle Sap Lake begins to recede and the floodplain area is decreasing in size. In 1995 there were about 9000 middle-scale fisheries in the area, each of them with an average catch of about 5,3 tonnes per annum (Navy et al. 2006). The large-scale fisheries have a two-year leasing system that they operate under and the gears used (e.g. bamboo barrage traps and seine nets) coves large areas and are rather non-selective, i.e. target many species (Nam S. and Roitana B. 2005).

Besides the use of low value fish for human consumption, the fish is of great importance in the culture of carnivorous and omnivorous fish species globally (Naylor et al. 2001, Funge-Smith et al. 2005). Most countries in the world use marine low value fish as feed, but in Cambodia mainly freshwater fish (97 %) is being used (Nam et al. 2005). Aquaculture is an important employment, food and income provider in many developing countries; therefore aquaculture has been encouraged (Funge-Smith et al. 2005 and Edwards et al. 2004). Aquaculture can be seen as an option to utilize low value fish (FAO 2005) but unfortunately and inevitably, such policy only creates an even higher pressure on the finite low value fish resource. In the Asia-Pacific region prices of low value fish is increasing due to the higher demand and declining catches (Funge-Smith et al. 2005). For a sustainable future of aquaculture alternative feeds are needed and it is also important to fully understand the interactions between capture fisheries and aquaculture (Funge-Smith et al. 2005).

1.3 Cambodian aquaculture

Aquaculture is practiced in most provinces of Cambodia and has a 100 years old history (CFDO-IMM 2005). In Cambodia the fish production of inland aquaculture increased from 1 610 tonnes in 1984 to 20 760 tonnes in 2004 and is estimated to increase even further (Nam et al. 2005). In 2004 8,3 % of total inland fisheries production in Cambodia came from aquaculture (Nam et al. 2005). Aquaculture in Cambodia is a diverse activity but as much as 60-90 % of the inland aquaculture production comes from cage cultures and depends on both seed and feed made of wild fish (Nam et al. 2005). A more recent culture system that has increased rapidly is pond culture and the most popular species being cultivated in ponds are e.g. Trey pra (*Pangasianodon hypophthalmus*) and Trey andaing (hybrid between *Clarias batrachus* and *Clarias gariepinis*) (Nam et al. 2005).

Cage culture: involves a cage floating in the water made of e.g. wood frames. Could be in association with a ”floating house” over it.
Pond culture: involves a pond dug on land.

Trey chdor, Giant snakehead (*Channa micropeltes*) was the most popular cage cultured fish species in Cambodia (Nam et al. 2005). In year 2003 a total quantity of 2 455 tonnes Giant Snakehead were produced in Cambodia, the quantity increased to 13 036 tonnes year 2005 (FAO 2008). Giant snakehead is a strict carnivore and the culture mainly depends on low value fish for feed (Nam et al. 2005). Low value fish constitute 60-100 % of the total feed used for Giant Snakehead, but many other species are also fed with low value fish (although not to the same extent) e.g. Trey pra (*Pangasianodon Hypophthalmus*), Trey chhpin

(*Barbonymus gonionotus*) and Trey po (*Pangasius larnaudii*) (Nam et al. 2005). Results from a study made by Rab et al. 2006 showed that one third of the households in Tonle Sap area practiced aquaculture. About 65 % of the fishermen practicing cage culture used parts of their fish catches as fish feed, but only 27 % of the fishermen having a pond culture. The growing demand for low value fish has resulted in a sharp increase of the price of low value fish (Nam et al. 2005). Cambodian aquaculture highly depends upon low value fish and at least 22 % of the total inland catches are low value fish used as feed in aquaculture (Nam et al. 2005). Inevitable there is a conflict between households that need low value fish for their livelihood and cultivators of fish that needs an income. Since Giant Snakehead culture created an increased need of fishing for low value fish, illegal methods for catching them are used (PRIAC 2006). In order to sustain future supplies of low value fish, the government in Cambodia banned snakehead culture in 2004 (CFDO-IMM 2005) and the law was implemented in 2005 (PRIAC 2006). The objective of the ban was to force people to investigate other alternatives for their aquaculture and hopefully to create positive ecological effects (PRIAC 2006).

The main aim of this study is to describe the effectiveness of the ban and present role of low value fish in Cambodian aquaculture located in the Tonle Sap area. The study focuses on possible effects, e.g. economical and/or availability, resulting from the ban on Giant Snakehead cultivation. Only fish farmers will be included in the study. Some more specific questions that will be addressed are:

- What species are being cultivated instead of Snakehead?
- Have the farmers' profits from aquaculture changed after the ban?
- Has the farmers' availability[2] of low value fish for local consumption increased after the ban? Uses in aquaculture are not considered.
- Is the ban an effective instrument for the maintenance of the low value fish species?

The results are compared with studies on Cambodian aquaculture made before the ban. The ban will might increase people's consumption of low value fish, something resulting from decrease in incomes. The ban will prevent low value fish from being used in Cambodian Snakehead farming, but as such culture is legal in e.g. Vietnam, there is a risk that fishing

[2] In this study availability means how easy the fish farmers can get hold of low value fish, e.g. at the local market and/or by own fishing. The availability is affected negatively if the low value fish has increased in price or if it is less low value fish at the market or in the river.

pressure remains high in Cambodia. Low value fish resources can easily be exported to Vietnam, and cultured Snakehead production can be exported from Vietnam to Cambodia. This is however not investigated in this study.

2. Study area and method

Tonle Sap Lake covers an area of 250,000 hectares during the dry season and it is the largest freshwater lake in Southeast Asia (Bonheur and Lane 2002). The lake interacts with the Mekong, and during the monsoon season flows water into the lake and the area increases to 1,25 million hectares, covering both forest and agriculture land (Bonheur and Lane 2002).

The analysis of this report was based on interviews from a field study and literature reviews. Other preparations before the field study included e.g. writing and testing the questionnaire. The field study was conducted in four different provinces (Kompong Chnang, Prey Veng, Kompong Cham and Kandal) in Cambodia during September and October 2007 (Fig. 2). The study sites were chosen out from the study made by Nam et al. (2005) (included totally seven study sites). The time spent in each province was one week. The selected provinces are characterised by a dependence on fish among lower socio-economic groups, and fish cultivators that depends or depended on low value fish for their aquaculture. Kompong Chnang and Kandal are located on the Tonle Sap, Prey Veng on the lower Mekong River and Kompong Cham on the upper Mekong River (Fig. 2).

Fig. 2 A map of Cambodia that shows selected study sites: Kompong Chnang (CHN), Prey Veng (PV), Kompong Cham (CH) and Kandal (KD). Modified from CIA 2008

Interviews with pond farmers and cage farmers were made using semi-structured interviews (Appendix 1). The questionnaire was tested before the field study (meeting one cage farmer and one pond farmer) in Kandal province in Cambodia. After the testing the interview was somewhat modified. A field guide (local provincial fisheries officer, one for each province) assisted in selection of families for the interviews. The field guide had directions to, as far as possible, select farmers that cultivated Giant Snakehead before the ban. This information was not available at beforehand and the selection by the fisheries officer was therefore crucial. The household head (usually an elderly man) answered the questions, and only at few occasions, if the household head was not available, someone else in the household answered the questions. This person had also knowledge about the household and the farm. An interpreter assisted during all the interviews. Interviews were made during daytime (not at lunch time) and most often in the homes of the interviewed. Smaller gifts were given to everyone that were interviewed and to their child/children, if any. It varied if the whole family were present during the interview or not.

The interviews provided information about the household structure and economy, species cultivated, both at present time and before the ban on cultivating Giant Snakehead, and about the fish feed, e.g. price of feed and kinds of feed. The interviews also provided information about perceptions and impacts of the ban, availability of low value fish for local consumption and general problems for the farmers.

3. Results

The total number of interviews made during the field study (excluding the two interviews when testing the interview) was 89 (51 cage farmers and 38 pond farmers, see Table 1). The number of interviews made in the different provinces was 21 in Kompong Chnang, 21 in Kompong Cham, 25 in Prey Veng and 22 in Kandal. The results have been divided between cage farmers and pond farmers for better comparison with the study made by Nam et al (2005).

Table 1. Totally 51 cage farmers and 38 pond farmers were interviewed in four different provinces during the field study of this study.

Province	Location	Cage farmers (number of interviews)	Pond farmers (number of interviews)	Date
Kompong Chnang	Tonle Sap lake	13	8	24-28/9-07
Kompong Cham	Upper Mekong	11	10	1-5/10-07
Prey Veng	Lower Mekong	15	10	15-19/10-07
Kandal	Tonle Sap lake	12	10	22-26/10-07
Total		51	38	

3.1 Pond aquaculture

3.1.1 Species

The average operation time for an aquaculture pond was 8 years, ranging from 1 year to 30 years. The most dominating species being cultivated was Trey pra (*Pangasianodon hypophthalmus*) (Table 2). Only one farmer did not cultivate Trey pra. Other species that were cultivated by many farmers were Trey tilapia (*Oreochromis niloticus*) and Trey andaing (the clariid catfish, hybrid between *Clarias batrachus* and *Clarias gariepinis*), although no farmers in the provinces Kompong Chnang and Kompong Cham cultivated these species (Table 2). Trey chhpin (*Barbonymus gonionotus*), Trey chdor (The Giant Snakehead *Channa micropeltes*) and Trey kap sor (*Hypopthalmichthys molitrix*) were cultivated only by two farmers. One farmer cultivated Trey po (*Pangasius larnaudii*) and another farmer cultivated Trey kap sismav (*Ctenopharyngodon idella*). Most farmers (58%) cultivated more than one species and a majority of these farmers (59 %) mixed the species in the pond (polyculture) instead of separating the different species in different ponds.

Table 2. Number of Cambodian pond farmers cultivating specific fish species and in which provinces.

Species	Number of pond farmers that cultivated the fish at present	Provinces* were cultivation of the specific species occurred
Trey pra (*Pangasianodon hypophthalmus*)	37	CHN, CH, PV, KD
Trey tilapia (*Oreochromis niloticus*)	14	PV, KD
Trey andaing (the clariid catfish, hybrid between *Clarias batrachus* and *Clarias gariepinis*)	11	CH, PV, KD
Trey chhpin (*Barbonymus gonionotus*)	7	PV, KD
Trey chdor (The Giant Snakehead *Channa micropeltes*)	2	CH, PV
Trey kap sor (*Hypopthalmichthys molitrix*)	2	KD
Trey po (*Pangasius larnaudii*)	1	CHN
Trey kap sismav (*Ctenopharyngodon idella*)	1	KD

* Kompong Chnang (CHN), Prey Veng (PV), Kompong Cham (CH) and Kandal (KD)

3.1.2 Resources

Fingerlings of Trey pra were in most cases bought from fishermen or traders, but some farmers went to Vietnam to buy fingerlings and some farmers fished the fingerlings themselves. Trey tilapia and Trey andaing fingerlings were generally bought from traders, fishermen or from hatcheries.

Trey pra, Trey tilapia and Trey andaing were fed rice bran and low value fish (Appendix 3) and to some extent pellet and waterlily. Additional feeds were rice leftovers, algae and kapok flour. See Appendices 2 and 3 for more details.

3.1.3 Effects on household economy and availability of low valued fish resources from ban of Snakehead farming

A majority of farmers (53 %) reported that their economy improved the last five years (i.e. after the ban on cultivating Giant Snakehead). The explanation that the farmers gave for this change was increased market value for the cultivated fish. Farms experiencing decreased profits (21 %) argued that higher costs for fish feed (e.g. rice bran and low value fish) were the main reason for this. A few farmers (26 %) said that they had not experienced any change in household economy for the past five years (Fig. 3).

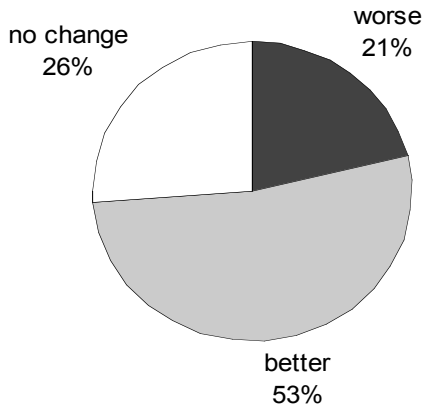

Fig. 3 The majority of the interviewed pond farmers experienced that their household economy was better now compared to five years ago, i.e. when the ban on cultivating Giant Snakehead had not been applied.

Only 14 farmers (37 % of all pond farmers) said that they cultivated Giant Snakehead before the ban (Table 3) (either alone or with other species), and 9 farmers reported decreased profits after the ban. The explanation for this was that Giant Snakehead had higher market value than the species they cultivate now. The other 5 farmers said that they get better profits from their cultivation after the ban mainly due to structural changes e.g. increase of fish stock densities in their ponds. A majority (64 %) of the farmers that cultivated Giant Snakehead before the ban did not cultivate any other species except Giant Snakehead. As a result of the ban most of these farmers replaced Giant Snakehead with Trey pra. Other farmers (36 %) already cultivated other species (e.g. Trey pra) before the ban and continued doing so after the ban.

Table 3. Number of Cambodian pond farmers cultivating Giant Snakehead (*Channa* micropeltes) before the ban and in which provinces.

Province	**Number of pond farmers that cultivated Giant Snakehead (*Channa micropeltes*) before the ban**
Kompong Chnang	3
Kompong Cham	4
Prey Veng	3
Kandal	4

A majority (58 %) of all the interviewed farmers experienced a decrease in the availability of low value fish after the ban. This was based on own experience of less low value fish in the river, or on information from fishermen or traders. Although some farmers (26 %) had, in the same way, experienced an increase of low value fish after ban (Fig. 4). Some of the farmers (16 %) did not know or had not experienced any change in availability of low value fish. These two last groups were combined into one group.

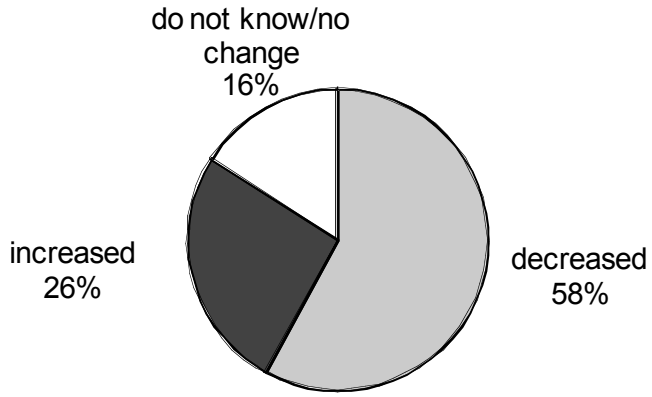

Fig. 4 Percentage of pond farmers agreeing with the different statements: "increased", "decreased" or "do not know/no change" in availability of low value fish after the ban. A majority experienced an increase in the availability of low value fish.

Many farmers thought that a ban on Giant Snakehead cultivation was appropriate as it would lessen the pressure on low value fish species. However, many farmers also expressed a concern that the low value fish will not increase despite the ban. The main arguments for this were that 1) many fishermen use illegal and disruptive gear when they fish (e.g. electric gear and small hole net), and 2) that low value fish are increasingly being exported to other countries (i.e. Vietnam). Some farmers were negative to the ban and argued that they could not see any "result" (e.g. increase in availability of low value fish) and that only having a ban on just Giant Snakehead farming was not effective since the culture of Trey andaing also depends of low value fish. However most farmers of Trey andaing gave a mixture of rice bran (approx. 50 %, by weight) and low value fish (approx. 50 %, by weight), this differs from Giant Snakehead that was fed only low value fish.

3.2 Cage aquaculture

3.2.1 Species

The average operation time for an aquaculture cage was 11 years, ranging from 1 to 26 years. Altogether Trey pra, as for the pond farmers, was the most dominating cultivated species. Although there was a major difference between the four provinces on species domination (Table 4). In Kompong Chnang dominated Trey pra and in Prey Veng was both Trey pra and Trey tilapia common. Only two farms cultivated Trey pra in Kompong Cham. Approximately 50% of the farmers in Kandal cultivated Trey pra. Trey chhpin, was the dominating species in Kompong Cham and Trey po, the second most popular species. Trey po and Trey ke (*Pangasius conchophilus*) dominated in Kandal. The second most popular species being cultivated, for all provinces altogether, was Trey po. Other species that many farmers cultivated was Trey chhpin, Trey ke, Trey tilapia, Trey kahe (*Barbonymus altus*), Trey pra kchau (*Pangasius bocourti*) and Trey prorlung (*Leptobarbus hoveni*). Giant Snakehead was, despite the ban, cultivated by 14 % of the farmers. Species being cultivated only by one or a few farmers in a province were Trey kampot (*Auriglobus nefastus*), Trey krum (*Osteochilus melanopleuras*), Trey carp (*Thryssocypris tonlesapensis*), Trey damrey (*Oxyeleotris marmorata*), Trey khya (*Hemibagrus wyckioides*), Trey kap samanh (*Cyprinus carpio*), Trey prual (*Cirrhinus microlepis*) and Trey chhlang (*Hemibagrus nemurus* and also *H. spilopterus*). One farmer had stopped cultivating fish completely after the ban (Table 4). Totally 76 % of the cage farmers cultivated more than one species, 82 % of these farmers mixed the species (polyculture).

Table 4. The number of cage farmers that cultivated specific fish species and in which province.

Species	Number of cage farmers that cultivated the fish at present	Provinces* were cultivation of the specific species occurred
Trey pra (*Pangasianodon hypophthalmus*)	23	CHN, CH, PV
Trey po (*Pangasius larnaudii*)	19	CHN, CH, PV, KD
Trey chhpin (*Barbonymus gonionotus*)	15	CHN, CH, PV, KD
Trey ke (*Pangasius conchophilus*)	11	CH, KD
Trey kahe (*Barbonymus altus*)	11	CHN, PV, KD
Trey tilapia (*Oreochromis niloticus*)	10	PV, KD
Trey pra kchau (*Pangasius bocourti*)	10	CHN, CH, PV, KD
Trey prorlung (*Leptobarbus hoveni*)	9	CHN, PV, KD
Trey chdor (The Giant Snakehead *Channa micropeltes*)	7	PV
Trey carp (*Thryssocypris tonlesapensis*)	4	CHN, PV
Trey damrey (*Oxyeleotris marmorata*)	3	CHN, CH
Trey khya (*Hemibagrus wyckioides*)	3	CH, KD
Trey prual (*Cirrhinus microlepis*)	3	KD
Trey krum (*Osteochilus melanopleuras*)	2	CHN
Trey kampot (*Auriglobus nefastus*)	2	CHN, CH
Trey kap samanh (*Cyprinus carpio*)	1	PV
Trey chhlang (*Hemibagrus nemurus* and also *H. spilopterus*)	1	KD
Stopped cultivating after ban	1	CHN

* Kompong Chnang (CHN), Prey Veng (PV), Kompong Cham (CH) and Kandal (KD)

3.2.2 Resources

Fingerlings of Trey pra were predominately bought from fishermen, but some farmers also fished fingerlings themselves, bought from hatcheries or from Vietnamese traders. Some farmers even travelled to Vietnam themselves to buy fingerlings. The majority of farmers of Trey po and Trey chhpin bought their fingerlings from fishermen, but other alternative sources were buying from traders or hatcheries and also from own fishing. Giant Snakehead

fingerlings were bought from fishermen or from Vietnamese traders (although some farmers went to Vietnam themselves to buy fingerlings). Fingerlings of Trey damrey were bought from fishermen or from traders.

The fish feed given to the most popular cultivated species Trey pra, Trey po, Trey chhpin and Trey tilapia were rice bran and low value fish. Trey chhpin was also given waterlily and organic wastes from restaurants (so called pig feed) by a few farmers. One farmer even gave Trey chhpin excrement from chicken, duck and pig as feed. Giant Snakehead was only given low value fish as feed. Main low value fish species being utilized as fish feed was Trey riel (*Henicorhynchus siamensis*, *Henicorhynchus cryptopogon* and *Henicorhynchus caudimaculatus*), Trey bandoul ampov (*Clupeichthys aesarnensis*), Trey khnorng veng (*Labiobarbus lineatus* and *Labiobarbus leptocheila*), Trey srakar kdarm (*Cyclocheilichthys lagleri*) and Trey linh (*Thynnichtys thynnoides*). See Appendices 2 and 3 for more details.

3.2.3 Effects on household economy and availability of low valued fish resources from ban of Snakehead farming

There was no major difference between the numbers of cage farmers that reported decreased, increased or no changed household economy after the Snakehead ban (Fig. 5). Of 51 interviewed cage farmers, 35 % said that their net profit had decreased due to more expensive fish feed, less profits from the cultivation, increased competition with other fish farmers and other difficulties e.g. fish diseases. The economy was better now for 32 % of the farmers, mainly because of increased income from fish compared to five years ago. A given explanation for the increased market price of cultivated fish was that the stock of wild fish had decreased but the demand for fish is still high; market price had increased both for wild fish and cultivated fish. The remaining 33 % of the farmers did not experience any change in their economy the past five years (Fig. 5).

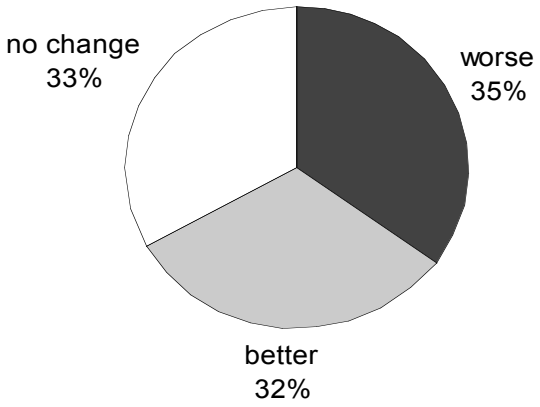

Fig. 5 There was no major difference on how the cage farmers experienced that their household economy had changed compared to five years ago, i.e. when the ban on cultivating Giant Snakehead had not been applied.

Of the interviewed cage farmers, 26 farmers (51 %) had cultivated Giant Snakehead before the ban (Table 5) and 18 farmers said that their profits decreased after the ban. The explanation given for this were 1) Giant Snakehead could be sold at a higher price, 2) the cost of fish feed (both low valued fish and agriculture products) had increased after the ban, and 3) the number of fish farmers had increased resulting in increased competition and lower prices of farmed fish. Another explanation put forward by some farmers was that rice bran now has to be bought to feed the fish. When Giant Snakehead was cultivated the farmers could themselves fish low value fish for free. Only 2 farmers said that their profits had increased after the ban. The reason for this was a diversified production (many different species reared together) that, according to the farmers, enabled them to sell the fish more easily. The other 6 farmers said that they did not experience any change in profits (or did not know), and some farmers said that they had compensated the income loss from not being able to farm Snakehead with e.g. increasing the size of the cages. Of the farmers producing Snakehead before the ban 52 % farmed no other species than Snakehead. After the ban most of these farmers replaced Snakehead with Trey pra. Farmers that had other species besides Giant Snakehead (48 %) also farmed Trey pra, Trey po, Trey pra kchau, Trey prorlung, Trey carp, and Trey kahe.

Table 5. Number of Cambodian cage farmers cultivating Giant Snakehead (*Channa* micropeltes) before the ban and in which provinces.

Province	Number of cage farmers that cultivated Giant Snakehead (*Channa micropeltes*) before the ban
Kompong Chnang	9
Kompong Cham	5
Prey Veng	5
Kandal	7

A majority (51 %) of all the farmers said they experienced a decreased availability of low value fish after the ban. As with the pond farmers this observation/opinion was based on information from fishermen they know or from own fishing activity. Many farmers did not know or did not experience any change in availability of low value fish. These two groups represented together 29 % of the interviewed cage farmers. Some of the farmers (20 %) did, however, said they noticed an increased availability of low value fish after the ban (Fig. 6).

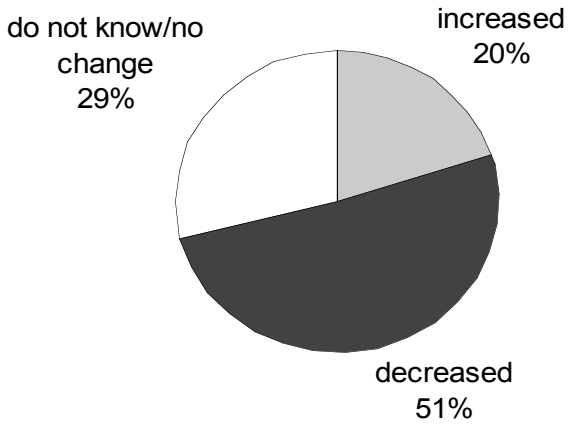

Fig. 6 Percentage of cage farmers agreeing with the different statements: "increased", "decreased" or "do not know/no change" of low value fish after the ban. A majority experienced a decrease in the availability of low value fish.

The most positive attitude against the ban was found in Kandal province. There many of the farmers believed that the ban could result in protection of low value fish resources. The most negative attitude against the ban was in Prey Veng province, where the farmers complained about decreased profits. General perception in all four provinces was that the ban could

contribute to the conservation of low value fish stocks, but that profits for farmers that before cultivated Giant Snakehead had decreased. Many farmers were concerned about activities that decrease the availability of low value fish, e.g. illegal fishing (using electric gear and small hole net) and increased fishing pressure due to increased population. Some farmers still find ways to continue farming Giant Snakehead despite the ban. This was by some farmers said to cause negative effects for farmers that followed the ban. The illegal operation could potentially imply extra costs for farming (e.g. for bribery) and also living with fear of being caught by the authorities. In some places this created some aggression from farmers that wanted to cultivate Giant Snakehead but could not afford "paying off" regulating officers (1 million KHR/cage was mentioned by a farmer). Some farmers (9 %) believed that the ban does not affect the availability low value fish, it only depends on natural causes e.g. the area of flooded forest every year. Many of the farmers had no perceptions of the ban since they did not experience any changes on availability of low valued fish.

3.3 General perceived constraints for aquaculture

Cage farming involved farming of more species compared to pond farming. There were totally 17 different species cultivated in cages and only 8 species in ponds. Some of the species that were cultivated were introduced species, i.e. Trey tilapia, Trey andaing, Trey kap sor, Trey kap sismav and Trey kap samanh. Exotic species constituted 50 % of all species being cultivated in ponds and only 12 % of all species cultivated in cages. There were more cage farmers (51 %) that had cultivated Giant Snakehead before the ban than pond farmers (37 %).

Major problems for both pond and cage farmers were problems with water quality (diseases), weather events (e.g. flooding) and increased household expenditures. Almost all of the interviewed farmers said that the cost of "everything", especially fish feed (but also for gasoline) had increased significantly over the past years. For some of the farmers, the higher market prices for their farmed fish could not compensate for the increased costs. The cost of both rice bran and low value fish has increased over the years (Fig. 7). The cost of rice bran year 2002 was based on data from 49 farms and the cost of rice bran year 2007 was based on data from 77 farms. The cost of low value fish year 2002 was based on data from 25 farms and the cost of low value fish year 2007 was based on data from 48 farms. Today all cultivated species (except Trey kap sor) generated a higher market price compared to five years ago. Trey damrey was the species with exceptional high market price compared to the

other species. The farmers o Trey damrey said that it is very difficult to cultivate (it get often sick and die) but its market value increased as a result of the ban. Figure 8 presents the market price for some of the fish species, for a more detailed list see Appendix 4.

Approximately 30 % of the farmers wanted to see a release of the ban and then start cultivating Giant Snakehead (if they not already cultivated Giant Snakehead). Many of these farmers argued that Giant Snakeheads were easier to feed because rice bran needs to be cooked and prepared before it can be given as feed. Farmers claiming that they never had cultivated Giant Snakehead had a more positive attitude towards the ban compared to farmers reporting that they cultivated Giant Snakehead before the ban. Farmers that had no perceptions about the ban or gave contradictory answers were in general farmers that cultivated Giant Snakehead before the ban.

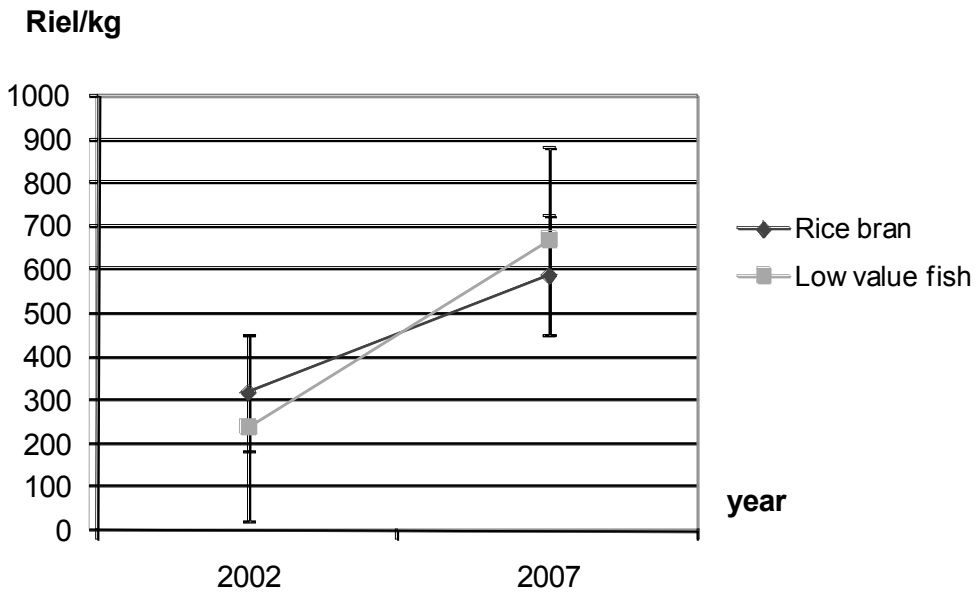

Fig. 7 Changes in cost of rice bran and low value fish over the past five years. The cost for both rice bran and low value fish had increased between year 2007 and 2002.

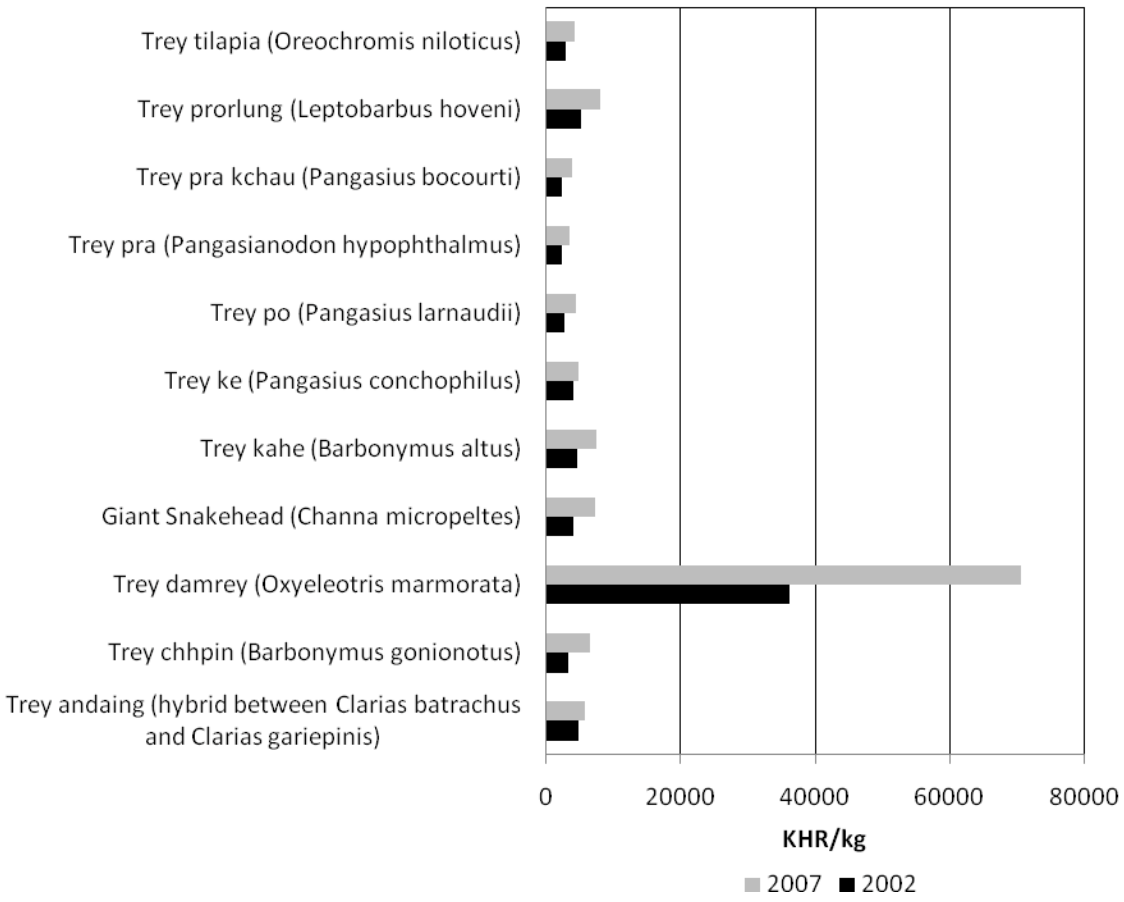

Fig. 8 The general income (KHR/kg) for some of the cultivated species. Exchange rate is approx. 4000 KHR (Khmer riel) per USD (CIA 2008).

All the farmers were also asked if they knew the sources of Giant Snakehead that was sold at the market, especially during the closed fishing season (June-October). Suggestions were 1) imported from Vietnam (40 farmers said this), 2) from hidden cultivations in Cambodia (32 farmers said this) and 3) caught in the wild in Cambodia (14 farmers said this).

For the cage and pond farmers together, 61 % of the interviewed farmers (63 % of the pond farmers and 59 % of the cage farmers) used low value fish to make feed to their cultures. A majority (65 %) of these farmers bought the low value fish directly from fishermen, and 17 % from traders. The trader came to the farmer's home and sold its products. Some (11 %) of the farmers fished themselves and only 7 % bought the low value fish at the local market.

Other species besides Giant Snakehead are fed low value fish e.g. Trey pra, Trey tilapia, Trey andaing, Trey po, Trey chhpin, Trey damrey, Trey ke and Trey kahe. These are often given low value fish in a mixed form with e.g. rice bran and/or waterlily. Some farmers only used low value fish during peak fishing season (Jan-Feb) when the price was low. Only Giant Snakehead, Trey kampot and Trey chhlang were fed low value fish directly. If Trey damrey was fed low value fish it was never mixed. Both cage and pond farmers using low value fish as fish feed used a mixture of several species, and almost all farmers used it in an unprocessed form. The dominating low value fish species was Trey riel (*Henicorhynchus siamensis* and to some extent *Henicorhynchus cryptopogon* and *Henicorhynchus caudimaculatus*). Commercially important species with a high market value constituted 20 % of the low value fish species used as fish feed (totally 40 different low value fish species were recognised in this study, see Appendix 3). Some of these commercially important species are marketed locally (Trey char keng, Trey chkok, Trey chhpin, Trey po and Trey ka hae) and others are exported (Trey pra thom and Trey khya) (So Nam IFReDI Cambodia, personal communication).

There was no clear difference in how farmers (both pond and cage farmers) between the four provinces experienced the availability of low value fish. Farmers in Kandal and Prey Veng did in general experience a more decreased availability compared to farmers in Kompong Cham and Kompong Chnang.

4. Discussion

Pond and cage aquaculture in Cambodia is still depending on low value fish and 61 % of the farmers included in this study use fresh low value fish as fish feed. Due to expansion of aquaculture the demand for low value fish in aquaculture is reported to increase (Nam et al. 2005). The aquaculture production increased from 8 450 tonnes in year 1992 to 14 100 tonnes in year 1998 (Nam and Thuok 1999). During the same period the amount of cultivated fish species not fed with fish increased from 10 % in 1992 to 20 % in 1998, but altogether the quantity of low value fish used as fish feed in aquaculture increased (Nam and Thuok 1999). Some of the low value fish species were juveniles of high commercially valuable species e.g. Trey chhpin, Trey khya and Trey po (Appendix 3). This study could not show any general trend of change in household economy for pond and cage farmers after the ban. The farmers' availability of low value fish for local consumption has not increased and a majority (54 %) of the farmers experienced a decreased availability of low value fish after the ban. Although, most of these experiences were based on information from fishermen/traders or own fishing activity and not from the local market.

4.1 Changes in species and fish feed after the ban

Nam et al. (2005) did a study that provided an understanding about the status and use of low value fish for aquaculture development in the Mekong basin of Cambodia. The study includes interviews (between April and May 2005) with totally 232 households (47 pond farmers, 134 cage farmers and 51 crocodile farmers) in seven different sampling locations covering six provinces (Prey Veng, Kompong Cham, Kandal, Kompong Chnang, Po Sat and Siem Reap). Main fish species being cultivated in ponds in the present study were the omnivorous Trey pra (*Pangasianodon hypophthalmus*) and Trey tilapia (*Oreochromis niloticus*). In the study made by Nam et al. (2005) Trey pra and Trey andaing (hybrid between *Clarias batrachus* and *Clarias gariepinis*) dominated and the present study also showed that Trey andaing is still very popular to cultivate. Both Trey andaing and Trey tilapia are exotic species and Trey pra indigenous. All three species are mainly fed rice bran and low value fish, something that also Nam et al. (2005) showed. Trey tilapia, Trey po and Trey pra were given a mixture containing 70 % rice bran and 30 % low value fish (by weight). Trey andaing, however, was given a mixture of low value fish and rice bran approximately in the proportion 1:1 (by weight). This result is of great importance as it shows that the ban on Snakehead culture does not stop the use of low value fish as fish feed. Low value fish is still used for other species although it is given in a mixed form with rice bran.

Nam et al. (2005) showed that Giant Snakehead was the most important species to be farmed in cages. This result has changed after the ban and this study shows that the native Trey pra (*Pangasianodon hypophthalmus*) and Trey po (*Pangasius larnaudii*) are now the dominating species in cage culture, although Giant Snakehead is still farmed after the ban by 14 % of the cage farmers. The observance of the ban is not complete and the control system in place seems subject to manipulation and bribery. Nam et al. (2005) listed other species that many cage farmers cultivated e.g. Trey ke (*Pangasius conchophilus*), Trey chhpin (*Barbonymus gonionotus*), Trey kahe (*Barbonymus altus*) and Trey pra kchau (*Pangasius bocourti*). These species were also important species to be farmed for this study group. Trey tilapia, a species not found in the study by Nam et al (2005) is now being cultivated by many farmers. Possible reasons for this could be that tilapia culture technology is simple and that Trey tilapia is acceptable at local markets (So Nam IFReDI Cambodia, personal communication). Rice bran and low value fish were the main fish feed given to Trey pra and Trey po, and Giant Snakehead was exclusively fed low value fish.

4.2 Utilization of low value fish

Although this study was less comprehensive compared to Nam et al. (2005) both studies identified Trey riel as the main low value fish species being used as fish feed. It was difficult to estimate quantities of the low value fish being used as fish feed and this is therefore not included. Approximately 88% of the fish species farmed in both ponds and cages were given low value fish as feed. This differs from the results of the study made by Nam et al. (2005) where not more than 25% of the species cultivated in ponds were given low value fish and where 100% of the species cultivated in cages were given low value fish as feed. A possible reason for this difference may be that the density of fish in the ponds/cages has increased and more fish feed is therefore used. Fish farmers who fish themselves might use the low value fish for their own cultivation instead of selling to Snakehead culture.

In a study on consumption patters made by Aldin-Lundgren (in prep.) 109 households (fish farmers, subsistence fishermen and rice farmers) were interviewed in the provinces Kompong Chnang, Kompong Cham, Prey Veng and Kandal. Results from this study showed that the reason for eating low value fish is often associated with household economy, i.e. low value fish is cheaper or that high value fish is too expensive. Trey riel (*Henicorynchus sp*) was the dominating low value fish species in that study and the average price (paid by the households) for this species was 3 400 KHR/kg. The prices for low value fish were generally much higher

in the study made by Aldin-Lundgren compared to this study. A majority (57 %) of the fish farmers in the study made by Aldin-Lundgren bought low value fish from the market. This is also different from this study where the majority (65 %) bought low value fish from fishermen. A possible reason for the differences in price and source of low value fish, could be that the low value fish in the study made by Aldin-Lundgren were used for human consumption and not fish feed, and is probably of better quality.

Nam et al. (2005) expressed a concern that fishes of low value were utilized in Cambodian aquaculture because it would result in increased fishing pressure and increased price of low value fish. This study showed that the cost of both rice bran and low value fish has increased considerably the past five years. The increase in price cannot solely be explained by inflation; inflation rate was 4,4 % year 2007 (CIA 2008.) An increased demand for fish trigger increase in prices and further establishment of fish farms would also increase prices (Nam et al. 2005). Increased export of low vale fish to Vietnam was reported by many farmers, something contradicting the analyse by Edward et al (2004). It found no import of low value fish to Vietnam during that time, but the ban of snakehead farming in Cambodia could explain this export. Culture of snakehead is legal in Vietnam and this trade of low value fish is of concern as it increases the fishing pressure (Be et al. 2007). For a sustainable management of both the Tonle Sap ecosystem and the aquaculture development in Cambodia, it is important to develop regional policies of this matter.

4.3 Associated problems

The total number of species used in cage farming was slightly higher compared to ponds, but only 12 % of the species cultivated in cages were exotic species, compared to 50 % of the species cultivated in ponds. Exotic species are defined as "species occurring outside its natural range" and the physical introduction being human assisted (Welcomme and Chavalit 2003). The use of exotic species in aquaculture may pose a risk to the sustainability of the ecosystem (Welcomme and Chavalit 2003). The impacts on the receiving ecosystem can cause numerous of problems, e.g. environmental disturbance, predation, competition, introduction of disease and genetic contamination/hybridization (Welcomme and Chavalit 2003). The impacts of exotic species in the Mekong basin is at present relatively minor and aquaculture has been the main reason for introduction of species in this area (Welcomme and Chavalit 2003). Although future alternations in the conditions of the ecosystem (e.g. damming and agriculture) may influence the establishment and impacts of exotic species because the native species will be

exposed to environmental stress and therefore be more vulnerable to any consequences of an introduction (Welcomme and Chavalit 2003).

Most of the fingerlings that were used in the cultivations covered by this study originated from wild supplies. This is in consistence with the study by Nam et al. (2005). Collection of juveniles from the wild may not appear to be a wasteful use of the resource, however, only limited information on this matter is available. What is known is that other species are discarded in the collection process, something that can impact negatively on wild fish populations (Naylor et al. 2001, Phillips 2002). Since 1990 the supply of small hatcheries has been promoted, and there are currently (2005) 30 private and 2 public sector hatcheries, their production of fingerlings doubled since 2000 (CFDO-IMM 2005).

4.4 Effects of the ban and general perceptions

Many pond farmers have experienced improved household economies after the ban, 53 % claiming to have a better economy now than five years ago. The majority of the pond farmers (58 %) experienced an decreased availability of low value fish after the ban, although it is important to remember that some of these opinions are based on second-hand information from fishermen and no own experience (such as increased market availability). Some, 35 %, of the cage farmers experienced worse household economies after the ban, but compared to 32 % experiencing improved economies it is difficult to make any conclusion on effects of the ban. A majority (51 %) of the cage farmers experienced a decreased availability of low value fish after the ban. This result is the same as the pond farmers' experience but this study could not show that this is correlated to the ban. The reasons for why the ban did not result in increased availability of low value fish could be a general increased use of low value fish for local consumption and aquaculture as a result of a growing population. It is however important to remember that the yield of the fishery is strongly affected by the year-to-year levels of the Mekong River (Baran et al. 2007).

Ahmed et al. (1998) surveyed households (both fishermen and farmers) in eight fishing provinces including Phnom Penh during 1995-1996. In this study people related the decreased abundance of low value fish to overexploitation and increased population. Aquaculture households covered by the present study were also concerned about these issues, but despite great concern about future supply of low value fish many farmers (30 %) wanted to release the ban. In Ahmed et al. (1998) 90 % of the interviewed households preferred a free and

unlimited access to the common property resources rather than a regulated situation. It is important to remember that this study was made 1998, and the same perception may not be valid when resources are declining further. This perception was explained by a fear of losing a traditional source of livelihood (Ahmed et al. 1998). This fear may also be applicable to the fish farmers of the present study since many farmers in had less profit after the ban and aquaculture is an old tradition, and that could then explain the contradiction of wanting to cultivate Giant Snakehead and maintain the supply of low value fish at the same time.

It is very difficult to predict how effective the ban has been/is on maintaining the low value fish due to contradictory/insufficient results from this study. The fact that some farmers still cultivate Giant Snakehead indicates that improved control systems, equal in all provinces, need to be established in Cambodia. The occurrence of illegal fishing also needs to be controlled since it adds to the many other factors affecting the availability of low value fish. Even though many farmers experienced a decreased availability of low value fish after the ban, a majority believed that the ban could contribute to maintain the low value fish populations. Although there are some indicators that the ban has been relatively successful 1) low number of farmers cultivating Giant Snakehead (Table 2 and 4), 2) no major decreases in household economies (Fig. 3 and 5), 3) few species rely heavily on low value fish as fish feed, many are given mixtures of feed (Appendix 2) and 4) the market value of Giant Snakehead is low and doesn't differ much from other species.

Ahmed et al. (1998) showed that only 70 % of the interviewed household (living in fishing provinces) were aware about the many number of regulations imposed by the Department of Fisheries in Cambodia. A majority of the households covered by that study wanted to have a stricter enforcement of the regulations in order to protect the fisheries. This opinion was also supported by few household covered by this study. It is easy to understand that people that feel their livelihood is threaten by snakehead farming would support this, however, also those that can afford bribery costs, e.g. continue to cultivate Giant Snakehead, would argue for the same as they benefit if competition decreases. The majority of the farmers in this study also seemed to understand why it is important to maintain the low value fish. A positive attitude to maintain the low value fish will probably make any further introduction of regulations easier.

4.5 Future problems and challenges

The communities around Tonle Sap Lake are very dependent on the aquatic resources the area provides them with, they are vulnerable to both short- and long-term climatic variations for example changes in the amount of rains, flood levels and duration, and changes in the size of flooded forest areas (Navy et al. 2006). Changes like this can also be induced by human activities such as dam construction, deforestation, use of pesticides in aquaculture and land development (Navy et al. 2006). These natural and anthropogenic changes on fisheries and aquatic resources can have direct consequences (Navy et al. 2006) such as smaller size of the fish caught, smaller fish catch per unit effort and disappearance of certain species (Bonheur and Lane 2002).

There are more activities that can lead to income reduction and ecosystem damage to the communities in this area, for example the use of illegal and destructive fishing gears and overfishing (Navy et al. 2006). Thus, some of the illegal gears (e.g. fine-mesh fences) catch all types of species including low value fish (Nam S. and Roitana B. 2005). Economic interests, population growth, poverty, agriculture, tourism, housing and weak governance are all challenges to a sustainable exploitation of the Tonle Sap area (Bonheur and Lane 2002). Government employees are often underqualified and need to have other jobs cause their wage is too low, resulting in weak governance (Bonheur and Lane 2002). The group of people that is going to be most affected is the poor people with low education that lives near the water and whose livelihoods have long been dependent on these resources. These people have not the same opportunity to switch to an alternative occupation (e.g. rice farming, fish processing and small business) (Navy et al. 2006).

Cambodia is a country recovering from decades of war and instability and the ongoing programmes of decentralisation will affect the management of natural resources (CFDO-IMM 2005). The aquaculture production is predicted to increase as population increase in the Asia-Pacific region (FAO 2005). This will result in an increased demand for fish feed (FAO 2005). What species that are farmed is only one of several factors influencing the feed demand and use, but a development of aquaculture that is based on wild capture fisheries and direct feeding of low value fish is not sustainable (FAO 2005). Existing resources must be better used and alternative feeds must be found (FAO 2005). The aquaculture expansion is a

transboundary issue with many social implications that will require collaboration between the countries of the region (FAO 2005).

A first, small, step in maintaining the low value fish could be the use of another classification of the resource, as these fishes are obviously not of "low value" to the people that depend on them for their survival. Another classification e.g. "small and juvenile fishes/small-sized fishes" could perhaps indicate a higher value of this resource and thereby increase the willingness to maintain it by all social groups and politicians. The use of low value fish in aquaculture has created an unsustainable system that is unable to develop and meet future demands on fish of a growing population and it is therefore necessary to identify all constrains and take action as soon as possible.

Both the international and national demand for fish feed will increase as population increase. This will lead to increased use of low value fish for consumption and aquaculture with many implications as a result e.g. affected market values of fish, possible increased introduction of exotic species in aquaculture and changes in household economies. All of this will have consequences on the environment and human wellbeing (Fig. 9). Low value fish is a key-factor in this chain and must be managed properly for future generations. The ban on cultivating Giant Snakehead is one of several factors affecting the supply of low value fish. Future studies on the occurrence and extent of illegal fishing and export of low value fish are particularly needed. It is also important to quantify how much low value fish that is fished and distributed to consumption and aquaculture.

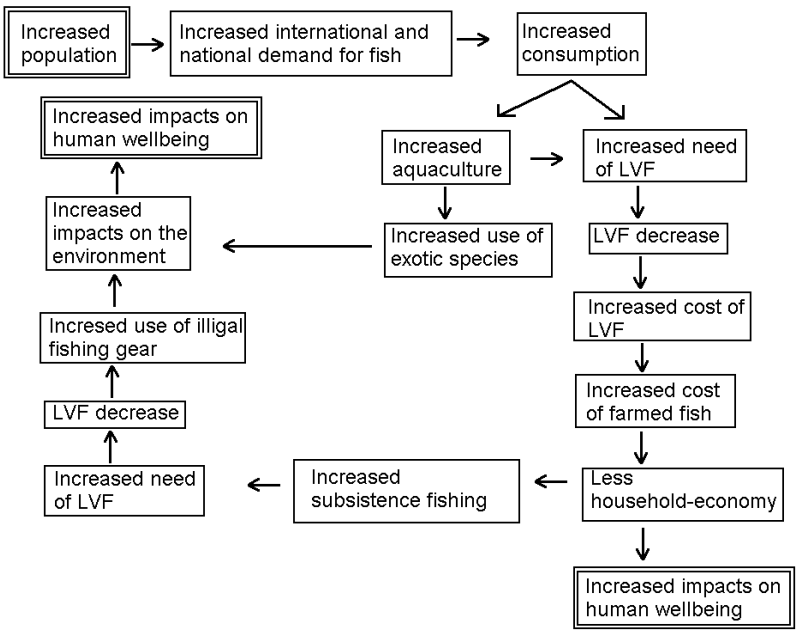

Fig. 9 The use of low value fish in aquaculture is not sustainable and constrains future development, necessary actions must be taken to meet the growing demand of fish.

A weakness of this study is that it is a limited study (considering both sample size and study area) and it did not include areas of northern Tonle Sap Lake and Mekong River. The questionnaire should have been tested on more than two families and more farmers that used to cultivate Giant Snakehead should have been interviewed. The latter was unfortunately something very difficult to target. Despite its limitations, some important conclusions and findings were identified in this study.

5. Conclusions

Trey pra was the most popular species to be cultivated by both pond and cage farmers. It was feed a mixture of low value fish and rice bran where rice bran was dominating and Trey riel (*Henicorynchus sp*) being the dominating low value fish species. The cost of both rice bran and low value fish has increased after the ban. Farmers that cultivated Giant Snakehead before the ban experienced decreased profits from their cultivation compared to previous situation before the ban. As a result of the ban most of these farmers stopped cultivating Giant Snakehead and started cultivating Trey pra instead, a species with lower market value than Giant Snakehead. This might explain the decreased profits. The farmers' availability of low value fish for local consumption has decreased after the ban. This might be due to increased utilization (both consumption and aquaculture) of low value fish or natural fluctuations. Although the household economy is better for a majority of the pond farmers and for many cage farmers after the ban. There are however some relatively positive effects of the ban but it is not the only solution since it is such a complex issue and low value fish is still used as fish feed. Improved control systems, increased collaboration and further studies are required about the flow and utilization of low value fish.

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7. References

Ahmed M., Navy H., Vuthy L., Tiongco M., 1998. *Socioeconomic assessment of freshwater capture fisheries of Cambodia: report on a household survey*. Mekong River Commission, Cambodia

Aldin-Lundgren E., in prep. *The role of Low Valued Fish for consumption and possible interactions/conflicts with the aquaculture in Cambodia*

Baran E., 2004. *Cambodia inland fisheries: facts, figures and context*. WorldFish Center and Inland Fisheries Research and Development Institute, Cambodia
ISBN: 983-2346-38-X

Baran E., Jantunen T., Chong C.K., 2007. *Values of inland fisheries in the Mekong River Basin*. WorldFish Center, Cambodia

Be T.T., Sinh B.T., Miller F., 2007. *Literature analysis – Challenges to sustainable development in the Mekong delta: regional and national policy issues and research needs*. The Sustainable Mekong Research Network, Thailand

Bonheur N. and Lane B.D., 2002. *Natural resources management for human security in Cambodia's Tonle Sap Biosphere Reserve.* In: *Environmental Science & Policy* No 5, page 33-41.

CFDO-IMM, 2005. *Cambodia Post-Harvest Fisheries Overview.* Community Fisheries Development Office, Department of Fisheries, Ministry of Agriculture, Forestry and Fisheries, Cambodia

CIA, 2008-02-23. Central Intelligence Agency, The World Factbook
homepage: https://www.cia.gov/library/publications/the-world-factbook/geos/cb.html

Edwards P., Tuan L.A., Allan G.L., 2004. *A survey of marine trash fish and fish meal as aquaculture feed ingredients in Vietnam*. ACIAR Working Paper No 57
ISBN: 186320-422-9

FAO, 2005. *APFIC Regional workshop on low value and "trash fish" in the Asia-Pacific region*. Asia-Pacific Fishery Commission, Rap publication 2005/21

FAO, 2008-03-25. Food and Agriculture Organization of the United Nations
homepage: http://www.fao.org/fishery/statistics/global-aquaculture-production

Funge-Smith S., Lindebo E., Staples D., 2005. *Asian fisheries today: The production and use of low value/trash fish from marine fisheries in the Asia-Pacific region*. Asia-Pacific Fishery Commission, Rap publication 2005/16

Hall S.R. and Mills E.L., 2000. *Exotic species in large lakes of the world*. In: *Aquatic ecosystem health and management* No 3, page 105-135

MAFF, 2007-04-05. Ministry of Agriculture, Forestry and Fisheries of Cambodia
homepage: http://www.maff.gov.kh/en/depts/fia.html

Nam S. and Thuok N., 1999. *Aquaculture sector review (1984-1999) and outline of aquaculture development plan (2000-2020) in Cambodia*. Ministry of Agriculture, Forestry and Fisheries of Cambodia, Department of Fisheries, Cambodia

Nam S. and Roitana B., 2005. *A review of inland fisheries management in Cambodia.* For Asian Productivity Organization (APO) and the International Seminar on Inland Fisheries Management 21-26 September 2005, India by Ministry of Agriculture, Forestry and Fisheries, Cambodia

Nam S., Tong E., Norng S., Hortle K., 2005. *Use of freshwater low value fish for aquaculture development in the Cambodia's Mekong basin*. Mekong River Commission, Assessment of Mekong Capture Fisheries Project, Cambodia

Navy H., Leang S., Chuenpagdee R., 2006. *Socioeconomics and livelihood values of Tonle Sap Lake fisheries*. Inland Fisheries Research and Development Institute, Cambodia

Naylor R.L.,Goldburg R.J., Primavera J., Kautsky N., Beveridge M.C.M., Clay J., Folke C., Lubchenco J., Mooney H., Troell M., 2001. *Effects of aquaculture on world fish supplies*. Issues in ecology No 8

Phillips M.J. 2002. *Freshwater aquaculture in the lower Mekong basin*. MRC Technical Paper No 7, Mekong River Commission, Cambodia
ISSN: 1683-1489

PRIAC, 2006. *Policy Reform Impact Assessment, Cambodia. Impacts of the fisheries policy reforms in Kampong Thom and Prey Veng provinces.* Community Fisheries Development Office of the Department of Fisheries, Cambodia

Rab M.A., Navy H., Ahmed M., Seng K., Viner K., 2006. *Socioeconomics and values of resources in great lake-Tonle Sap and Mekong-Bassac area: results from a sample survey in Kampong Chhnang, Siem Reap and Kandal provinces, Cambodia.* WorldFish Center Discussion series No 4

Roos N., Chamnan C., Loeung D., Jakobsen J., Thilsted S.H., 2007. *Freshwater fish as a dietary source of vitamin A in Cambodia*. In: *Food Chemistry* No 103, page 1104-1111

Welcomme R. and Chavalit V., 2003. *The impacts of introduction and stocking of exotic species in the Mekong Basin and policies for their control.* MRC Technical Paper No 9, Mekong River Commission, Cambodia
ISSN: 1683-1489

Appendix 1

The questionnaire used in the field study.

Questionnaire fish farmers – Role of low valued fish in aquaculture in Cambodia: *socio-economic impact assessment after ban on cultivating Giant Snakehead*

1-General information

1.1 Interviewed

1.1.1-Name
1.1.2-Date & Time
1.1.3-Sex (M=male, F=female)
1.1.4-Age

1.2 Address

1.2.1-Village name
1.2.2-Commune
1.2.3-District name
1.2.4-Province

1.3 Household and income

1.3.1-How many people are there in your household? men, women and children
1.3.2-What is your main cultivating system? pond/cage
1.3.3-Number of ponds?
1.3.4-Number of cages?
1.3.5-How long have you been a fish farmer?
0.1.3.5-Has there been any change in occupation (e.g. change in cultivating system or change in number of ponds/cages) the past five years? Why?
1.3.6-Has there been any change in household income the past five years? better/worse/no change
1.3.7-If there has been a change in income, do you know the cause?
1.3.8-If the income is less now than five years ago, how do you compensate for it?
1.3.9-Has there been any change in sources of food (i.e. expansion of food generation activities)?

2-Aquaculture

2.1 What fish species do you cultivate now? Source of fingerlings?
2.1.1-Did you cultivate these fish species before the ban? Why?

2.2 Feed to species

2.2.1-Total amount feed used in the cultivations? (kg/time)
2.2.2-How many times do you feed the fish? (days/week)
2.2.3-How long is a cultivating period?
2.2.4-Feeding composition? feed type, amount (kg or %) and cost (riel/kg)
2.2.5-Change in feeding composition or cost the last five years? How? Why?
2.2.6-What kind of low valued fish do you feed the fishes with? species, quality (fresh/not fresh), size (small/big), proportions and source

2.3 Effects of the ban on Snakehead culture

2.3.1-Income from the cultivation? species, riel/kg and change in the last five years, how?
2.3.2-Is the fish species you are cultivating now more or less profitable than snakehead species? Why?
2.3.3-What sources of supply of snakehead fish are for the local market now, especially during the closed fishing season (June-October)?
2.3.4-What are your perceptions of the ban on snakehead culture?
a) Has the availability of low valued fish for local consumption increased after the ban? Why?
b) Is the ban an effective solution of maintenance of the low valued fish species? Why?
2.3.5-Can you tell any positive and negative impacts of the ban? Why?

3-Other information

3.1 Describe any change of the availability of fish feed the last five years. Consider cost, time and effort. Why?
3.2 Are there any problems you are facing or have faced? How? Why?
3.3 Any suggestions to improve your aquaculture or household income? Why?

Appendix 2

The number of pond farmers (totally 38 interviewed) that gave a certain fish feed to the fishes in his/her cultivation.

Fish feed / Species	Rice bran	Low value fish	Waterlily	Pellet	Algae	Other*
Trey pra (*Pangasianodon hypophthalmus*)	37	22	13	8	1	11
Trey tilapia (*Oreochromis niloticus*)	10	6				
Trey andaing (the clariid catfish, hybrid between *Clarias batrachus* and *Clarias gariepinis*)	9	7	1	3	1	5
Trey chhpin (*Barbonymus gonionotus*)	4	1	1	4	3	7
Trey chdor (The Giant Snakehead *Channa micropeltes*)		2				
Trey kap sor (*Hypopthalmichthys molitrix*)	1	1				1
Trey po (*Pangasius larnaudii*)	1		1			1
Trey kap sismav (*Ctenopharyngodon idella*)	1	1				1

* e.g. cassava waste and kapok flour

The number of cage farmers (totally 51 interviewed) that gave a certain fish feed to the fishes in his/her cultivation.

Fish feed / Species	Rice Bran	Low value fish	Waterlily	Pellet	Algae	Other*
Trey pra (*Pangasianodon hypophthalmus*)	23	7	3			2
Trey po (*Pangasius larnaudii*)	17	12				
Trey chhpin (*Barbonymus gonionotus*)	12	9	3			4
Trey ke (*Pangasius conchophilus*)	11	9				
Trey kahe (*Barbonymus altus*)	11	7	1			
Trey tilapia (*Oreochromis niloticus*)	10	2	1			
Trey pra kchau (*Pangasius bocourti*)	9	4	1			
Trey prorlung (*Leptobarbus hoveni*)	8	4	3	1	1	
Trey chdor (The Giant Snakehead *Channa micropeltes*)		7				
Trey carp (*Thryssocypris tonlesapensis*)	4		1			
Trey damrey (*Oxyeleotris marmorata*)	1	1	1			
Trey khya (*Hemibagrus wyckioides*)	2	2				1
Trey prual (*Cirrhinus microlepis*)	3	3				
Trey krum (*Osteochilus melanopleuras*)	2					
Trey kampot (*Auriglobus nefastus*)		2				
Trey kap samanh (*Cyprinus carpio*)	1	1	1			
Trey chhlang (*Hemibagrus nemurus* and also *H. spilopterus*)		1				

* e.g. horse intestines, horse skin and excrement of chicken, duck and pig

Appendix 3

The different species of low value fish that were used as fish feed and how many farmers (both pond and cage) that gave that particular species as feed (totally 54 farmers gave low value fish as fish feed). Note that all farmers gave a mix of species.

Low value fish species	Number of farmers using the fish as feed
Trey riel (*Henicorhynchus siamensis*)	52
Trey riel (*Henicorhynchus cryptopogon*)	46
Trey riel (*Henicorhynchus caudimaculatus*)	42
Trey bandoul ampov (*Clupeichthys aesarnensis*)	34
Trey khnorng veng (*Labiobarbus lineatus*)	33
Trey khnorng veng (*Labiobarbus leptocheila*)	31
Trey srakar kdarm (*Cyclocheilichthys lagleri*)	31
Trey linh (*Thynnichtys thynnoides*)	30
Trey slek russey (*Paralaubuca typus*)	27
Trey kanchos (*Mystus albolineatus*)	26
Trey kanchos (*Mystus mysticetus*)	25
Trey kampleanh (*Trichogaster trichopterus*)	25
Trey kros (*Osteochilus waandersii*)	23
Trey kampleanh (*Trichogaster microlepis*)	21
Trey changva runoung (*Lobocheilos quadrilineatus*)	16
Trey arch kok (*Labiobarbus siamensis*)	15
Trey changva runoung (*Lobocheilos melanotaenia*)	14
Trey char keng (*Puntioplites waandersi*)*	14
Trey chkok (*Cyclocheilichthys sp.*)*	13
Trey kaek (*Labeo chrysophekadion*)	12
Trey kanhchras thom (*Parambassis apogonoides*)	11
Trey chunlunh moaw (*Coilia lindmani*)	11
Trey chhpin (*Hypsibarbus lagleri*)*	8
Trey chunteas phluk (*Parachela siamensis*)	8
Trey chhpin (*Hypsibarbus malcolmi*)*	7
Trey kranh (*Anabas testudineus*)	7
Trey kompream (*Polynemus multifilis*)	7
Trey kantrop (*Pristolepis fasciata*)	5
Trey angkot prak (*Puntius brevis*)	5
Trey pra thom (*Pangasianodon hypophthalmus*)*	4
Trey kanhchruk (*Yasuhikotakia modesta*)	4
Trey kantrang preng (*Parambassis wolffi*)	3
Trey khya (*Hemibagrus wyckioides*)*	3
Trey chveat (*Pangasius pleurotaenia*)	2
Trey chveat (*Pangasius polyuranodon*)	1
Trey chveat (*Pangasius* macronema)	1
Trey po (*Pangasius larnaudii*)*	1
Trey ka hae (*Barbodes schwanenfeldi*)*	1
Trey phkar kou (*Cirrhinus molitorella*)	1
Trey chmar (*Setipinna melanochir*)	1

* commercially important species

Appendix 4

The income from the different cultivated species when they were sold.

Fish species	Income year 2002 from the different species (KHR/kg)*	Income year 2007 from the different species (KHR/kg)*
Trey andaing (the clariid catfish, hybrid between *Clarias batrachus* and *Clarias gariepinis*)	4780	5670
Trey carp (*Thryssocypris tonlesapensis*)	2950	4140
Trey chdor (The Giant Snakehead *Channa micropeltes*)	3970	7240
Trey chhlang (*Hemibagrus nemurus* and also *H. spilopterus*)	2000	5000
Trey chhpin (*Barbonymus gonionotus*)	3300	6500
Trey damrey (*Oxyeleotris marmorata*)	36250	70750
Trey kahe (*Barbonymus altus*)	4510	7450
Trey kampot (*Auriglobus nefastus*)	9750	12500
Trey kap samanh (*Cyprinus carpio*)	3000	5000
Trey kap sismav (*Ctenopharyngodon idella*)	2000	3000
Trey kap sor (*Hypopthalmichthys molitrix*)	13000	8000
Trey ke (*Pangasius conchophilus*)	3980	4680
Trey khya (*Hemibagrus wyckioides*)	7750	10600
Trey krum (*Osteochilus melanopleuras*)	5500	9500
Trey po (*Pangasius larnaudii*)	2690	4380
Trey pra (*Pangasianodon hypophthalmus*)	2360	3520
Trey pra kchau (*Pangasius bocourti*)	2240	3750
Trey prorlung (*Leptobarbus hoveni*)	5180	7920
Trey prual (*Cirrhinus microlepis*)	4000	6700
Trey tilapia (*Oreochromis niloticus*)	2860	4170

* Exchange rate is approx. 4000 KHR (Khmer riel) per USD (CIA 2008).