

សេចក្តីបន្ថែមទី ២:

របាយការណ៍សិក្សាពីរុក្ខិ

KINGDOM OF CAMBODIA
Nation Religion King

Report

**Assessment on Fisheries Natural Resources
for
Lower Sesan 2 Hydropower Plant Project**



Conjunction of the Sesan and Sre Pok would be the Basin of the Sesan 2 HPP. Sourced: Chheng Phen

Prepared by

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Close collaboration with

**The Inland Fisheries Research and Development Institute
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ACRONYM

FIA	: Fisheries Administration
IFReDI	: Inland Fisheries Research and Development Institute
KCC	: Key Consultant Cambodia
MAFF	: Ministry of Agriculture Forestry and Fisheries
MRC	: Mekong River Commission
RUA	: Royal University of Agriculture Forestry and Fisheries
Sesan 2 HPP	: Sesan 2 Hydropower Plant Project

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1 INTRODUCTION

This paper presented results of the environment impact assessment (EIA) on fisheries resources study what could be resulted from the impact of the Sesan 2 Hydropower Plant Project (Sesan 2 HPP). The study conducted by the Key Consultant Cambodia (KCC) in collaboration with Faculty of Fisheries of the Royal University of Agriculture Forestry and Fisheries (RUA) and the Inland Fisheries Research and Development Institute (IFReDI) of the Fisheries Administration (FiA), Ministry of Agriculture Forestry and Fisheries (MAFF).

Cambodia economy is developing rapidly these last decades. In the same pattern, energy demand is increasing accordingly. Hydropower energy is the cheap energy source. Numerous hydropower plants have built and worked effectively globally and regionally. There are 48 hydropower sites in Cambodia Mekong Basin. Amongst that, 11 have been conducted feasibility study and 1 was committed. The Sesan River is under the feasibility study.

Beside the economic beneficiary, a hydropower plant always has bad impacts on the natural environment; especially on the Fisheries Natural Resources what is a very important protein source and primary incomes to local people, especially the poor. This is why we have to do this study to determine the impact of the project on fisheries natural resources.

1.1 Objectives of the Study

This study has 5 main objectives

- 1) To determine fish species which are dominantly very important in the Sesan and Srepok river, so that decision on which and how many dominant fish species would be the target for further study of their biological characteristics and for breeding at the planned hatchery which will be built on the site. As a result stock enhancement program will be established to improve fish stocks in Se San and Srepok River.
- 2) To determine fish catch by local fishers in order to define compensating mitigation measure for local fishers.
- 3) To study fish migration in Se San and Srepok river in relationship with the Mekong mainstream and Tonle Sap Lake.
- 4) To determine the impacts of the Sesan 2 HPP Project on Sesan and Srepok River fisheries resources and their consequence on the downstream Mekong, Tonle Sap and Cambodia inland fish production.
- 5) To seek for possible and feasible fish pass/route for fish migration upstream

1.2 Study Area

The study mainly conducted in Sesan district, Stung Treng Province. Sesan district has 4 communes. Three communes located in the proposed hydropower basin, namely Sre Kor, Talat and Kbal Romeas communes and one commune namely Phluk located close downstream of the proposed hydropower dam (see Figure 1). We selected these four communes as the study sites. However, due to the impact of the dam could spread over Mekong system, especially the Tonle Sap fish production, thus many sites in the Mekong system could be included.

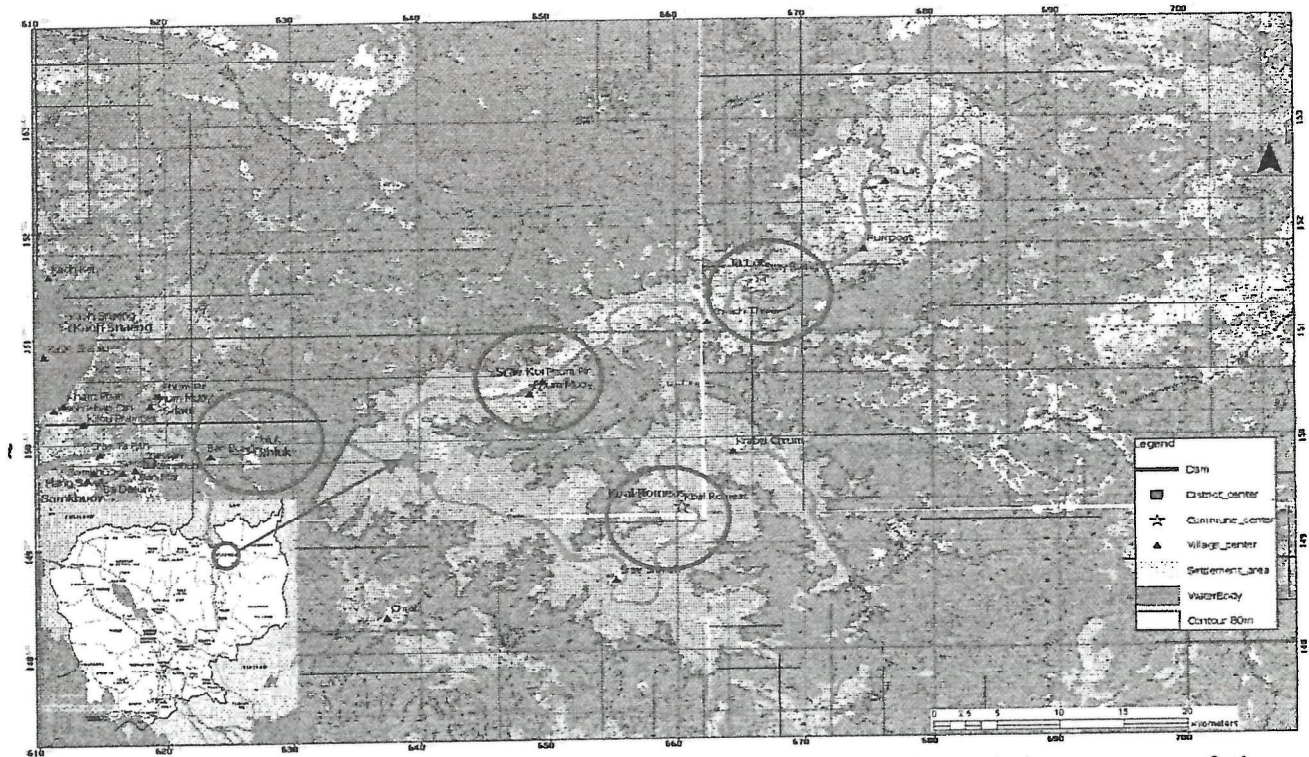


Figure 1: The red circle are study sites where Phluk commune located downstream of the proposed dam site, Kbal Romeas commune located on Sre Pok River, Sre Kor and Talat communes located on Sesan River upstream of the proposed dam site

1.3 Site Description

The proposed hydropower dam is at the Lower (Sesan Krom) about 2 km downstream of the Sesan and Sre pok junction, in Phluk commune, Sesan district of Stung Treng province. The Sesan and Sre Pok River originated in highland Vietnam, runs cross two provinces, Ratanakiri and Stung Treng. Total length of Sesan River is 278.32 km. Total length of Sre Pok River is 249.92 km. The Sre Pok joined Sesan about 8 km upstream from Phluk commune. From the conjunction point downward called Sesan Krom. The Sesan Krom joined Mekong mainstream at Stung Treng City. Sesan and Sre Pok rivers are the mountainous river, with rocky bottom, many small rocky islands, and deep pools. Water levels in dry season of these two rivers are much lower than their banks. There is no explicit study about fish habitat in these rivers, but some study conducted on the Mekong mainstream, e.g. Chan S. Putrea S and Hortle, K. G. 2004; Sinthavong, et la, 2004; and MRC, 2005 Technical No3, 2005. The deep pools study is very difficult and costly. Thus, here we could only use the deep pool information in a local knowledge book that produced by the Culture and Environment Preservation Association (CEPA), in 2008. The book listed that there are eleven deep pools in Sre Pok River in Kbal Romeas commune and seventy deep pools in Sesan River. These deep pools are small and shallow. River banks covers by inundated forests, periodic flooded when ever heavy rains over the upstream highland.

1.4 Population in the project area

. The Sesan district comprises four communes, Talat, Srekor, Kbal Romeas and Phluk. Total population of the district is 7,544 persons from 1,657 families. Talat commune comprises four villages, Talat, Rum Poit, Svay Rieng, and Khsach Tmey. The total population of the commune is 2,915 persons from 636 families. Srekor commune comprises two villages: Srekor Muoy and Srekor Pir. The total commune population is 1,477 persons from 323 families. Phluk commune comprises two villages, Phluk and Ban Bung. Total population of the commune is 1,092 persons from 264 families. Kbal Romeas commune comprises four villages, Krobei Chrum, Kbal

Romeas, Sre Sronok and Srepok. The total population of the commune is 2,060 persons from 434 families (Commune profile, 2007).

2 METHODOLOGY OF THE STUDY

The study analyzed 4 primary datasets, two from the faculty of fisheries of RUA, three from IFRReDI, MAFF. In addition, many secondary data and information available at IFRReDI were used to complement the above primary data and information in order to achieve the above objectives.

2.1 Datasets

- a. Fish_dataset_Sesan_Sre Pok_Rivers_Fishers_Local_fishing_gears_2008. Faculty of fisheries, RUA.

Nature of data:

- Sampling Sites:
 - Phluk commune located on lower Sesan River, downstream proposed dam site.
 - Sre Kor commune located on upper Sesan River upstream proposed dam site.
 - Ta Lat commune located on upper Sesan River upstream proposed dam site.
 - Kbal Romeas commune located on Sre Pok River, upstream proposed dam site.
- Timing: February and March 2008
- Research method: selected 18 fishers fished in the project areas. 6 fisheries in Sesan river, upstream of the proposed dam site, 6 fisheries in Sesan river, downstream of the proposed dam site, 6 fisheries in Sre Pok river upstream of the proposed dam site. The fishers selected and trained to identify and record their daily catch in the provided logbooks. Species those could not indentified by fishers would brought to the RUA for further identification. The researcher regularly collected the rccorded logbooks from the selected fishers and manipulates data.
- Fishing Gears: each fisher used at least 2 types of gears what commonly in their locality, e.g. Gillnet, Cast net, long-line hooks, single hook,etc.
- Data usage: this data was used for calculating fish production what suppose to catch by all local fishers per year from their locality watershed by multiple the average catch of 1 fisher per day and average number of fishing day of the local fishers per year and number of local fishers.

- b. Fish_Catch_Assessment_Sesan_Sre Pok_Rivers_PRA_2008, faculty of fisheries, RUA.

Nature of data:

- Sampling Sites:
 - Phluk and Banh Bung villages, Phluk commune located on Sesan River, downstream of the proposed dam site.
 - Sre kor 1 and Sre Kor 2 villages , Sre Kor commune located on Sesan River upstream of the proposed dam site.
 - Talat, Svay Reang and Khsach Thmey Villages, Ta Lat commune located on Sesan River upstream of the proposed dam site.
 - Kbal Romeas, Krobey Chrum, and Sre Sronok, Kbal Romeas commune located on Sre Pok River, upstream of the proposed dam site.
- Timing: February and March 2008
- Research method: Participatory Rural Appraisal (PRA). Interviewed 127 persons from 127 selected households of the total 1,859 households in ten villages in the project area.

- Data usage: this data was used for calculating fish production what suppose to catch by all local fishers per year from their locality watershed by using Beverton and Holt's models (1966) of catch estimation. Meanwhile, knowing fish species occurred in this region

c. Fisheries_dataset_8FS_Tonle Sap_2006. IFReDI, FiA.

Nature of data:

- Sampling Sites: 13 sites, 8 fish sanctuaries and 5 sites out side sanctuaries, Tonle Sap Great Lank
- Timing: 2008-2006
- Research method: Multi mesh-size Trammel Net fish sampling, 8 fishing per site, in dry season and wet season.
- Fishing Gears: Trammel Nets
- Data usage: this data was used to define fish species occurrence, and migrating species.

d. Database_fish_&_fisheries_Srepok_2008. IFReDI, FiA.

Nature of data:

- Sampling Sites: Srepok River, Stung Treng Province
- Timing: 2008
- Research method: Interview, Participatory Rural Appraisal (PRA).
- Data usage: this data was used to define fish species occurrence, and migrating species.

2.2 Methodology:

2.2.1 Dominance fish species by number in the project area

The dominance species by number in the project area were manipulated from dataset "a" . That is the number of individual of each species caught by the 18 selected fishers who used multi-local fishing gear fished in their local river. The number of individual was descending sorted. Therefore, the top ten species is the top ten dominant species by number in the project area.

2.2.2 Dominant fish species by weight in the project area

The dominant species by weight in the project area were manipulated from the dataset "a" . That is the biomass of each species caught by the 18 selected fishers who used multi-local fishing gear fished in their local river. The biomass was descending sorted. Therefore, the top ten species is the top ten dominant species by weight in the project area.

2.2.3 Fish species diversity in the project area

Fish species: there were two ways of fish species identification: 1). identified in the catch by 18 selected fishers who fished in their rivers by use of multiple fishing gears. 2). reported by local fishers by PRA method.

2.2.4 Migrating fish species in the project area

Migrating species were assigned by matching species found in project area with the list of longitudinal migrating species reported by Jorgensen, *et al.*, 1998.

2.2.5 Endangered fish species in the project area

Endangered species were assigned by matching species identified in project area with the list of endangered species produced by Fisheries Administration (2009) and the CITES (2009).

2.2.6 Important fish species for local livelihoods in the project area

We match the longitudinal migrating species those in the top ten dominant species both by number and by weight with the dominant taxa of Tonle Sap, Eric E and Chhang P, 2003.

2.2.7 Fish catch of Sesan and Srepok Rivers from Phluk Commune upward

The dam will block Lower Sesan River, so that the fishers in Phluk commune and from the dam site upward along Sesan and Sre Pok River would be directly affected by the dam and their daily income would be also directly impacted. Here we divided the directed impacted area to two subareas

2.2.7.1 Fish catch of the Project area:

The project area are included the dam reservoir and the location downstream of the Phluk commune, Stung Treng province. There were two ways of fish catch calculations:

- 1). directed fish sampling, by multiplying number of households in each location of the project area with average catch per fisher per year;
- 2). by Participatory Rural Appraisal (PRA) method.

2.2.7.2 Fish catch of the upstream of project area:

The upstream of project area are included Sesan and Srepok rivers in Ratanakiri province. This upstream area will physically remain the same, but it could be impacted by losing migrating species from downstream. Fish catch of the upstream of the project area was calculated by using secondary data from Meach and Baird, 2005 by multiplying average catch per fisher per year with number of fishers in that area.

2.2.8 Market value of fish production

Market value of fish production in the project area was the outcome of fish catch in the project area multiplied with a given price of 2.5 USD per kg of fish.

Market value of fish production in the upstream of project area was the outcome of fish catch in the upstream of project area multiplied with a given price of 3 USD per kg of fish.

The total market value of fish production of Sesan and Srepok River from Phluk Commune upward was the sum of the market value of the fish production in project area and upstream of project area

2.2.9 Other aquatic species richness in the project area

Birds, reptiles, and inundated forests: defined by interviewed local people and using secondary data and other publications.

2.2.10 Possible impacts on fisheries and hydrology

The dam could have three important impacts to the downstream fisheries and hydrology

- Impact on the Project area fisheries: Impact of the dam on local people who stay in the project area (Phluk Commune and the planned dam's basis) and in the upstream of project area (along Sesan and Srepok Rivers in Ratanakiri Province)
- Impact on Tonle Sap fish and fisheries: Impact on the longitudinal migrating species those are feeding and growing in the downstream Mekong and Tonle Sap, and migrating upstream for spawning or completing their life cycle. Here, we match the longitudinal migrating species those found in project area with the Top Ten dominant taxa of Tonle Sap, Baran E & Chheng P. (2003).
- Impact on hydrological regime: There are three major hydrological factors could impact Cambodia inland fish and fisheries production. Those are flood timing, flood duration, flood level (John Kurien, Eric Banran, and So Nam, 2006). However, there was no explicit study to

determine level of impact of each modification of the above three factors. Here we only calculated the possible water regime modification by calculating water discharge of the Sasan and Srepok contributed to the Mekong mainstream.

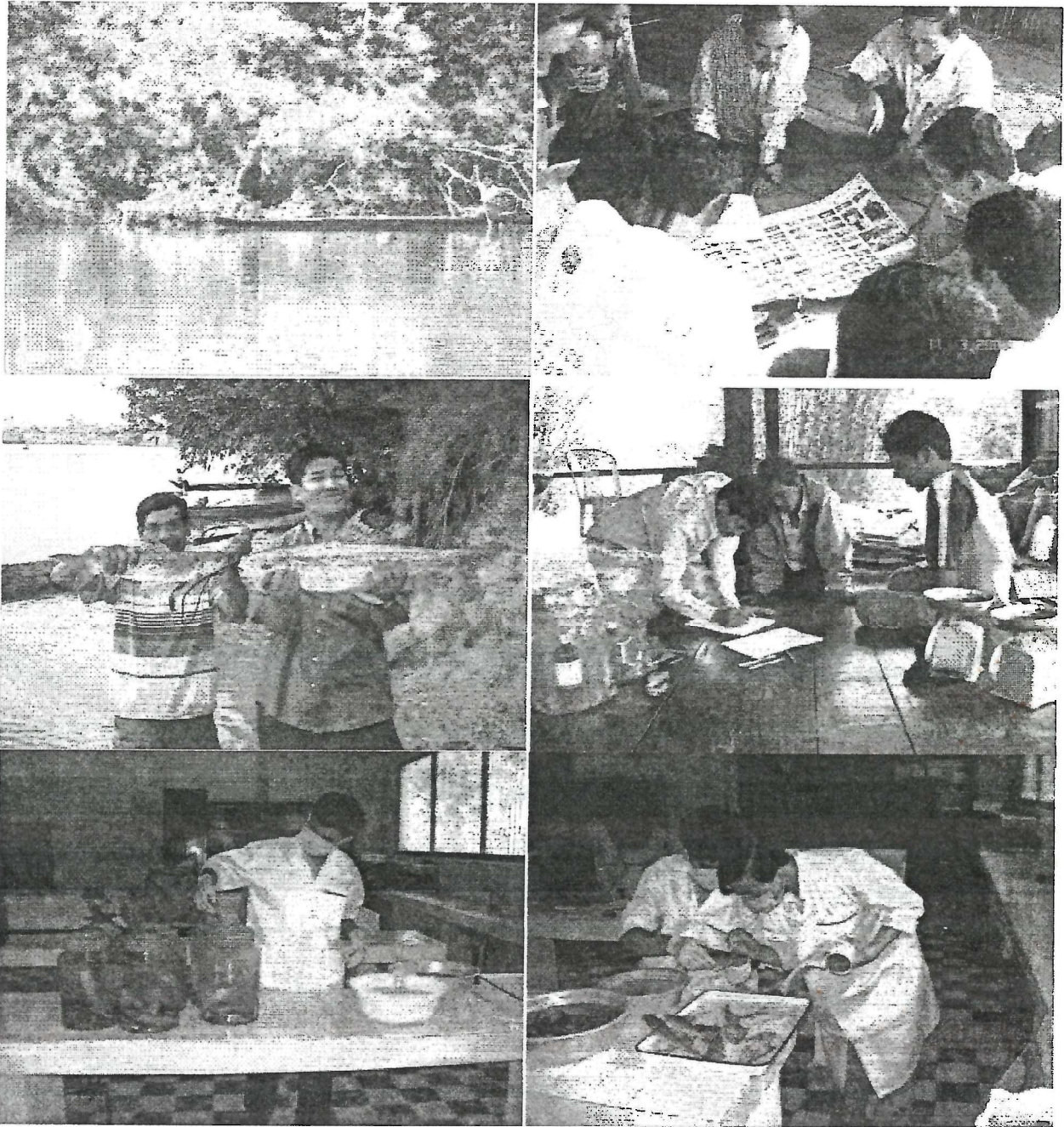


Figure 2: Fish sampling activities, fish species identification by PRA, and fish species identification in the laboratory of the RUA.

3 RESULTS AND DICUSIONS

3.1 Dominant fish species by number in the project area

There were 83 fish species identified in the project area by 18 selected fishers who used at least two types of fishing gear to catch fish. Of which, *Henicorhynchus lobatus*, *Osphronemus exodon*, *Cirrhinus molitorella*, *Acantopsis sp.*, *Hemibagrus nemurus*, *Hypsibarbus malcolmi*, *Gyrinocheilus pennocki*, *Mystus sp.*, *Barbodes chwanefeldi*, and *Osteochilus hasselti* were ten most dominant species by number in the Project area. These top ten fish species contributed up to around 82 % of total number of individuals caught by selected fishers in the project area (See Table 1).

Table 1: List species and number composition in the catch by selected fishers in project area (* top ten dominant fish species by number)

Number	Scientific name	Khmer Name	Total (Individual)	Percentage (%)
1	<i>Henicorhynchus lobatus*</i>	ត្រីរៀល	4,618	39.82
2	<i>Osphronemus exodon*</i>	ត្រីរមាស	2,018	17.4
3	<i>Cirrhinus molitorella*</i>	ត្រីផ្កាគ	801	6.91
4	<i>Acantopsis sp.*</i>	ត្រីបួសចេក	579	4.99
5	<i>Hemibagrus nemurus*</i>	ត្រីឆ្នាំង	408	3.52
6	<i>Hypsibarbus malcolmi*</i>	ត្រីឆ្អិនត្នា	277	2.39
7	<i>Gyrinocheilus pennocki*</i>	ត្រីស្មុត	248	2.14
8	<i>Mystus sp.*</i>	ត្រីកញ្ចុះ	199	1.72
9	<i>Barbodes schwanefeldi*</i>	ត្រីកាហែលឡើង	172	1.48
10	<i>Osteochilus hasselti*</i>	ត្រីក្រស	153	1.32
11	<i>Clarias batrachus</i>	ត្រីអណ្តែងរឹង	139	1.2
12	<i>Puntioplites falcifer</i>	ត្រីច្រកែង	131	1.13
13	<i>Cyclocheilichthys sp.</i>	ត្រីឆ្កោក	123	1.06
14	<i>Rasbora tornieri</i>	ត្រីចង្វាមូល	112	0.97
15	<i>Channa striata</i>	ត្រីផ្កា	101	0.87
16	<i>Micronema micronema</i>	ត្រីកេស	94	0.81
17	<i>Coius undecimradiatus</i>	ត្រីខ្លា	93	0.8
18	<i>Helicophagus waandersi</i>	ត្រីប្រាកណុរ	89	0.77
19	<i>Dangila spilopleura</i>	ត្រីអាចម៍កុក	80	0.69
20	<i>Cyclocheilichthys enoplos</i>	ត្រីឆ្កោក	75	0.65
21	<i>Morulius chrysophekadion</i>	ត្រីក្អែក	75	0.65
22	<i>Paralaubucus typus</i>	ត្រីស្លឹកឫស្សី	75	0.65
23	<i>Bagrichthys macropterus</i>	ត្រីចេកទុំ	67	0.58
24	<i>Cyclocheilichthys furcatus</i>	ត្រីឆ្កោកភ្លើង	66	0.57
25	<i>Hemibagrus wyckioides</i>	ត្រីខ្យា	58	0.5

26	<i>Rasbora spp.</i>	ត្រីចង្វា	51	0.44
27	<i>Pangasius cf. polyuranodom</i>	ត្រីជៀត	46	0.4
28	<i>Barbodes altus</i>	ត្រីការហៃ	44	0.38
29	<i>Bagarius yarrelli</i>	ត្រីក្របី	41	0.35
30	<i>Henicorhynchus siamensis</i>	ត្រីរៀលតូប	41	0.35
31	<i>Mekongina erythrospila</i>	ត្រីប៉ាសេអ៊ី	36	0.31
32	<i>Micronema bleekeri</i>	ត្រីកេសជំរុវ	29	0.25
33	<i>Botia modesta</i>	ត្រីកញ្ចក់ក្រហម	28	0.24
34	<i>Anabas testudineus</i>	ត្រីក្រាញ់	27	0.23
35	<i>Lebeo erythropterus</i>	ត្រីប៉ារ៉ាមុខមួយ	27	0.23
36	<i>Glossogobius giurus</i>	ត្រីខ្យាន	24	0.21
37	<i>Pangasius larnaudii</i>	ត្រីពៅ	23	0.2
38	<i>Pristolepis fasciata</i>	ត្រីកន្ត្រប់	23	0.2
39	<i>Bangana behri</i>	ត្រីប៉ារ៉ាមុខពីរ	21	0.18
40	<i>Trichogaster trichopterus</i>	ត្រីកំភ្លាញ	19	0.16
41	<i>Cirrhinus microlepis</i>	ត្រីព្រួល	18	0.16
42	<i>Botia lecontei</i>	ត្រីកញ្ចក់ព្រួយ	16	0.14
43	<i>Oxyeleotris marmorata</i>	ត្រីដីរ	15	0.13
44	<i>Chitala blanci</i>	ត្រីក្រាយ	14	0.12
45	<i>Kryptopterus moorei</i>	ត្រីស្នាបមាត់	14	0.12
46	<i>Hampala dispar</i>	ត្រីខ្មាន់	13	0.11
47	<i>Cosmocheilus harmandi</i>	ត្រីកំពូលបាយ	12	0.1
48	<i>Mystus multiradiatus</i>	ត្រីកញ្ចុះឆ្នុត	12	0.1
49	<i>Pangasius bocourti</i>	ត្រីប្រាខ្មៅ	11	0.09
50	<i>Pangasius concophilus</i>	ត្រីប្រាតែ	11	0.09
51	<i>Heterobagrus bocourti</i>	ត្រីកញ្ចុះក្តោង	10	0.09
52	<i>Leiocassis siamensis</i>	ត្រីកញ្ចុះប៉ារ៉ា	10	0.09
53	<i>Ompok bimaculatus</i>	ត្រីក្រម៉ម	10	0.09
54	<i>Discherodontus ashmeadi</i>	ត្រីកន្ទុយក្រហម	9	0.08
55	<i>Amblyrhynchichthys truncates</i>	ត្រីកំបុតច្រមុះ	8	0.07
56	<i>Cirrhinus jullieni</i>	ត្រីផ្កាចា	8	0.07
57	<i>Channa macropeltes</i>	ត្រីឆ្កែ	7	0.06
58	<i>Achiroides sp.</i>	ត្រីអណ្តែតផ្លែ	6	0.05
59	<i>Leptobarbus hoeveni</i>	ត្រីច្រាវឡាង	6	0.05
60	<i>Mystus filamentus</i>	ត្រីតានេល	5	0.04

61	<i>Wallago attu</i>	ត្រីសណ្តាយ	5	0.04
62	<i>Chitala ornata</i>	ត្រីក្រាយ	4	0.03
63	<i>Hypsibarbus sp.</i>	ត្រីឆ្អិនមាស	4	0.03
64	<i>Notopterus notopterus</i>	ត្រីស្លាត	4	0.03
65	<i>Thynnichthys thynnoides</i>	ត្រីលិញ	4	0.03
66	<i>Albulichthys albuloides</i>	ត្រីឆ្កែកទីមួយ	3	0.03
67	<i>Mastacemblus sp.</i>	ត្រីខ្លីង	3	0.03
68	<i>Kryptopterus cryptopterus</i>	ត្រីកំភ្លៀវ	2	0.02
69	<i>Mystus wolffi</i>	ត្រីកញ្ចុះ	2	0.02
70	<i>Ompok hypophthalmus</i>	ត្រីតាអោន	2	0.02
71	<i>Osteochilus melanopleurus</i>	ត្រីត្រី	2	0.02
72	<i>Osteochilus schlegeli</i>	ត្រីលលកស	2	0.02
73	<i>Pangasius hypophthalmus</i>	ត្រីប្រា	2	0.02
74	<i>Pangasius macronema</i>	ត្រីឈ្មួញតត្តោង	2	0.02
75	<i>Channa sp.</i>	ត្រីអំបូង	1	0.01
76	<i>Hypsibarbus pierrei</i>	ត្រីឆ្អិនព្រួយ	1	0.01
77	<i>Lalates siamensis</i>	ត្រីឈ្មួញប្រាក់	1	0.01
78	<i>Luciosoma bleekeri</i>	ត្រីចង្វារនោង	1	0.01
79	<i>Macrochirichthys macrochirus</i>	ត្រីដងខ្លែង	1	0.01
80	<i>Poropuntius deauratus</i>	ត្រីលលកស/ក្រសភ្នំ	1	0.01
81	<i>Probarbus jullieni</i>	ត្រីត្រសក់	1	0.01
82	<i>Wallago leeri</i>	ត្រីស្នាក់	1	0.01
83	<i>Xenentodon cancila</i>	ត្រីផ្កាង	1	0.01

3.2 Dominant fish species by weight in the project area

The top ten dominant fish species by weight in the project area were *Hemibagrus nemurus*, *Hemibagrus nemurus*, *Morulius chrysophekadion*, *Hemibagrus wyckioides*, *Gyrinocheilus pennocki*, *Pangasius larnaudii*, *Cyclocheilichthys enoplos*, *Cirrhinus microlepis*, *Helicophagus waandersi*, and *Henicorhynchus lobatus*. Total biomass of these top ten dominant fish species is around 57% of the total fish biomass. These top ten species were all big-size and long life species, and have high market value (See Table 2).

Table 2: List of species and biomass composition in the catch by selected fishers in project area (* Top ten dominant species by weight)

Number	Scientific name	Khmer Name	Total Weight (g)	Percentage (%)
1	<i>Hemibagrus nemurus</i> *	ត្រីឆ្នាំង	111,800	9.62
2	<i>Hypsibarbus malcolmi</i> *	ត្រីឆ្កិលត្តា	110,550	9.52
3	<i>Morulius chrysophekadion</i> *	ត្រីក្អែក	108,800	9.37
4	<i>Hemibagrus wyckioides</i> *	ត្រីឡា	64,350	5.54
5	<i>Gyrinocheilus pennocki</i> *	ត្រីស្មុត	55,150	4.75
6	<i>Pangasius larnaudii</i> *	ត្រីពោ	50,300	4.33
7	<i>Cyclocheilichthys enoplos</i> *	ត្រីឆ្កោក	44,650	3.84
8	<i>Cirrhinus microlepis</i> *	ត្រីព្រួល	39,500	3.40
9	<i>Helicophagus waandersi</i> *	ត្រីប្រាកណ្តុរ	38,000	3.27
10	<i>Henicorhynchus lobatus</i> *	ត្រីរៀល	37,400	3.22
12	<i>Lebeo erythropterus</i>	ត្រីប៉ារ៉ាមុខមួយ	34,000	2.93
13	<i>Cyclocheilichthys furcatus</i>	ត្រីឆ្កោកភ្លើង	33,100	2.85
14	<i>Micronema micronema</i>	ត្រីកេស	30,750	2.65
15	<i>Bangana behri</i>	ត្រីប៉ារ៉ាមុខពីរ	27,200	2.34
16	<i>Clarias batrachus</i>	ត្រីអណ្តែងរឹង	27,100	2.33
17	<i>Barbodes schwanefeldi</i>	ត្រីកាំបែលឿង	26,600	2.29
18	<i>Chitala blanci</i>	ត្រីក្រាយ	22,950	1.98
19	<i>Puntioplites falcifer</i>	ត្រីច្រកែង	21,750	1.87
20	<i>Channa macropeltes</i>	ត្រីឆ្កា	20,100	1.73
21	<i>Bagarius yarrelli</i>	ត្រីក្របី	19,850	1.71
22	<i>Coius undecimradiatus</i>	ត្រីខ្លា	19,400	1.67
23	<i>Mekongina erythrospila</i>	ត្រីប៉ាសេអ៊ី	15,900	1.37
24	<i>Mystus sp.</i>	ត្រីកញ្ចុះ	15,600	1.34
25	<i>Osphronemus exodon</i>	ត្រីរមាស	13,301	1.15
26	<i>Bagrichthys macropterus</i>	ត្រីចេកទុំ	10,070	0.87
27	<i>Pangasius hypophthalmus</i>	ត្រីប្រា	8,600	0.74
28	<i>Cirrhinus molitorella</i>	ត្រីផ្កាត	7,852	0.68

29	<i>Acantopsis sp.</i>	ត្រីបួសចេក	7,650	0.66
30	<i>Wallago attu</i>	ត្រីសណ្តាយ	7,300	0.63
31	<i>Wallago leeri</i>	ត្រីស្នាក់	7,300	0.63
32	<i>Mystus filamentus</i>	ត្រីតាឆេល	6,500	0.56
33	<i>Osteochilus hasselti</i>	ត្រីក្រែស	6,100	0.53
34	<i>Pangasius concophilus</i>	ត្រីប្រាក់	5,950	0.51
35	<i>Chitala ornata</i>	ត្រីក្រាយ	5,900	0.51
36	<i>Micronema bleekeri</i>	ត្រីកេសជំរុវ	5,500	0.47
37	<i>Cyclocheilichthys sp.</i>	ត្រីឆ្កែក	4,550	0.39
38	<i>Barbodes altus</i>	ត្រីការហៃ	4,450	0.38
39	<i>Oxyeleotris marmorata</i>	ត្រីដីរី	4,400	0.38
40	<i>Pangasius bocourti</i>	ត្រីប្រាខ្មៅ	3,950	0.34
41	<i>Osteochilus melanopleurus</i>	ត្រីភ្នំ	3,300	0.28
42	<i>Hampala dispar</i>	ត្រីខ្លាន់	3,150	0.27
43	<i>Henicorhynchus siamensis</i>	ត្រីរៀលតុប	2,850	0.25
44	<i>Dangila spilopleura</i>	ត្រីអាចម៍កុក	2,650	0.23
45	<i>Pangasius cf. polyuranodom</i>	ត្រីជៀត	2,500	0.22
46	<i>Ompok bimaculatus</i>	ត្រីក្រមម	2,200	0.19
47	<i>Paralabucus typus</i>	ត្រីស្លឹកឫស្សី	2,050	0.18
48	<i>Pristolepis fasciata</i>	ត្រីកន្ត្រប់	2,050	0.18
49	<i>Channa sp.</i>	ត្រីអំបូង	2,000	0.17
50	<i>Kryptopterus moorei</i>	ត្រីស្លាបមាន់	1,750	0.15
51	<i>Mastacemblus sp.</i>	ត្រីខ្លាំង	1,700	0.15
52	<i>Hypsibarbus sp.</i>	ត្រីឆ្កិនមាស	1,500	0.13
53	<i>Rasbora tornieri</i>	ត្រីចង្វាមូល	1,400	0.12
54	<i>Amblyrhynchichthys truncates</i>	ត្រីកំបុតច្រមុះ	1,150	0.1
55	<i>Botia lecontei</i>	ត្រីកញ្ជ្រូកព្រាយ	1,050	0.09
56	<i>Rasbora spp.</i>	ត្រីចង្វា	1,000	0.09
57	<i>Cosmocheilus harmandi</i>	ត្រីកំពូលបាយ	900	0.08
58	<i>Notopterus notopterus</i>	ត្រីស្វាត	900	0.08
59	<i>Osteochilus schlegeli</i>	ត្រីលលកស	750	0.06
60	<i>Albulichthys albuloides</i>	ត្រីឆ្កែកទីទុយ	600	0.05
61	<i>Botia modesta</i>	ត្រីកញ្ជ្រូកក្រហម	600	0.05
62	<i>Achiroides sp.</i>	ត្រីអណ្តែតផ្កា	550	0.05
63	<i>Anabas testudineus</i>	ត្រីក្រាញ់	550	0.05

64	<i>Glossogobius giuris</i>	ត្រីខ្យាន	500	0.04
65	<i>Heterobagrus bocourti</i>	ត្រីកញ្ចុះក្តោង	500	0.04
66	<i>Leptobarbus hoeveni</i>	ត្រីច្រវែងខ្យង	500	0.04
67	<i>Pangasius macronema</i>	ត្រីឈ្មៅតក្តោង	500	0.04
68	<i>Thynnichthys thynnoides</i>	ត្រីសិញ	500	0.04
69	<i>Mystus multiradiatus</i>	ត្រីកញ្ចុះឆ្នុត	400	0.03
70	<i>Probarbus jullieni</i>	ត្រីត្រសក់	400	0.03
71	<i>Discherodontus ashmeadi</i>	ត្រីកន្ទុយក្រហម	300	0.03
72	<i>Lalates siamensis</i>	ត្រីឈ្មៅប្រាក់	300	0.03
73	<i>Trichogaster trichopterus</i>	ត្រីកំភ្លាញ	250	0.02
74	<i>Cirrhinus jullieni</i>	ត្រីផ្កាថា	200	0.02
75	<i>Hypsibarbus pierrei</i>	ត្រីឆ្អិនព្រួយ	200	0.02
76	<i>Ompok hypophthalmus</i>	ត្រីតាអោន	200	0.02
77	<i>Kryptopterus cryptopterus</i>	ត្រីកំភ្លៅវី	150	0.01
78	<i>Mystus wolffi</i>	ត្រីកញ្ចុះ	150	0.01
79	<i>Luciosoma bleekeri</i>	ត្រីចង្ការនោង	100	0.01
80	<i>Poropunitus deauratus</i>	ត្រីលលកស/ក្រសក្នំ	100	0.01
81	<i>Xenentodon cancila</i>	ត្រីផ្កាង	100	0.01
82	<i>Leiocassis siamensis</i>	ត្រីកញ្ចុះប៉ារ៉ា	60	0.01
83	<i>Macrochirichthys macrochirus</i>	ត្រីដងខ្មែង	50	0
Total			1,161,633	100

3.3 Fish species diversity in the project area

Fish species in the project area were defined by two methods, (1) PRA and (2) sampling by selected fishers in the project area. Ninety four fish species were reported by PRA method. Eighty three fish species were recorded by selected fishers sampling method. Eleven fish species reported by PRA but did not catch by the selected fishers. This case is very common because we could not catch all fish species in a large and long river (The most effective fish species richness sampling method is poisoning in a small closed area).

On the other hand, twelve fish species were caught by selected fishers, but absent in the list of species reported by PRA. This case quite uncommon, possibly the fish posters using during PRA did not have all fish species in the local area. Thus, we had to integrate these two lists and made a conclusion that fish species in the project area (Sesan and Srepok) were at least 106 species. This result is lower than the previous PRA research by CEPA in 2006 (130 species) and by Chan Sokheng, Putrea Solida and So Nam in 2007 (193 species) due to different years of study.

Table 3: List of fish species recorded in the project area by use of PRA method and fisher sampling method (1 matched in the list of overall fish species found in project area)

No	Scientific name	Khmer Name	Species Reported by local people (PRA)	Species identified in the catch of selected fishers
1	<i>Acantopsis sp.</i>	ត្រីបួសចេក	1	1
2	<i>Achiroides sp.</i>	ត្រីអណ្តែតឆ្កែ	1	1
3	<i>Albulichthys albuloides</i>	ត្រីឆ្កែកមីទុយ		1
4	<i>Amblyrhynchichthys truncates</i>	ត្រីកំបុតច្រមុះ	1	1
5	<i>Amphotistius sp</i>	ត្រីបបែល	1	
6	<i>Anabas testudineus</i>	ត្រីក្រាញ់	1	1
7	<i>Arinus sp.</i>	ត្រីក្អក	1	
8	<i>Bagarius yarrelli</i>	ត្រីក្របី	1	1
9	<i>Bagrichthys macropterus</i>	ត្រីចេកទុំ	1	1
10	<i>Bangana behri</i>	ត្រីបារ៉ាមុខពីរ	1	1
11	<i>Barbodes altus</i>	ត្រីការហៃ	1	1
12	<i>Barbodes schwanefeldi</i>	ត្រីការហៃលឿង	1	1
13	<i>Belodonticthys dinema</i>	ត្រីក្លាំងហាយ	1	
14	<i>Bobodes gonionotus</i>	ត្រីឆ្អិន	1	
15	<i>Boesemania microlepis</i>	ត្រីប្រម៉ា	1	
16	<i>Botia lecontei</i>	ត្រីកញ្ជ្រូកព្រួយ	1	1
17	<i>Botia modesta</i>	ត្រីកញ្ជ្រូកក្រហម	1	1
18	<i>Channa macropeltes</i>	ត្រីឆ្កែ	1	1
19	<i>channa orientalis</i>	ត្រីក្សាន្ត	1	
20	<i>Channa sp.</i>	ត្រីអំបូង	1	1
21	<i>Channa striata</i>	ត្រីផ្កក់	1	1
22	<i>Chitala blanci</i>	ត្រីក្រាយ	1	1
23	<i>Chitala ornata</i>	ត្រីក្រាយ	1	1
24	<i>Cirrhinus molitorella</i>	ត្រីផ្កាគ	1	1
25	<i>Cirrihnus jullieni</i>	ត្រីផ្កាចា	1	1
26	<i>Cirrihnus microlepis</i>	ត្រីព្រួល	1	1
27	<i>Clarias macrocephalus</i>	ត្រីអណ្តែងទន់	1	
28	<i>Clarias batrachus</i>	ត្រីអណ្តែងរឹង	1	1
29	<i>Coius undecimradiatus</i>	ត្រីខ្លា		1
30	<i>Cosmocheilus harmandi</i>	ត្រីកំពូលបាយ	1	1
31	<i>Cyclocheilichthys enoplos</i>	ត្រីឆ្កែក	1	1
32	<i>Cyclocheilichthys sp.</i>	ត្រីឆ្កែក	1	1

33	<i>Cyclocheilichthys furcatus</i>	ត្រីអ្នកភ្លើង	1	1
34	<i>Dangila spilopleura</i>	ត្រីអាចម៍កុក	1	1
35	<i>Datnioides quadrifasciatus</i>	ត្រីខ្លា	1	
36	<i>Datnioides microlepis</i>	ត្រីខ្លា	1	
37	<i>Discherodontus ashmeadi</i>	ត្រីកន្ទុយក្រហម	1	1
38	<i>Glossogobius giuris</i>	ត្រីខ្យាន		1
39	<i>Gyrinocheilus pennocki</i>	ត្រីស្មុគ	1	1
40	<i>Hampala dispar</i>	ត្រីខ្លាន់	1	1
41	<i>Helicophagus waandersi</i>	ត្រីប្រាកណ្តុរ	1	1
42	<i>Hemibagrus nemurus</i>	ត្រីឆ្កាំង	1	1
43	<i>Henicorhynchus cryptopogon</i>	ត្រីរៀលអង្កាម	1	
44	<i>Henicorhynchus lobatus</i>	ត្រីរៀល		1
45	<i>Henicorhynchus siamensis</i>	ត្រីរៀលតុប	1	1
46	<i>Heterobagrus bocourti</i>	ត្រីកញ្ចុះក្តោង	1	1
47	<i>Hypsibarbus sp.cf.vernayi</i>	ត្រីឆ្កិនមាស	1	
48	<i>Hypsibarbus wetmorei</i>	ត្រីឆ្កិនក្រហម	1	
49	<i>Hypsibarbus malcolmi</i>	ត្រីឆ្កិនក្តា		1
50	<i>Hypsibarbus pierrei</i>	ត្រីឆ្កិនប្រាយ		1
51	<i>Hypsibarbus sp.</i>	ត្រីឆ្កិនមាស		1
52	<i>Kryptopterus kryptopterus</i>	ត្រីកំភ្លៀវ	1	1
53	<i>Kryptopterus moorei</i>	ត្រីស្លាបមាត់	1	1
54	<i>Laides siamensis</i>	ត្រីឈ្មួតប្រាក់	1	1
55	<i>Lebeo erythropterus</i>	ត្រីប៉ារីមុខមួយ	1	1
56	<i>Leiocassis siamensis</i>	ត្រីកញ្ចុះប៉ារី		1
57	<i>Leptobarbus hoeveni</i>	ត្រីច្រាវឡាង		1
58	<i>Luciosoma bleekeri</i>	ត្រីចង្វារនោង	1	1
59	<i>Macrochirichthys macrochirus</i>	ត្រីដងខ្លែង	1	1
60	<i>Macragnathus siamensis</i>	ត្រីផ្លូញ	1	
61	<i>Mastacemblus sp.</i>	ត្រីខ្លាំង	1	1
62	<i>Mekongina erythrospila</i>	ត្រីប៉ាសេអ៊ី	1	1
63	<i>Micronema bleekeri</i>	ត្រីកេសជ័រវ័រ	1	1
64	<i>Micronema micronema</i>	ត្រីកេស	1	1
65	<i>Monotreta sp</i>	ត្រីកំពត	1	
66	<i>Morulius Chrysophekadion</i>	ត្រីវ័ក្ក	1	1
67	<i>Mystus filamentus</i>	ត្រីតានេល	1	1

68	<i>Mystus multiradiatus</i>	ត្រីកញ្ចុះឆ្មុត	1	1
69	<i>Mystus sp.</i>	ត្រីកញ្ចុះ	1	1
70	<i>Mystus wolffi</i>	ត្រីកញ្ចុះ	1	1
71	<i>Hemibagrus wyckioides</i>	ត្រីខ្យា	1	1
72	<i>Notopterus notopterus</i>	ត្រីស្លាត	1	1
73	<i>Ompok bimaculatus</i>	ត្រីក្រម៉ម	1	1
74	<i>Ompok hypophthalmus</i>	ត្រីតាអោន	1	1
75	<i>Ophisternon bengalense</i>	អន្ទង	1	
76	<i>Opsarius koratensis</i>	ត្រីចង្វា	1	
77	<i>Osphronemus exodon</i>	ត្រីវមាស	1	1
78	<i>Osteochilus hasselti</i>	ត្រីក្រុស	1	1
79	<i>Osteochilus melanopleurus</i>	ត្រីគ្រំ	1	1
80	<i>Osteochilus schlegeli</i>	ត្រីលលកស	1	1
81	<i>Oxyeleotris marmorata</i>	ត្រីដីរី	1	1
82	<i>Pangasius bocourti</i>	ត្រីប្រាខ្មៅ		1
83	<i>Pangasius cf. polyuranodom</i>	ត្រីជៀត		1
84	<i>Pangasius concophilus</i>	ត្រីប្រាតែ	1	1
85	<i>Pangasius hypophthalmus</i>	ត្រីប្រា		1
86	<i>Pangasius larnaudiei</i>	ត្រីពោ	1	1
87	<i>Pangasius macronema</i>	ត្រីឈ្មៀតក្តោង	1	1
88	<i>Pangasius sanitwongsei</i>	ត្រីពោព្រាយ	1	
89	<i>Paralaubucus typus</i>	ត្រីស្លឹកឫស្សី	1	1
90	<i>Parambassis wolffi</i>	ត្រីកន្ត្រងប្រេង	1	
91	<i>Polynemus sp</i>	ត្រីព្រាម	1	
92	<i>Poropunitus deauratus</i>	ត្រីលលកស/ក្រុសភ្នំ	1	1
93	<i>Pristolepis fasciata</i>	ត្រីកន្ត្រប់	1	1
94	<i>Probarbus jullieni</i>	ត្រីត្រសក់	1	1
95	<i>Puntioplites falcifer</i>	ត្រីច្រកែង	1	1
96	<i>Rabora borapetensis</i>	ត្រីចង្វា	1	
97	<i>Rasbora spp.</i>	ត្រីចង្វា	1	1
98	<i>Rasbora tornieri</i>	ត្រីចង្វាមូល	1	1
99	<i>Schistura sp</i>	ត្រីប៉ាកក	1	
100	<i>Tenualosa thibaudeaui</i>	ត្រីក្បក	1	
101	<i>Thynnichthys thynnoides</i>	ត្រីសិញ	1	1
102	<i>Trichogaster pectoralis</i>	ត្រីកន្ទរ	1	

103	<i>Trichogaster trichopterus</i>	ត្រីកំភ្លាញ	1	1
104	<i>Wallago attu</i>	ត្រីសណ្តាយ	1	1
105	<i>Wallago leeri</i>	ត្រីស្នាក់	1	1
106	<i>Xenentodom cancila</i>	ត្រីផ្កាង	1	1
Total	106		94	83

3.4 Migratory fish species in the project area

We quoted names of longitudinal migrating fish species in Jorgensen, *et al.*, 1998 as benchmark (Table 4). Thirty four species were matched with the list, corresponds to 32% of species found in the project area (Table 1, Table 3). Amongst those thirty four species, four species were in the top ten dominant species by number in the project area. Those species were *Henicorhynchus lobatus*, *Cirrhinus molitorella*., *Hypsibarbus malcolmi*, and *Osteochilus hasseltii*. Seven species were in the top ten dominant species by weight in the project area. Those species were *Hypsibarbus malcolmi*, *Hemibagrus wyckioides*, *Gyrinocheilus pennocki*, *Pangasius larnaudii*, *Cyclocheilichthys enoplos*, *Helicophagus waandersi*, and *Henicorhynchus lobatus*. Therefore, there are nine (i.e. *Cirrhinus molitorella*, *Osteochilus hasseltii*, *Hypsibarbus malcolmi*, *Hemibagrus wyckioides*, *Gyrinocheilus pennocki*, *Pangasius larnaudii*, *Cyclocheilichthys enoplos*, *Helicophagus waandersi*, and *Henicorhynchus lobatus*) dominant fish species found in the project area are long distance migratory fish species, which could perform a long distance migration between Tonle Sap or Cambodia lower Mekong and the project area.

Table 4: List of migrating species by Jorgensen, et al., 1998 and migrating fish species identified in the project areas. (1 matched in longitudinal migrating species)

Number	Family	List of longitudinal migrating species collected from Jorgensen, et al., 1998.	Species recorded in the project area
1	Cyprinidae	<i>Bangana behri</i>	1
2	Cyprinidae	<i>Barbonymus altus</i>	1
3	Siluridae	<i>Belodontichthys sp.</i>	
4	Sciaenidae	<i>Boesemania microlepis</i>	1
5	Cobitidae	<i>Botia modesta</i>	1
6	Cyprinidae	<i>Cirrhinus microlepis</i>	1
7	Cyprinidae	<i>Cirrhinus molitorella</i>	1
8	Cyprinidae	<i>Cirrhinus sp.</i>	1
9	Cyprinidae	<i>Cosmochilus harmandi</i>	1
10	Cyprinidae	<i>Crossocheilus sp.</i>	1
11	Cyprinidae	<i>Cyclocheilichthys enoplos</i>	1
12	Cyprinidae	<i>Cyclocheilichthys repasson</i>	
13	Cyprinidae	<i>Cyprinus carpio</i>	
14	Gyrinocheilidae	<i>Gyrinocheilus pennocki</i>	1
15	Pangasiidae	<i>Helicophagus waandersii</i>	1
16	Bagridae	<i>Hemibagrus wyckioides</i>	1
17	Siluridae	<i>Hemisilurus mekongensis</i>	
18	Cyprinidae	<i>Henicorhynchus lineatus</i>	
19	Cyprinidae	<i>Henicorhynchus siamensis</i>	1
20	Cyprinidae	<i>Henicorhynchus lobatus</i>	1

21	Cyprinidae	<i>Hypsibarbus lagleri</i>	
22	Cyprinidae	<i>Hypsibarbus pierrei</i>	1
23	Cyprinidae	<i>Hypsibarbus suvattii</i>	
24	Cyprinidae	<i>Hypsibarbus suvattii</i>	
25	Cyprinidae	<i>Hypsibarbus malcolmi</i>	1
26	Cyprinidae	<i>Kryotopterus sp.</i>	1
27	Cyprinidae	<i>Labeo erythropterus</i>	1
28	Cyprinidae	<i>Labiobarbus leptocheila</i>	
29	Cyprinidae	<i>Lobocheilos melanotaenia</i>	
30	Cyprinidae	<i>Mekongina erythrospila</i>	1
31	Siluridae	<i>Micronema bleekeri</i>	1
32	Cyprinidae	<i>Morulius chrysophekadion</i>	1
33	Siluridae	<i>Ompok hypophthalmus</i>	1
34	Cyprinidae	<i>Osteochilus hasseltii</i>	1
35	Cyprinidae	<i>Osteochilus microcephalus</i>	
36	Cyprinidae	<i>Osteochilus sp.</i>	1
37	Pangasiidae	<i>Pangasianodon gigas</i>	
38	Pangasiidae	<i>Pangasius bocourti</i>	1
39	Pangasiidae	<i>Pangasius conchophilus</i>	1
40	Pangasiidae	<i>Pangasius hypophthalmus</i>	1
41	Pangasiidae	<i>Pangasius krempfi</i>	
42	Pangasiidae	<i>Pangasius larnaudii</i>	1
43	Pangasiidae	<i>Pangasius macronema</i>	1
44	Pangasiidae	<i>Pangasius pleurotaenia</i>	
45	Pangasiidae	<i>Pangasius sanitwongsei</i>	
46	Pangasiidae	<i>Pangasius siamensis</i>	
47	Cyprinidae	<i>Paralaubuca typus</i>	1
48	Cyprinidae	<i>Probarbus jullieni</i>	1
49	Cyprinidae	<i>Probarbus labeamajor</i>	
50	Cyprinidae	<i>Puntius sp.</i>	1
51	Cyprinidae	<i>Scaphognathops bandanensis</i>	
52	Cyprinidae	<i>Scaphognathops stejnegeri</i>	
53	Clupeidae	<i>Tenualosa thibaudeaui</i>	1
54	Cyprinidae	<i>Tor tambroides</i>	
Total		54	34

3.5 Endangered fish species

There were 5 fish species occurred in the project area matched to the list of Cambodia Endangered Fish Species (FiA, 2009). Namely: *Puntius partipentazona*, *Probarbus jullieni*, *Osphronemus exodon*, *Tenualosa thibaudeaui*, and *wallago leeri*. Only one fish species *Probarbus jullieni* matched to the CITES.

Table 5: Species matched in the Cambodia Endangered Fish Species, 2009, Number (1 matched species)

Scientific Name	Khmer Name	CITES of Cambodia fish	Accursed in Project Area
<i>Scleropages formosus</i>	ត្រីតាពត ឬ ត្រីនាគ	I	
<i>Pristis microdon</i>	ត្រីផ្តុំ	I	
<i>Puntius partipentazona</i>	ត្រីបីកំណាត់ ឬ ត្រីខ្លា		1
<i>Balantiocheilos melanopterus</i>	ត្រីកៀតស្រង់		
<i>Puntioplites bulu</i>	ត្រីតជ្រា		
<i>Orcaella brevirostris</i>	ផ្សោតក្បាល ត្រឡោក	I	
<i>Pangasianodon gigas</i>	ត្រីរាជ	I	
<i>Catlocarpio siamensis</i>	ត្រីគល់រាំង		
<i>Probarbus jullieni</i>	ត្រីត្រសក់ក្រហម	I	1
<i>Probarbus labeamajor</i>	ត្រីត្រសក់		
<i>Probarbus labeaminor</i>	ត្រីត្រសក់ស		
<i>Batagur baska</i>	អណ្តើកប្លុង ឬ សរសៃ	I	
<i>Osphronemus exodon</i>	ត្រីត្រចៀកដំរី		1
<i>Osphronemus goramy</i>	ត្រីរមាស		
<i>Datnioides undecimradiatus</i>	ត្រីកន្ត្រប់ខ្លា		
<i>Tenualosa thibaudeaui</i>	ត្រីក្បក		1
<i>Glyptothorax fuscus</i>	ត្រីកញ្ចុះក្របី		
<i>Wallago leeri</i>	ត្រីស្នាក់		1
<i>Heosemys annandalii</i>	អណ្តើកសង្កត់	II	
<i>Siebenrockiella crassicollis</i>	អណ្តើកក្អែក	II	
<i>Bagarius bagarius</i>	ត្រីក្របី		
<i>Bagarius suchus</i>	ត្រីក្របី		
<i>Bagarius yarrelli</i>	ត្រីក្របី		
<i>Lycotrissa crocodilus</i>	ត្រីឆ្មាត្រពិ		
<i>Crocodylus siamensis</i>	ត្រីពិ	I	
<i>Malayemys subtrijuga</i>	អណ្តើកស្រែ	II	
<i>Heosemys grandis</i>	អណ្តើកសោម	II	
<i>Amyda cartilaginea</i>	កន្ទាយអាស៊ី	II	
<i>Pelochelys cantorii</i>	កន្ទាយក្បាលកង្កែប	II	

3.6 Important fish species for local livelihoods in the project area

Top ten dominant species by weight are important for local fishers and people livelihoods. However they are big-size fish, not much dominant by number. On the other hand, the top ten dominant species by number are plenty in the local river. These species are also very important to local fishers, especially the poor. Therefore, we have to combine these two categories have an list of important species for local livelihoods. Due to four species are overlapped, thus, fish species of local importance are 16 (Table 3). These 16 species had about 87% of the total fish number of the catch and about 64% of total biomass of the catch.

Table 6: Species important to local livelihoods in the project area

Number	Scientific Name	Khmer Name
1	<i>Hemibagrus nemurus</i>	ត្រីស្នាំង
2	<i>Hypsibarbus malcolmi</i>	ត្រីឆ្កិនត្នា
3	<i>Morulus chrysophekadion</i>	ត្រីក្អែក
4	<i>Mystus wyckioides</i>	ត្រីខ្យា
5	<i>Gyrinocheilus pennocki</i>	ត្រីស្មុត
6	<i>Pangasius lamaudii</i>	ត្រីពោ
7	<i>Cyclocheilichthys enoplos</i>	ត្រីឆ្កោក
8	<i>Cirrhinus microlepis</i>	ត្រីព្រួល
9	<i>Helicophagus waandersi</i>	ត្រីប្រាកណុរ
10	<i>Henicorhynchus lobatus</i>	ត្រីរៀល
11	<i>Cirrhinus molitorella</i>	ត្រីផ្កាត
12	<i>Hypsibarbus malcolmi</i>	ត្រីឆ្កិនត្នា
13	<i>Barbodes schwanefeldi</i>	ត្រីកាំហៃលឿង
14	<i>Osteochilus hasselti</i>	ត្រីក្រស
15	<i>Acantopsis sp.</i>	ត្រីបួសចេក
16	<i>Mystus sp.</i>	ត្រីកញ្ចុះ

3.7 Fish catch in Sesan and Srepok Rivers from Phluk Commune upward

3.7.1 Fish catch in the project area

3.7.1.1 Fish catch estimated by the 18 selected fishers

Based on fish catch estimates in project area through catch sampling by selected fishers, the annual fish catch in Sesan River, upstream of the proposed dam site, was 118.04 tons. Total catch in Sesan River, downstream of the proposed dam, was 45.27 tones. Total catch in Srepok River was 55.07 tones. Thus, total catch in the project area was 218.38 tons. Given price of 1 kg of fish is 2.5 USD; the fish catch value in the Project area was approximately 545,950 USD.

Table 7: Catch estimation in the project area through catch per unit effort by selected fishers

Location	Fishing Gear	Number families	Average catch per fisher per hour (g)	Number hours per day	Number days per month	Number Months	Yield (tons)
Catch in Sesan river, upstream dam site	Morning	911	3.36	12	20	12	8.82
	Samnanh	456	531.76	2	10	12	58.2
	Ronorng	456	77.16	12	10	12	50.67
	Tom	46	8.89	12	6	12	0.35
Subtotal							118.04
Catch in Sesan river, downstream dam site	Morning	251	1.2	12	20	12	0.87
	Samnanh	126	717.94	2	18	12	39.08
	Ronorng	126	29.31	12	10	12	5.32
Subtotal							45.27
Catch in Srepok River	Morning	368	0.3	12	20	12	0.32
	Samnanh	184	770.61	2	15	12	51.05
	Ronorng	184	23.28	12	6	12	3.7
Subtotal							55.07
Total							218.38

❖ Calculation of average catch per unit effort (CUPE) of the project area

The average catch per local fisher in project area per year was calculated by the formula:

$$\text{Average household catch per year} = \frac{218.38 \text{ tons} \times 1,000\text{kg}}{1,859 \text{ households}} = 117.47 \text{ kg/household}$$

3.7.1.2 Fish catch in the project area by PRA method

There were 251 fishing families in the Sesan river, downstream of the proposed dam site, 911 fishing families in the Sesan river, upstream of the proposed dam site, and 604 fishing families in the Srepok River of the project areas. Total fishing families in the project area were 1,765 out of the total 1,859 families living around the Project area, representing 95%.

Table 8: Number of total families and fishing families in project area

Village Name	Total Family	95% of total households are doing fishing
Sesan river, stream of proposed dam site		
Phluk	196	186
Banh Bung	68	65
Total:	264	251
Sesan river, upstream of proposed dam site		
Srekor 1	165	157
Srekor 2	158	150
Talat	72	68
Svay Reang	256	243
Rompot	53	50
Khsach hmey	255	242
Total	959	911
Srepok River		
Sre Sronok	104	99
Kbal Romeas	106	101
Krobei Chrum	177	168
Total:	636	604
Grand total	1,859	1,765

Total fish catch in the dry season in the project area estimated by PRA was approximately 140.33 tons. Total fish catch in the wet season in the project area estimated by PRA was approximately 172.30 tons. The total annual catch in the project area estimated by PRA was approximately 312.59 tons. Given price of 1 kg of fish is 2.5 USD; thus, annual market value of fish production in the local area was approximately 781,477 USD.

Table 9: Fish production estimated by PRA in dry season in each location of the project area

Project Areas	Daily catch/ family, in Kg			
	(report by local people)	Fishing family	Fishing days	Total catch, in ton
Downstream of Sesan	0.5	251	255	32.00
Upstream of Sesan	0.2	911	147	26.78
Srepork	0.6	604	225	81.55
Sub Total 1				140.33

Table 10: Fish production estimated by PRA in wet season in each location of the project area

Project Areas	Daily catch/ family, in Kg			
	(report by local people)	Fishing family	Fishing days	Total catch in Kg
Downstream of Sesan	0.6	251	250	37.65
Upstream of Sesan	0.5	911	90	41.00
Srepork	0.5	604	310	93.62
Sub Total 2				172.27
Grand Total (kg)				312.59

3.7.2 Fish catch estimate in upstream of the project area

Sesan and Sre Pok in Ratanakiri are upstream, so that the impact of the project dam could affect to local fishers in Ratanakiri as well. In this study, we used the catch results from Meach and Baird, 2005 for estimating total fish value of the two rivers in the Ratanakiri. The total catch was 650 tons. Given fish price of 1kg was 3 USD. Thus, annual market value of fish production from both rivers, upstream of project area in Ratanakiri was 1,950,000 USD.

Table 11: Estimated catch of upstream of the project area (data based on Meach and Baird, 2005) and total population was used the source from 3S River, 2006.

Location	Number of families	Total annual catch (ton)	Unit price USD/kg	Subtotal (USD)
Sesan, Ratanakiri	3,664	473	3	1,419,000
Sre Pok, Ratanakiri	1,361	177	3	531,000
Total	5,025	650		1,950,000

3.8 Market value of fish production

Market value of fish production in the project area ranged from 545,950 to 781,477 USD. Market value of fish production upstream of the project area was 1,950,000 USD. Thus, total market value of fish production in Sesan and Srepok Rivers from Phluk Commune upward ranged from 2,495,950 to 2,731,477 USD.

Table 12: Total market value of fish production in the project area in Stung Treng province and upstream of the project area in the Ratanakiri province

Location	Fish cost by directed catch (USD)	Fish cost by PRA (USD)
Project area Stung Treng	545,950	781,477
Upstream Project area, Ratanakiri		1,950,000
Total (USD)	Fish value range= 2,495,950 - 2,731,477 USD	

3.9 Other aquatic species richness in the project area

3.9.1 Birds

Eleven species of wild birds found along the Sesan River (Table 13).

Table 13: Birds species in the project area

No	Khmer Name	Scientific Name	English Name
1	Kok	<i>Egretta garzetta</i>	Little Engret
2	Morn Teuk	<i>Amaurormis phoenicuru</i>	White-breasted water hen
3	Pro Vek	<i>Dendrocygna javanica</i>	Lesser whistling duck
4	Tro Dok	<i>Leptoptilos dubius</i>	Greater Adjutant
5	Kror Sa	<i>Ardea cinerea</i>	Grey Heron
6	Kaek Teuk	<i>Phalacrocorax niger</i>	Little Cormorant
7	Roneal Sor	<i>Mycteria cinerea</i>	Milky Stork
8	Traw Yong	<i>Threskiornis melanocephalus</i>	Black-headed Ibis
9	Ork Trey	<i>Ichthyophaga humilis</i>	Lesser Fish Eagle
10	Ty Tuy	<i>Bubo nipalensis</i>	Spot-bellied Eagle Owl
11	Kreal	<i>Grus antigone</i>	Sarus Crane

(Source from villager and Tan Sehta and Colin Poole, 2003)

3.9.2 Reptiles

Local people reported that there were turtles, many species of snakes, crocodiles at the Pluk village, Pluk commune areas. However, reptiles less appeared progressively in the local areas.

3.9.3 Inundated Forest

There are 30 kinds of inundated forest recorded along the Sesan and Srepok River. Some of the inundated forest were used as traditional medicine by villagers, fed by some fish during wet season. Inundated forest plays a very important role for fish habitat such as for fish spawning in rainy season, feeding and escaping from predators CEPA, 2005-2006.

3.10 Possible impacts on downstream fisheries

3.10.1 Impact on project site's fish and fisheries

The Sesan 2 HPP could impact on the total annual catch in the project area up to 313 tons that is equivalent to approximately US\$ 781,477, and in the upstream section of the project area up to 650 tons per year that is equivalent to approximately US\$ 1,950,000. Hence the total fish catch is 963 tons, with the market value of 2.7 million, will be impacted by the dam.

3.10.2 Impact on Tonle Sap fish and fisheries

Four of the nine dominant long distance migratory fish species found in the project area (*Cyclocheilichthys enoplos*, *Henicorhynchus lobatus*, *Osteochilus hasselti*, and *Pangasius larnaudii*) matched in the top ten taxa of Tonle Sap. However, the two fish species *Cyclocheilichthys enoplos* and *Henicorhynchus lobatus* known as migrating fish species that can upstream migrate beyond the Khone Falls during dry season peak migration from the Tonle Sap (Baird, 2009; Jogensen, *et al*, 1998; MRC, 1992, Interactive e-Book, and MRC, inter@ctiveCD, 2003). Therefore the populations of these two fish species found in Sesan river might be genetically different from the populations in the Mekong mainstream. The main habitats of *Pangasius larnaudii* are within the Mekong mainstream, especially in the section between Mekong mainstream of Kampong Cham and Khone Falls. The *Osteochilus hasseltii* is a common species that occurs basin-wide, from the Thai-Lao-Myanmar border in the North, to the Mekong delta in the South. The species is also able to adapt to impoundments and has established viable populations in many reservoirs, and undertaking short migrations from rivers to flood-plain habitats at the onset of the flood season, and returning to river habitats at the end of that period. Each major tributary may hold its own distinct population (MRC, inter@ctiveCD, 2003). Based on these findings, we could conclude that the Sesan 2 HPP would not cause serious impact on the annually recruitment of the top ten dominant taxa of the Tonle Sap.

Table 14: Dominant long distance migratory fish species of the project area matched in the Top Ten dominant taxa of Tonle Sap , (* matching species)

Tonle Sap Dominant Taxa Baran E & Chheng P. 2003		Dominant longitudinal migrating species of the project area	
Scientific Name	Khmer Name	Scientific Name	Khmer Name
<i>Channa micropeltes</i>	ត្រីឆ្កែ	<i>Cirrhinus molitorella</i>	ត្រីផ្កាត
<i>Channa striata</i>	ត្រីរស់	<i>Cyclocheilichthys enoplos</i> *	ត្រីឆ្កែក
<i>Cirrhinus microlepis</i>	ប្រួល	<i>Gyrinocheilus pennocki</i>	ត្រីស្កុត
<i>Cyclocheilichthys spp.</i> *	ត្រីឆ្កែក	<i>Helicophagus waandersi</i>	ត្រីប្រាកណ្តុរ
<i>Henicorhynchus spp.</i> *	ត្រីរៀល	<i>Hemibagrus wyckioides</i>	ត្រីឡា

<i>Labiobarbus spp.</i>	ត្រីខ្នងវែង	<i>Henicorhynchus lobatus*</i>	ត្រីរៀល
<i>Osteochilus spp.*</i>	ត្រីក្រស	<i>Hypsibarbus malcolmi</i>	ត្រីម្ពិសក្តា
<i>Pangasius sp.*</i>	ត្រីប្រា	<i>Osteochilus hasselti*</i>	ត្រីក្រស
<i>Paralaubuca typus</i>	ត្រីស្លឹកឫស្សី	<i>Pangasius larnaudii*</i>	ត្រីពោ
<i>Thynnichthys thynnoides</i>	ត្រីសិញ		

3.10.3 Impact on hydrology

The Sesan 2 HPP will block the Sesan Krom River about 2 km below the joining point of Sesan and Sre Pok. This dam will modify water regime of the entire rivers, and possibly the Mekong mainstream. Data from the Ministry of Water Resources showed that average discharge of the Sesan is 633 m³/s and average discharge of Sre Pok was 667 m³/s. The total of average discharge of the two tributary rivers is 1,300 m³/s. The average discharge of the Mekong mainstream was 15,000 m³/s, (mrcmekong.org, 2009). Thus Sesan and Sre Pok discharge contributed nearly 10% to the Mekong. That meant that there will be 10% modification of the water discharge during a short period of filling dam's reservoir. The average downstream discharge will become normal when ever the entire reservoir is filled.

3.11 Impact on upstream migration and fish route

Due to geographical condition and economical feasibility, no fish pass will be installed in the Sesan 2 HPP. This is meant that the proposed dam will totally block upstream migration of fish. At least 52 species are long migratory species in the Cambodia Mekong basin. They compose numerous families, genera, body shapes and structures. Thus a specific type of fish pass could not accommodate the entire Cambodia Mekong migratory fish species. As raised by the International Rivers that in the Mekong basin there are no good examples of an effective fish pass. Here is no prospect that a fish pass could make a significant difference to the blocking effects of hydropower dam on fish migration. In addition, Baran, *et al.* (2009) recommended that there are no fish passes that can accommodate the size and intensity of mainstream migrations in the Lower Mekong Basin. Probably a fish pass of more than 15 meters high could not accommodate numerous of migrating fish species of the Mekong basin.

4 CONCLUSIONS

There are **106** fish species found in the Sesan 2 HPP project area, Sesan District, Stung Treng province. Of which, **16** are dominant fish species, being equal to **15%** of the total fish species found in the project area: *Hemibagrus nemurus*, *Hypsibarbus malcolmi*, *Morulius chrysophekadion*, *Hemibagrus wyckioides*, *Gyrinocheilus pennocki*, *Pangasius larnaudii*, *Cyclocheilichthys enoplos*, *Cirrhinus microlepis*, *Helicophagus waandersi*, *Henicorhynchus lobatus*, *Cirrhinus molitorella*, *Hypsibarbus malcolmi*, *Barbodes schwanefeldi*, *Osteochilus hasselti*, *Acantopsis sp.*, and *Mystus sp.* However, these **16** dominant fish species (or **15%**) contribute more than **60%** of total catch in the Project area. These fish species are very important for the local livelihoods of the poor in terms of household food security and income generation. Thus, they have to be considered in the fish breeding and stock enhancement program, and fish monitoring program, which will be supported by the Project as an ecological and economical compensation scheme provided the Project.

There are **34** long distance migratory fish species found in the project area, made up **32%** of total number of fish species reported in the project area. **Nine** of the 34 long distance migratory fish species are dominant species in the project area: *Cirrhinus molitorella*, *Osteochilus hasselti*, *Hypsibarbus malcolmi*, *Hemibagrus wyckioides*, *Gyrinocheilus pennocki*, *Pangasius larnaudii*, *Cyclocheilichthys enoplos*, *Helicophagus waandersi*, and *Henicorhynchus lobatus*. **Four** of the nine dominant long distance migratory species are in the list of the top ten dominant taxa of the Tonle Sap: *Cyclocheilichthys enoplos*, *Henicorhynchus lobatus*, *Osteochilus hasselti*, and *Pangasius larnaudii*. Therefore only **four fish species** (or **4%** of the total **106** fish species) found in the project area are dominant and perform long distance upstream migration, probably from Tonle Sap.

There are **five** fish endangered fish species occurred in the project area, namely *Puntius partipentazona*, *Probarbus jullieni*, *Osphronemus exodon*, *Tenuialosa thibaudeaui*, and *Batagur baska*. One fish species *Probarbus jullieni* matched to the CITES.

Annual fish catch of the project area (Sesan 2 HPP reservoir and Phluk commune) is **266 tons**, being equal to a market value of **US\$ 0.7 million**. Annual fish catch of upstream of the project area (Sesan and Srepok Rivers in Ratanakiri province) is **650 tons**, being equal to a market value of **US\$ 1.9 million**. Thus, the total annual market value of fish production of Sesan and Srepok River from Phluk River up to Cambodia-Vietnam border is approximately **US\$ 2.6 million**.

5 MITIGATION IMPACT MEASURES

The Project owner shall compensate to local people and fisheries natural resources what are expected to be lost by the negative impacts of the Sesan 2 HPP.

5.1 Managing fisheries resources and developing aquaculture

The Project owner shall compensate to the quantitative loss of fish and fisheries impacted by the dam by provision of funds to support the following programs.

5.1.1 Establishment and implementation of fish and fisheries monitoring program

The main activities of the program consist of:

- Bio-hydrology Monitoring Center
- Fish catch monitoring,
- Migratory fish species monitoring,

- Water quality monitoring (in relation to fish and fisheries resources)
- Fisheries ecology monitoring,
- Hydrological regime monitoring ,
- Socio-economics and livelihood assessment of fisheries resources

Program period: 10 years, starting from 2010.

Budget: US\$ 1,200,000.00

5.1.2 Establishment of hatchery and breeding of Mekong indigenous fish program

The main activities of the program are the followings:

- Building hatchery station in project area
- Studying biological characteristics of the 12 dominant and important fish species: *Cirrhinus molitorella*, *Hypsibarbus malcolmi*, *Barbodes schwanefeldi*, *Hemibagrus wyckioides*, *Morulius chrysophekadion*, *Cirrhinus microlepis*, *Cyclocheilichthys enoplos*, *Gyrinocheilus pennocki*, *Hemibagrus nemurus*, *Osteochilus hasselti*, and *Pangasius lamarudii*
- Researching and developing breeding techniques of the above 12 dominant and important fish species
- Producing fingerlings of the above 12 fish species to support aquaculture development in the surrounded area and to support stock enhancement of the Sesan and Srepok rivers

Program period: 15 years, starting from 2011.

Budget: US\$ 1,500,000.00

5.2 Supporting livelihoods of local people

- Adequate annual compensation to upstream local people who stay along Sesan and Srepok River based on the value of fish lost that impacted by the dam. The compensation may be given in terms of livelihood improvement initiatives (Agricultural supported program) but full annual compensation will be given by the project owner until it can be shown that any livelihood initiatives are being successful and are sustainable. This determination shall be made by an independent evaluator.

Program period: 10 years, starting from 2014

Budget: US\$ 3,234,000.00

- Agricultural support program shall be provided to the affected people in project area with adequate resources and duration that can sustain local livelihoods. This program consists of three separated sub-programs. 1). the livestock supported sub-program including cattle, chicken, duck, and other animal raising, 2). Agronomic supported sub-program including rice, vegetables, and other crop production, and 3). Aquaculture supported sub-program, including breeding of dominant indigenous fish species identified in this study.

Program period: 5 years, starting from 2014

Budget: US\$ 1,638,000.00

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