

HighARCS Situation Analysis Report— China Site

Research Team of South China Agricultural University

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The project “Highland aquatic resources conservation and sustainable development” (HighARCS) is an international research project supported by the European Union for four years from 2009. According to the “Annex I- Description of Work” of this research proposal (HighARCS- Proposal Number 213015, 2008):“Project partner will complete a detailed multidisciplinary situation analysis of highland aquatic resources, focused on values, livelihoods, conservation issues and wise-use options at five sites in Asia (Guangdong, China; Uttrakhand and West Bengal, India and northern and central Vietnam). Factors assessed will include biodiversity and ecosystem services, including provisioning, regulating, supporting and cultural services. Livelihood strategies of households dependent on ecosystem services derived from highland aquatic resources, in particular poor, food-insecure and vulnerable people, will be assessed within a sustainable livelihoods framework and opportunities to enhance such livelihoods assessed. Institutional features, including local, national and international policy and legislation, trajectories of change, stakeholder values associated with highland aquatic resources and areas of conflict will be assessed.” It also states that “Action plans will be implemented by stakeholders at four sites displaying high biodiversity in Asia and the ecosystem, livelihoods and institutional impacts assessed through participatory monitoring and evaluation. Best practices aimed at conserving biodiversity and sustaining ecosystem services will be communicated to potential users to promote uptake and enhanced policy formulation.” This situation report is from the China site, in the upper reach of the Beijiang River (North River) in Guangdong, South China.

1. Introduction

1.1 Objective of the research project

The study is focused in the Beijiang River in Shaoguan city. Previously aquatic resources were plentiful in this area. However, there has been a tremendous decline in aquatic resources because of industrial and economic development. No in-depth and comprehensive study has been conducted to understand these constraints and explore possible ways of addressing them. Based on the above mentioned problem, the study was thus justified with specific objectives as follows:

- To investigate and evaluate the biodiversity of aquatic resource and ecological service of ecosystem in the northern part of Beijiang River which is the upper reach of the Pearl River in a highland area.
- To analyze the main factors that contributes to decreasing aquatic resources.
- To identify different groups of fishermen to better target new development efforts.
- To identify stakeholders, their roles and linkages in relation to highland aquatic resource in Beijiang river.
- To identify the possible livelihood development strategies of households dependent on aquatic resources.
- To formulate and implement action plans to enhance poor livelihoods and aquatic resource conservation.

1.2 Methods adopted in the first stage of the research

In order to understand the background of the Beijiang River Watershed, a multidisciplinary team, which include 6 experts in ecology, 6 experts in aquatic species, plant species and dragonfly, 3 experts in law and 4 experts in economics, was organized. In August 2009, we spend four days in the site for a general discussion with different stakeholders which included different government officers, industrial leaders, and fishermen. We investigate the general situation of the watershed land use situation from mining, housing, forestry, fishery, to agriculture. We visited fishing villages and talked with fishermen about their lives and production. We also visited different fish markets and collected species samples from the Beijiang River. We collected 43 volumes of data and material related to our research from the Shaoguan government. Literature including books, articles, statistical data and internet WebPages related to our research were also collected by individual researchers according to their specialization and needs. After some discussion within our team, we went back to the fishing village to talk more with fishermen and their family in November, 2009. After finishing the draft of the situation report, we held a workshop in Shaoguan and discussed our findings with different stakeholders to get their feedback in May, 2010. (That feedback is presented in a separated report.)

1.3 Background of the Research Site---Beijiang River

The Pearl River Watershed stretches from 21° 31' to 26° 49' north latitude and from 102° 14' to 115° 53' east longitude. The Pearl River is the third largest river in China. The major river branches are the Xijiang River (West River), Beijiang River (North River), and Dongjiang River (East River). After they merge together and form the main stream of the river, it runs into the Pearl River Delta and then to the South China Sea. The West River flows through Yunnan Province, Guangxi Province, Guangdong Province, while the North River runs through Hunan, Jiangxi and Guangdong Province. The East River runs through Jiangxi and Guangdong Province.



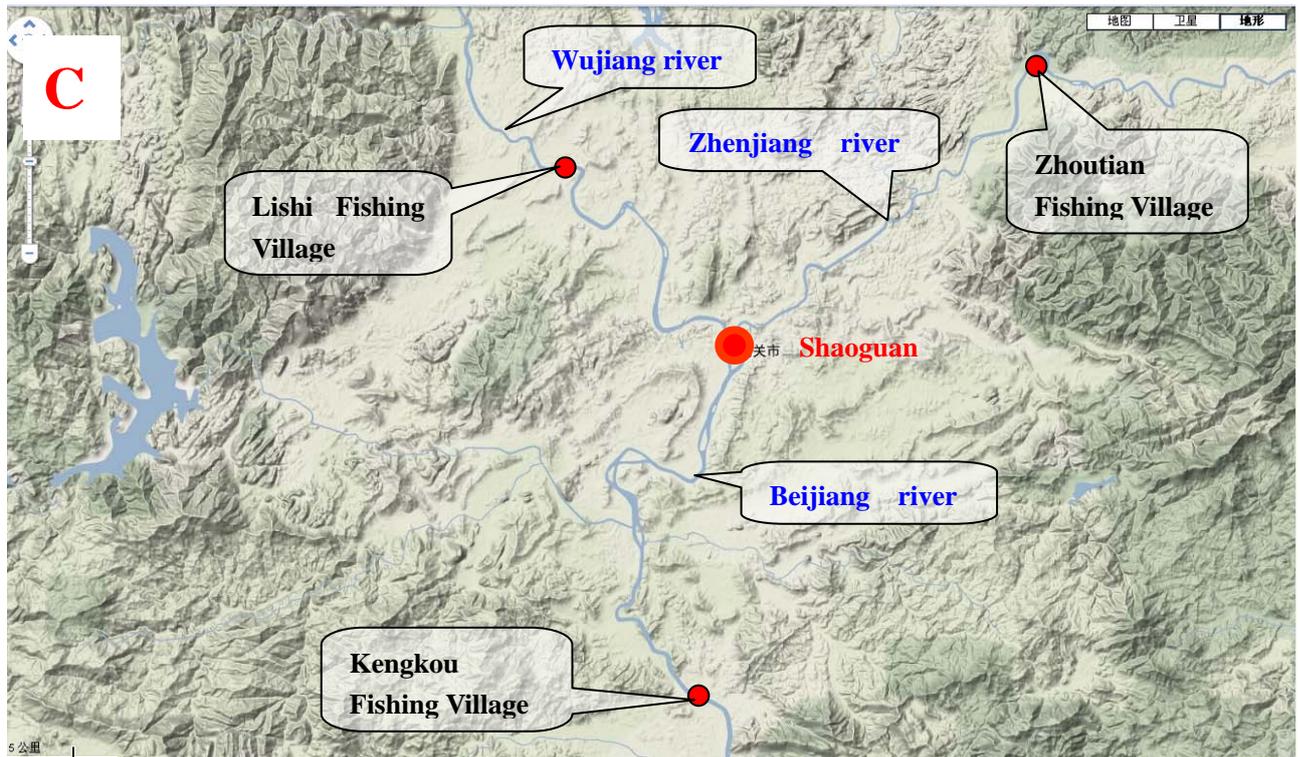


Fig. 1 The Location of Beijiang River Watershed in Pearl River Watershed (Map A, small map in the left corner shows the location of Pearl River Watershed in China) , the location of Shaoguan Municipal Area (Map B) and the locations of the sample villages of this research project (Map C). Notice that all sample villages are located in the mountainous area of the upper reach of the Pearl River and villagers are heavily relying on fishing) (sources: <http://www.chinabaike.com/article/sort0525/sort0543/2007/20070801157011.html>, <http://www.ipe.org.cn/index.jsp?qybh=1911> and Google Map)

Total length of the river reaches 2214 km, and with a watershed area of 453690 km², of which 442100 km² is in China and an annual runoff of 330000 billion m³. The Pearl River whose crisscrossing tributaries form a network of waterways in the downstream delta, flows into the South China Sea through eight entrances of Humen, Jiaomen, Hongqili, Hengmen, Modaomen, Jitimen, Hutiaomen and Yamen. (Committee for Annals of Shaoguan, Guangdong Province, 2001) (<http://2004.chinawater.com.cn>, 2009)

The watershed area of the Pearl River in Guangdong Province is 11125 km², which includes part of the Xijiang watershed, most of the Beijiang watershed, the Dongjiang watershed and the entire Pearl River Delta with 114400 billion m³ runoff. The theoretical water resources deposit is 4.8984 MW (=14.6% of the deposit in the whole watershed). The available water resource is 4.4375 MW. The annual generating capacity is 1666.4 MW.

The Beijiang River (North River) is the second largest water system in the Pearl River System (Fig.1). It's also one of the most important rivers in Guangdong Province. There are two sources of the upper Beijiang River. One is the Zhenjiang River-the east branch which runs from Xinfeng county of Jiangxi Province. Another one is the Wujiang

River-the west branch which runs from Linwu county of Hunan Province. The two sources join together in Shazhouwei of Shaoguan City. Then it is called Beijiang River. On its way to sea, other branches such as the Wenjiang River, the Lianjiang River, Beijiang River and the Suijiang River join into the Beijiang River. Beijiang River meets Xijiang River in Sanshui River-mouth and then runs into the Pearl River Delta. The Beijiang River is 573 km in length with a watershed area of 52068 km², most of which is in the Guangdong Province (42930 km²). The part of the Beijiang Watershed takes 38.5% of the area of Pearl River Basin in Guangdong Province and with 45700 billion m³ annual water flow.

The Beijiang River flows through Shaoguan City, Qingyuan City and Foshan City from north to south. The end of the upper reach of the Beijiang River is Shazhouwei, Shaoguan City. The main tributaries in the upper reach are the Mojiang River, the Jinjiang River and the Wujiang River. The middle section of the Beijiang River is from Shazhouwei to Feilaixia Gorge, Qingyuan City. The main tributaries in the middle section are the Nanshui River, the Wenjiang River and the Lianjiang River. The downstream of Beijiang River is from Feilaixia Gorge to Sixianjiao, Sanshui City. The main tributaries in the lower reach are the Pajiang River, the Binjiang River and the Suijiang River. The lower reach of Beijiang River lies in a plain area. There are artificial dike along the river bank. The watershed area of the major tributaries is larger than 1000 km². The major big tributaries, including Mojiang River, Jinjiang River, Wujiang River, Nanshui River and Wenjiang River are within Shaoguan City. Other major tributaries including the Lianjiang River, Pajiang River, Binjiang River, and Suijiang River enter in Qingyuan City. The whole upper reach and the most part of the middle section of Beijiang River is located in Shaoguan City. It is therefore an ideal location to study the biodiversity of the aquatic organisms and the basin ecological serving function in Shaoguan city. (Committee for Annals of Shaoguan, Guangdong Province, 2001) (<http://2004.chinawater.com.cn>, 2009)

1.4 Natural Environment in the upper and middle reach area of Beijiang River

1.4.1 Topography and physiognomy

The upper and the middle reach of the Beijiang River lies in the northern Guangdong Province where Hunan Province, Jiangxi Province and Guangdong Province meet. It's within 23° 5' -25° 31' north and 112° 50' -114° 45' east. There are 18.6 million m² in this area. It is 10.5% of the Guangdong Province.

The Shaoguan City is in the south of the Nanling Mountain. It lies in the Hunan Guangdong Fold Belt. The geological structure is complex. The igneous rock is widespread while karst landforms also cover much of the land.

There are many different types of rocks such as red sandy conglomerate, sandstone, metamorphic rock, granite and limestone and a lot of gorges, cliffs and mountains. The surface of the ground slopes down from north to south. The highest mountain in Guangdong Province is Shikengkong Mountain. It is 1902m above the sea-level the lowest point in Beijiang River Valley is only 35m above the sea-level. (Committee for Annals of Shaoguan, Guangdong Province, 2001.)

1.4.2 Climate

Shaoguan is in the subtropical humid monsoon climate zone and affected by the monsoon all the year. It is wet in the spring, dry in the autumn, cool in the winter and both hot and humid in the summer. The average annual temperature is 18.8°C-21.6°C. The average temperature of the coldest month(January) is 8°C-11°C and the average temperature of the hottest month(July) is 28°C-29°C. The rain is plentiful. The annual rainfall is 1300-2400mm. The rainy season is from March to August while the dry season is from September to February. Most of the solar radiation (90%) comes along with warm and rainy season with daily average temperature higher than 10°C It is good for the growth of plants and the agricultural crops. There are 310 days frost-free in a year. The annual total sun shine reaches 1473-1925h. Snows usually only occur in the northern part of the mountain area in winter. (Committee for Annals of Shaoguan, Guangdong Province, 2001.)

1.4.3 Vegetation

The primary vegetation in Shaoguan City is subtropical evergreen forest (Fig. 2). Forest resources are rich in Shaoguan, and it contains the largest renewable energy stock and gene bank of living organisms in Guangdong. The water conserving forest in Shaoguan and Hairy bamboo (*Phyllostachys*) forest are important for Guangdong. The forest covers reaches 50% in Shaoguan with a wood storage of 500 million m³. The available logging quantity is 250 million m³. The timber forests are mainly formed by Chinese fir, pine, and Hairy bamboo. The forests of cassia (*Cinnamomum*), paulownia (*Pauownia*), nanmu (*Machilus namu*), common jujube (*Ziziphus jujba* var. *spinosa*), yew (*Taxus cuspidata*), Chinese torreyia (*Torreya grandis*), oak (*Quercus*), cypress (*Cupressus* L.) are also important. (Office of Shaoguan Flora Compilation.1993)



Fig. 2 Vegetation in Shaoguan

1.4.4 Soil

The total land cover in Shaoguan is 17100 km² which is 92.8% of the total area within the Boundary of Shaoguan City. There are many different types of soil in Shaoguan with 11 soil classes, 17 soil subclasses, 78 soil genus, 285 soil species. The 11 classes of the soil can be sorted into 3 kinds——natural soil, upland soil and paddy soil. The soil can be sorted horizontally into 2 kinds——latosolic red soil in south and red soil in the north (the red earth is Central China tropical zonal soil). The soil can be sorted vertically from mountain top to the plain area into 4 kinds which are Southern hilly meadow soil, yellow soil, red soil, latosolic red soil. The red soil covers the most area. The soil fertility is medium in hilly and mountainous area, and very poor in the karst region. (Statistical Bureau of Shaoguan.2008)

1.5 Social and economic status

1.5.1 Population

By the end of 2008, the population of Shaoguan City is 3,230,900, among which 1,248,000 are living in town or city and considered as nonagricultural residents, and 1,982,900 are living in the rural area and considered as agricultural residents. (Agricultural Statistical Yearbook of Guangdong, 2002-2009) Shaoguan City is a multi-ethnic area, most of which are Han people.

1.5.2 Industrial structure

The local GDP is 54.587 billion Yuan RMB in 2008, increased by 10.6% than that in 2007. The primary industry increased by 7.76 billion. The secondary industry increased by 26.256 billion. The third industries have an increase of 20.555 billion. According to the resident population, the GDP per capita is 18503 Yuan. The structure of the three industries has changed from 31.7:48.6:19.7 in 1978 to 22.8:39.3:37.9 in year 2000 and 14.2:48.1:37.7 in year 2008 (Table 1). The structure of economic changed from the order of secondary industry, agriculture, service (2, 1, 3 pattern) in the early days to secondary industry, service and industry (2, 3, 1 pattern.) at present.

Shaoguan City has superiority in agricultural production owing to the rich climate resources. The per capita arable land ranks no.1 in Guangdong Province. In the recent years, the agricultural and rural facilities have been improved and the value of agricultural output value has increased. The seven main products of agricultures in the region are vegetable, high-quality rice, high-quality livestock, high-quality fish, local fruit, bamboo and tobacco. The grain planting area was 1,567,266 ha with a total production of 8,446,000 t in 2008. The planting area of high-quality rice was 564,933 ha with a total production of 3,894,000 t. The planting area for peanut was 402,133 ha with a total production of 1,011,000 t. The product of meat was 135,000 t, including 104,900 t pork. The aquatic product was 625,000 t. The production of *Megalobrama terminalis* has increased in many large and medium-scale reservoirs. The high-quality fish product is increasing from 20% to 50% in year 2008, 60% of the aquaculture output is high-quality fish product

Table 1 the economic indexes in Shaoguan City in some years

(Agricultural Statistical Yearbook of Guangdong, 2002-2009)

Year	1、 population ($\times 10^6$)			2、 GDP ($\times 10^8$ yuan)			GDP per capita (yuan)	The structure of GDP (%)			
	Total	Nonagricultural population	Agricultural population	Total GDP	from primary industry	from secondary industry		from third industry	*from primary industry	*from secondary industry	*from third industry
1978	2.3155	0.5467	1.7688	9.56	3.04	4.64	1.88	410	31.7	48.6	19.7
1980	2.3962	0.5837	1.8125	12.50	3.74	6.03	2.73	516	29.0	48.2	21.9
1985	2.5912	0.7302	1.8610	24.46	7.96	10.66	5.85	936	32.5	43.6	23.9
1990	2.7915	0.8455	1.9460	55.00	16.17	23.14	15.68	1956	29.4	42.1	28.5
1995	2.9362	1.0080	1.9282	133.47	37.91	50.70	44.86	4752	28.4	38.0	33.6
2000	3.1093	1.0965	2.0128	192.72	44.01	75.71	73.00	7045	22.8	39.3	37.9
2005	3.1866	1.261	1.9256	335.81	55.47	144.41	135.93	11566	16.5	43.0	40.5
2007	3.2119	1.2587	1.9532	471.69	66.94	228.64	176.12	16049	14.2	48.5	37.3
2008	3.2309	1.248	1.9829	545.87	77.76	262.56	205.55	18503	14.2	48.1	37.7

★ The statistic of primary production includes mainly crop, forestry, fishery and animal husbandry, secondary production mainly includes manufacture industry and mining industry, third industry mainly includes education, culture and banking service.

In 2007, the aquaculture output of Shaoguan City was 60,395t, including 59,612t fish, 393t shellfish, 202t shrimps and crabs (Table 2). In 2007, the aquaculture output value was 431.87 million taking 3.93% of the total agriculture output value.



Fig 3. Fishing Activity in Beijiang River, Shaoguan, Guangdong Province

Table 2 The aquiculture output of Shaoguan City in 2007

(Statistical Bureau of Shaoguan,2008)

	Yield(t)
Total aquiculture output	60395
1.fish	59612
(1)high-quantity fish	18420
<i>Ophicephalus argus</i>	166
<i>Siniperca chuatsi</i>	130
<i>Micropterus Salomoides</i>	526
<i>Colossomabrachypomum</i>	2009
<i>Oreochromis</i>	5118
<i>Carassius auratus</i>	3809
(2) other fish	41192
<i>Ctenopharyngodon idllus</i>	14781
<i>Aristichthys nobilis</i>	9194
<i>Hypophthalmichthys molitrix</i> (Cuv.et Val.)	10126
<i>Cyprinus carpio</i> L.	4853
2.shellfish	393
3. shrimps and crabs	202

1.5.3 Fishermen's organization and labor

The population of households is increasing year by year. The number of fishery households has increased from 19,440 in 1998 to 20,299 in 2007, but the number of fishing workers is decreasing. The number of fishing workers has descended from 546 in 1998 to 395 in 2007, not only because of the effect caused by the newly-built hydropower stations and dams which reduces the fish resources but also because fishing is a hard work and young people do not want to do it (Fig.3).

Table 3 Current situation of the number of the fishery workers in Shaoguan city

(Department of Aquaculture of Shaoguan City, 2008)

	1998	2000	2001	2002	2003	2004	2005	2006	2007
Fishery families	19440	18046	18123	19047	18179	19983	21174	20163	20299
Fishery population	96389	80709	81078	90549	88784	92838	97051	93846	94717
Professional fishing workers	546	469	482	445	386	432	389	391	395
Part-time fishing workers	715	518	470	352	331	457	1071	437	429

2. Ecosystem goods and services

2.1 Biodiversity and conservation

2.1.1 Biodiversity and conservation of aquatic resources in Beijiang River

(1) Fish resources in Beijiang River

According to the fish investigation in 1990s, there were 144 species in Beijiang River. The major families belong to *Cypriniformes* Order (Table 4). In the past, the fish resource in the north river has been very rich. The fishing activity there could produce 8, 000 ton annually in 1950's. The species captured included eel, grass carp, black Chinese roach, mud carp, triangular bream, eastern barbell, *Spinibarbus hollandi*, spotted long barbell catfish, and some local rare species, such as *Sinilabeo decorus*, *Sinilabeo discognathoides*, *Ptychidio jordani*, *Tor(Folifer)brevifilis*. But now the fish resources have been decreasing at a surprising rate. The annual fishing production has been no more than 2,000 t since 2000. Most of the fish species captured were of the lower valued species such as *Saurogobio dabryi* Bleaker and *Hmculter leucisxulus*. The traditional economic species are decreasing (Fig.4). The total aquatic production has been continuously increasing since 1970, but the increase was from cultivated fish in ponds. The fish caught from fishing in the river has decreased (Fig. 6). The conservation of species such as Asian giant soft-shell turtle, marbled eel, hilsa herring, wattle-necked soft-shell turtle, *Luciobrama macrocephalus* (Lacépède, 1803) are very rare in north river today (Fig.7, Fig.8) (Le, P.Q.,1998).



Fig. 4 Different fish species in the morning retail market along Beijiang River in Shaoguan City

Table 4 Fish Species in Beijiang River (Institute of Aquaculture of Shaoguang City.1991.)

Order	Family	Species	Percentage (%)
<i>Clupeiformes</i>	1	1	0.66
<i>Salmoniformes</i>	1	2	1.32
<i>Anguilliformes</i>	2	3	1.99
<i>Cypriniformes</i>	3	98	69.54
<i>Siluriformes</i>	5	17	11.26
<i>Cyprinodontiformes</i>	1	1	0.66
<i>Synbranchiformes</i>	1	1	0.66
<i>Perciformes</i>	7	19	12.58
<i>Pleuronectiformes</i>	1	1	0.66
<i>Tetraodontiformes</i>	1	1	0.66
Total	23	144	100



Fig. 5 Net-Cage method for fish culture in reservoir, Shaoguan

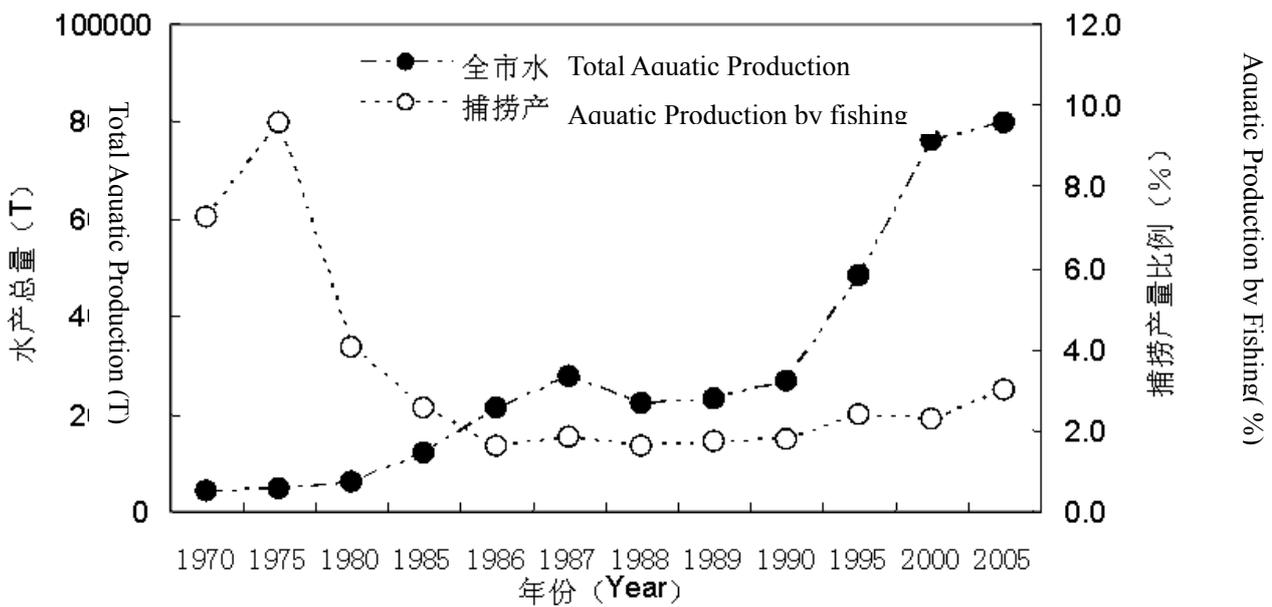


Fig. 6 The aquatic production by fishing in Shaoguan

(Department of Aquaculture of Shaoguan City. 2008)

In order to protect the local aquatic species and fish resources, according to “Fisheries Law of the People's Republic of China”(1986) and “ Protection Law of Wildlife” (1988), nine conservation areas with an area more than 3,780 ha have been set up in order to protect the biodiversity in Shaoguan. The protection species include Asian giant soft-shell turtle, marbled eel, wattle-necked soft-shell turtle etc (Table 6). At the same time, crude fishing methods such as those using explosives, poison or electricity were prohibited. Fishermen acquire their

Fishing License from Shaoguan Fisheries Administration Team. There are 180 families with Fishing License at present. Fry releasing effort has been strengthened in the past decade (Table 5) (Fig.9, Fig.10).

Table 5 the restocking species in Shaoguan
(Department of Aquaculture of Shaoguan City. 2008)

Year	Restocking species	Number released million
2005	Carp, Crucian carp	8
2004	Chinese sturgeon, Carp, spotted silver carp, <i>Megalobrama terminalis</i>	8
2003	Carp, Crucian carp, <i>Spinibarbus hollandi</i> , <i>M. terminalis</i>	8
2002	Carp, Crucian carp, Grass carp, spotted silver carp, <i>M. terminalis</i>	7
2001	Same as 2002	7
2000	Same as 2002	6.15
1999	Same as 2002	6.05
1998	Carp, Crucian carp, Grass carp	5.04
1998	Carp, Crucian carp, Grass carp	5.
1997	Carp, Crucian carp, Grass carp	5
1996	Carp, Crucian carp, Grass carp	5
1996	Carp, Crucian carp	5
1995	Carp, Crucian carp	4
1994	No, flood disaster	
1993	Carp, Crucian carp	2.475
1992	Carp, Crucian carp	2.001
1991	Carp, Crucian carp, Grass carp	0.864
1990	Carp, Crucian carp, Grass carp	0.853
1989	Carp, Crucian carp, Grass carp	0.503
1988	Carp, Crucian carp, Grass carp	0.05
1987	Carp, Crucian carp, Grass carp	0.11
1986	Carp, Crucian carp, Grass carp	0.025



Fig. 7 A rare species *Sinilabeo decorus* from Beijiang River



Fig. 8 A special species *Sinilabeo discognathoides* from Beijiang River



Fig. 9 Fry releasing platform in Shaoguan

Table 6 The aquatic conservation area in Shaoguan

(Institute of Aquaculture of Shaoguan City.1991)

Name	Object of protection	Protected areas
Shaoguan Beijiang endemic and rare fish Provincial conversation area	high quality and rare fish in North river	From Guitou bridge in Wujiang River to Haiguan Island, 2820 ha.
Huangmaoxia endemic and rare fish conversation area	high quality and rare fish resources	From Madongji to Baisha Tangkou in Beijiang river, 160 ha.
Wujiang aquatic resources conservation area	Fresh Aquatic fish resources (<i>Semilabeo notabilis Peters</i>)	<i>Semilabeo notabilis</i> Spawning area in Luojiadu, Wujiang river, 400 ha
wattle-necked soft-shell turtle conversation area in Ruyuan	wattle-necked soft-shell turtle	400 ha
Sixi River aquatic animals conversation area	Aquatic animals	Sixi River
Chishijin aquatic animals conversation area	Aquatic animals	Chishijin
Hongshan aquatic animals conversation area	Aquatic animals	Hongshan
Wangshishan Salamander conversation	giant salamander	Wangshishan
Jinjiang fish biodiversity conversation area	Fish	Jinjiang river



Fig. 10 Practicing fish releasing activity on the platform

(2) Mollusc resources in Beijiang River

There have been very few surveys on mollusc resources in Beijiang River in recent years. In this investigation, the number of mollusc species and population of mollusc have been found to be reducing gradually according to local residents (Fig.11). The main reasons are as follows: (1) The growth, reproduction and habitat environment of mollusc were destroyed by dam building and dredging *etc*; (2) The habitat of mollusc is getting worse because of the pollution with pyrite, tin and oil; (3) Many molluscs were buried by floods in 2006 which brought a large amount of sand and was with a devastating impact on populations; (4) The numbers and species of local mollusc were greatly reduced by the invasion of Apple Snail (*Ampullarius gigas* Spix); (5) Fishing efforts increased while there have been little efforts at breeding.



Fig. 11 Snail is a common dish in restaurant

Table 7 Common mollusc species found in preliminary investigation of Beijiang River

No.	species	Genus	Family	Collection time	Collection place
1	<i>Libertina</i>	<i>Semisulcospira</i>	Melaniidae	2009.11.13	Shaoguan, Guangdong
2	<i>Largillierti</i>	<i>Corbicula</i>	Corbiculidae	2009.11.13	Shaoguan, Guangdong
3	<i>Chinensis</i>	<i>Cipangopaludina</i>	Viviparidae	2009.11.13	Shaoguan, Guangdong
4	<i>Polyzonata</i>	<i>Angulyagra</i>	Viviparidae	2009.08.21	Shaoguan, Guangdong
5	<i>Ampulliformis</i>	<i>Cipangopaludina</i>	Viviparidae	2009.08.21	Shaoguan, Guangdong



Fig. 12 The tools for mollusc-catching (both A and B)

Fishermen mainly live on catching fish and some of them collect mollusc occasionally when they are not busy. They use triangular nets as shown in Figure 12 A and B. Common species found in our preliminary investigation are shown in Table 7.

2.1.2 Plant Biodiversity and Conservation in Mountains and in Rivers

(1) Forestry cover in mountains

Shaoguan is located in a mid-subtropical and south-subtropical climate zone. It is not only the major forest area in Guangdong Province, but also an important ecological buffer zone of the Pearl River Delta. The total forest area has been continuously increasing since 2005 (Fig.13), which covers 78% of the total land area of Shaoguan (Fig. 14). So far, 1270×10^3 ha of the lands are covered by forest or plantations. The forest coverage is relatively higher than other regions in Guangdong Province. The live wood stock is 62.85×10^6 m³ (Fig. 15). Forestry plays a very important role in the Shaoguan social economy and its sustainable development. The major wood products are timbers of China Fir (*Cunninghamia lanceolata*), Pine wood (*Pinus* spp.), Eucalypt wood (*Eucalyptus* spp.), and Hairy Bamboo (*Phyllostachys edulis*).

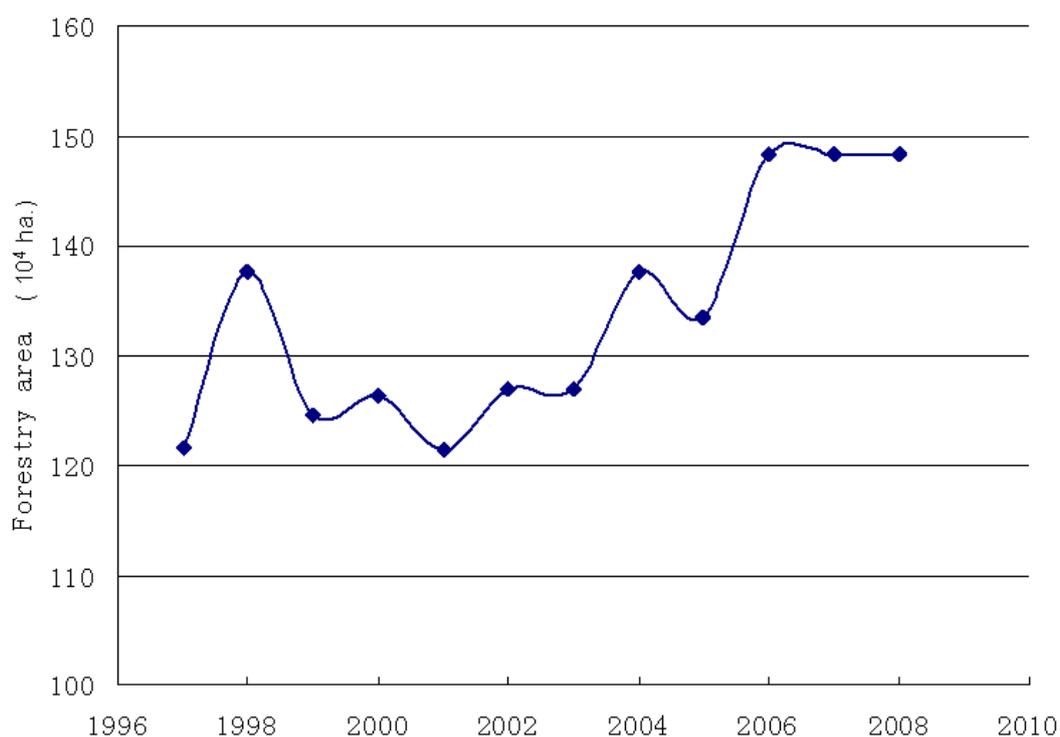


Fig.13 Forestry area in Shaoguan (Guangdong Bureau of Statistics 2002-2009)

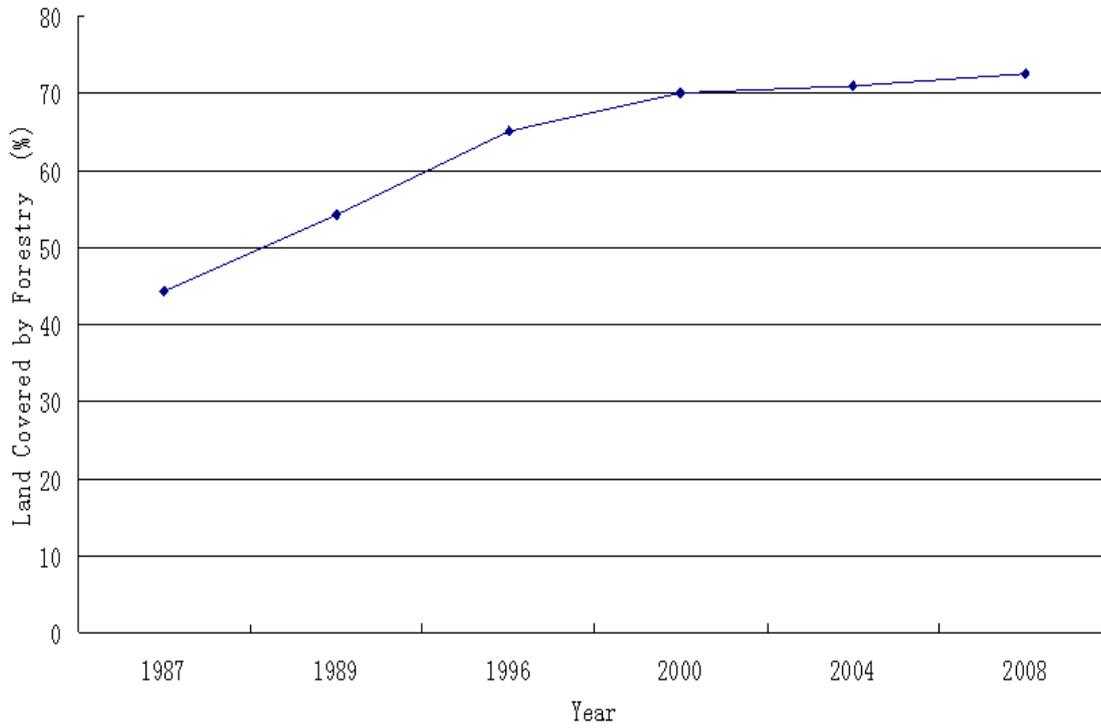


Fig.14 Land covered by forestry in Shaoguan (Sources: <http://number.cnki.net/>)

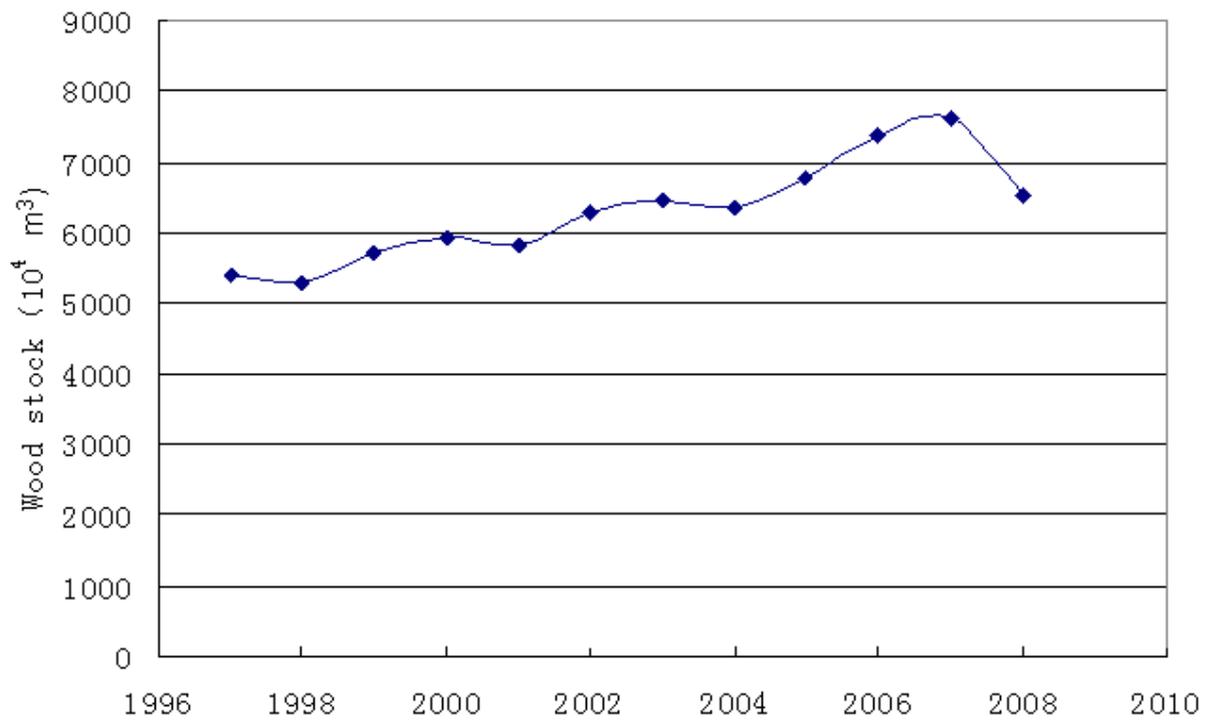


Fig.15 Wood stock in Shaoguan (Guangdong Bureau of Statistics 2002-2009)

It is estimated that there are 2686 species of higher plants, belonging to 271 families and 1031 genera. Of these, there are 206 species of bryophytes, 186 species of pteridophytes, 30 species of gymnosperms, and 2262 species of angiosperms. There are 443 species of vertebrates, belonging to 34 orders, 99 families, and 263 genera. They include 86 species of mammals, 217 species of birds, 74 species of reptiles, 33 species of amphibians. There are also more than 3000 species of non-vertebrates. Eight species are protected in the first rank of the national protected list, such as South China Tiger (*Panthera tigris amoyensis*), Cloud Clouded Leopard Rumbaugh (*Neofelis nebulosa*), Cabot's Tragopan (*Tragopan caboti*), Black Muntjac (*Muntiacus crinifrons*), and Chinese crocodile lizard (*Shinisaurus crocodilurus*). Sixty seven species are in the second rank of the national protected animals, such as Chinese pangolin (*Manis pentadactyla*) and Rhesus macaque (*Macaca mulatta mulatta*). In addition, there are 36 plant species, such as Water Pine (*Glyptostrobus pensilis*), Chinese Yew tree (*Taxus chinensis*) and Guangdong Pine (*Pinus kwantungensis*) are listed in the national key protected list.

There are 22 nature reserves in Shaoguan City, which cover a total area of 25.3×10^6 ha. Of these, 3 are national, 13 are provincial, and 6 are city level. There are also 11 Forest Parks, covering a total area of 5.3×10^4 hm². Among these, 3 are national, 2 are provincial, and 6 are county level.

Since 1999, all the forests are classified as commercial forest and ecological forest based on their major function. In 2008, 31.54% of forest land has been designated as ecological forest in Shaoguan City. Based on the Management and Compensation Regulation of Guangdong Ecological Forest (issued in 1999), all the ecological forests are not allowed to be cut and the owners will obtain some compensation from the Government. The compensation fees varied from 37.5 Yuan/ hm² in 1999 to 180 Yuan/ hm² in 2009.

The forest disturbances caused by fire wood cutting has decreased dramatically since 1985. However, the disturbances caused by the building of hydropower stations still exist. It was observed that construction of hydropower stations not only directly disturbs the vegetation, but also has great impacts on the aquatic biological communities by building the headwater channels. So far, the information on the impacts of disturbances by hydropower station construction is limited.

(2) Aquatic Plants in Beijiang River System

According to recent literature, there are 332 freshwater plant species, varieties and forms of higher plants, belonging to 156 families and 437 genera, in the Pearl River region. However, only a few studies have examined the freshwater plants of the Pearl River Region (Yan, 1989; Tian, 1998; Shi, 2007; Chen et al., 2007). So far, the most detailed study was the work done by Yan (1989). It was reported the floristic composition of the 131 aquatic plants belonging to 44 families and 81 genera in the Pearl River Region of Guangdong Province. They occupied

32.75% species, 68% families, and 66.6% genera of the total freshwater aquatic plants of China. Of these aquatic plants, 70 were emerged plants, 33 submerged plants, and 28 floating plants (Fig.16). 57 species of these were recorded in Beijiang River, which occupied 43.8% of the total aquatic flora of the Pearl River Region.

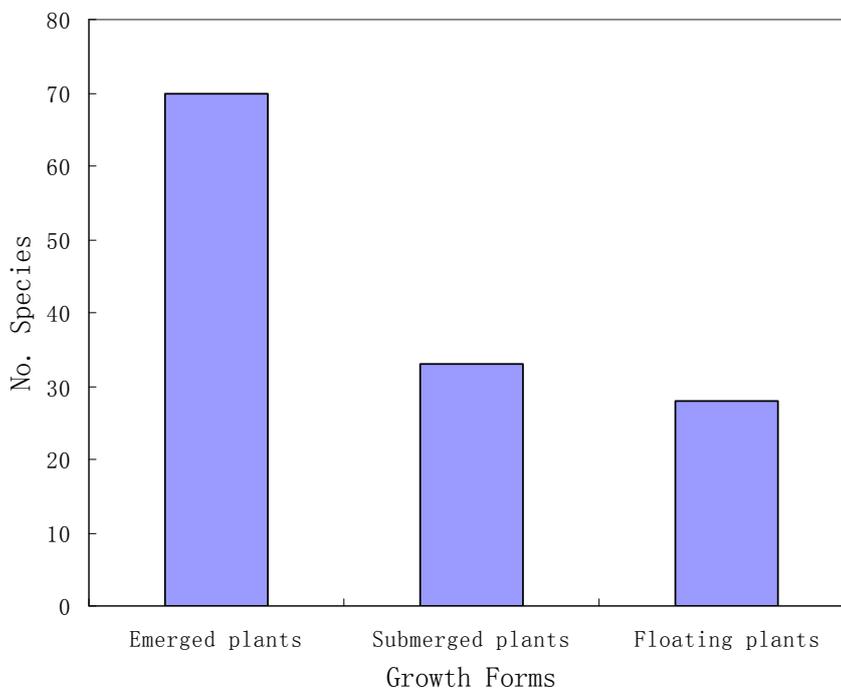


Fig. 16 Composition of the aquatic flora of the Pearl River Region
(Yan S.Z.,1989)

The most common species in the riparian areas of the Pearl River are *Vallisneria denseserrulata* (Hydrocharitaceae). The other dominant species were *Hydrilla verticillata* (Hydrocharitaceae), *Ceratophyllum demersum* (Ceratophyllaceae), *Potamogeton malaianus* (Potamogetonaceae), *Colocasia antiquorum* (Araceae), and *Lemna minor* (Lemmaceae).

A field survey of freshwater plants was done in Shaoguan in October 2009. Ten freshwater species were recorded in the less disturbed river bank sections (Table 8). The largest population was Water Hyacinth (*Eichhornia crassipes*), which was found not only in rivers, but also in ponds near villages and agricultural areas. Water cabbage (*Pistia stratiotes*) and Duckweed (*Lemna minor*) are also common in ponds elsewhere. Some native submerged plants such as *Vallisneria natans* and *Hydrilla verticillata* were only found in the site which were less disturbed, but were seldom seen in the streams or rivers with serious physical disturbances and water pollution in the Pearl River. The dominant plant species from the above survey was similar to Yan (1989), but attention should be paid to the widespread presence of some exotic plants. Therefore, more field studies in other subsidiary streams

are needed for understanding the current status of the aquatic plants, especially submerged plants in the Pearl River Region.

Table 8 The Plants Found in Two Study Sites of Beijiang River within Shaoguan

No.	Chinese name	Botanical Name	Family name	Growth form	Frequency
1	野芋	<i>Colocasia antiquorum</i>	Araceae	water tolerant	+
2	*大藻	<i>Pistia stratiotes</i>	Araceae	Floating	+
3	西洋菜	<i>Nasturtium officinale</i>	Brassicaceae	Emerged	+
4	狐尾藻	<i>Myriophyllum verticillatum</i>	Haloragidaceae	Submerged	+
5	黑藻	<i>Hydrilla verticillata</i>	Hydrocharitaceae	Submerged	++
6	苦草	<i>Vallisneria spiralis</i>	Hydrocharitaceae	Submerged	+++
7	水龙	<i>Ludwigia adscendens</i>	Onagraceae	Floating	+
8	*水浮莲	<i>Eichhornia crassipes</i>	Pontederiaceae	Floating	+++
9	菹草	<i>Potamogeton crispus</i>	Potamogetonaceae	Submerged	+
10	竹叶眼子菜	<i>Potamogeton malaianus</i>	Potamogetonaceae	Submerged	+

2.1.3 Biodiversity of farming system and agricultural activity

In Shaoguan area, the main crops include rice, maize, potato, tobacco, peanut, soybean, and sugarcane etc. There are 500 varieties of vegetable, 411 varieties of fruits including orange, peach, plum, grape, and Chinese gooseberry etc., 352 species of medicinal plant, 57 species of natural fibrous plant, 261 species of oil plant, 79 species of aroma herbs plant, 35 species of starch plants, 42 species of green and ornamental plants. According to species resource investigation in 1980s, wild rice, wild soybean and wild tea were found and could be used by agriculture in this area. The main animals include pig, chicken, aquatic animals and silkworm etc.

The diversity of topology and climate leads to the diversity in agricultural production. According to the classification of topology, there are four types of agricultural areas, including basins and plains, hilly area and low mountain, low and medium mountain, and limestone areas. With the development of modern agricultural methods, the number of traditional crop varieties has decreased quickly and been replaced with modern high-yielding varieties.

The grain production area in Shaoguan has decreased from 181.53×10^3 ha in 2007 to 156.73×10^3 ha in 2008 because of industry and social economy development (Fig. 17). The total GDP from agricultural was 13.1 billion RMB Yuan in 2008, an increase of 5.4% as compared to that in 2007 (Fig. 18). The amount of fertiliser applied in 2006, 2007, and 2008 has constituted increases of 17.9%, 23.0% and 23.9% as compared to that in 2005 (Fig. 19), which would also contribute to the non-point agricultural pollution. (Agricultural Statistical Yearbook of Guangdong, 2002-2009)

In year 2008, the production of poultry and pigs reached 19.32 and 2.18 million respectively, 26,820 sheep and goat were farmed and 7112 tons of silk worm cocoons were produced. There about 50,000 pigsties around fishponds (Department of Aquaculture of Shaoguan City, 2008).

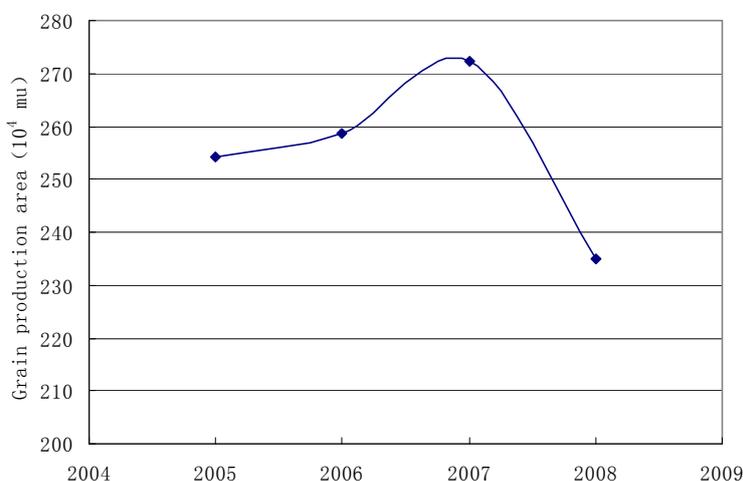


Fig.17 Grain production area in Shaoguan (Agricultural Statistical Yearbook of Guangdong, 2002-2009)

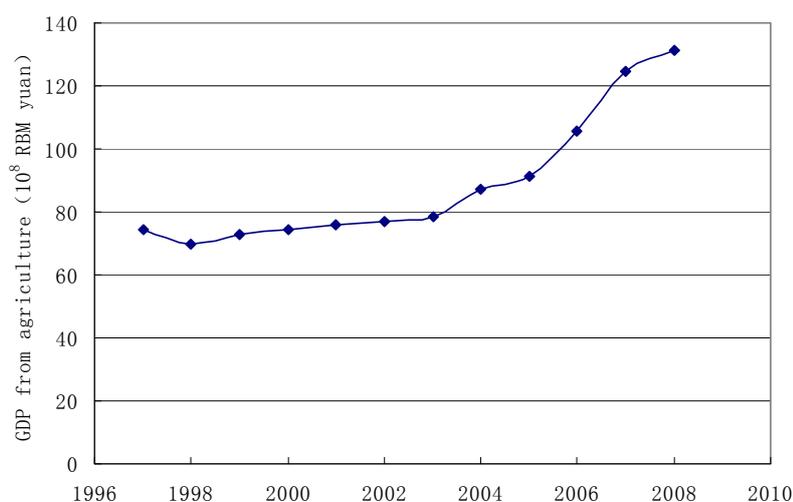


Fig. 18 GDP from agriculture in Shaoguan (Agricultural Statistical Yearbook of Guangdong, 2002-2009)

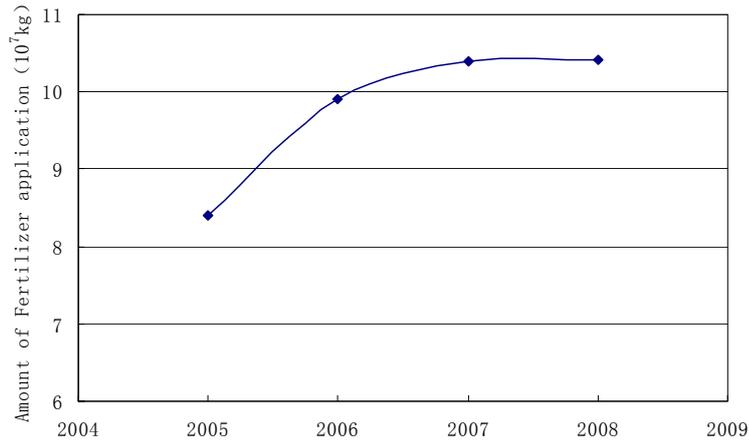


Fig.19 Amount of fertilizer application in Shaoguan (Statistical Bureau of Shaoguan, 2008)

2.2 Ecosystem service function and ecological compensation

2.2.1 Ecosystem service

Ecosystem services are the conditions and processes through which natural ecosystems, and the species that make them sustain and fulfill human life (Daily, G. C, 1997). They maintain biodiversity and the production of ecosystem goods, such as seafood, forage timber, biomass fuel, natural fiber, and many pharmaceuticals, industrial products, and their precursors. The American ecologists (Costanza et al., 1997) called the products and services provided by ecosystem as “ecosystem services” and divided them into 17 different types. In this study, we consider the mechanisms, types and efficiency of the ecosystem services and sorted it into 4 types: ①Product supply, including food, water, fuel, fiber, biochemistry product and gene resources etc. ②Ecological maintenance, including climatic regulation, hydrological regulation, self-purification function, soil erosion control, natural disaster control, pollination etc. ③Culture functions, including spirits and encouragement, entertainment, physical culture, appreciation, education etc. ④Support functions, including soil development and materials circulation etc.

(1) Structure of Beijiang River Watershed Ecosystem

The Beijiang River Watershed Ecosystem (Fig. 20) contains a large area of vegetation cover with natural forestry, artificial forestry, orchards and tea plantations in hilly and mountainous areas. Occasionally, the vegetation has been destroyed due to mining activity and the planting of new vegetations such as eucalyptus tree which is the fastest growing tree in South China. These activities could cause soil erosion. Many reservoirs have been built in the upper branches of the river for irrigation, drinking water and electricity. Fish raising was also encouraged in some reservoirs if they were not the sources of drinking water. Sometimes fish raising can cause eutrophication in

these reservoirs. There is agricultural land along both sides of the main stream of the river. Irrigation water from the river benefits crop production such as rice and vegetables. The increasing use of fertilizer and pesticide and the increasing number of animals have caused some threats to the water quality. In recent years, biogas techniques to digest animal waste are becoming more popular under the encouragement policy implemented by the local government. Fishing from the river is a traditional activity. It is still an important activity for many fishermen's families. However, cultured fish from fish ponds are becoming more important for the increasing demand in the market. The fish compositing and quantity have been greatly affected by the construction of many big dams across river and by the sand mining from river bed. Pollution discharged from factories, cities and towns also have a negative effect on the river. At this point we will discuss the ecosystem services provided by rivers, and reservoirs. In section 2.1.1 we will discuss the biodiversity situation, focusing on the effects of dam building and sand mining activities. In section 2.2.2, we will provide more information about pollution.

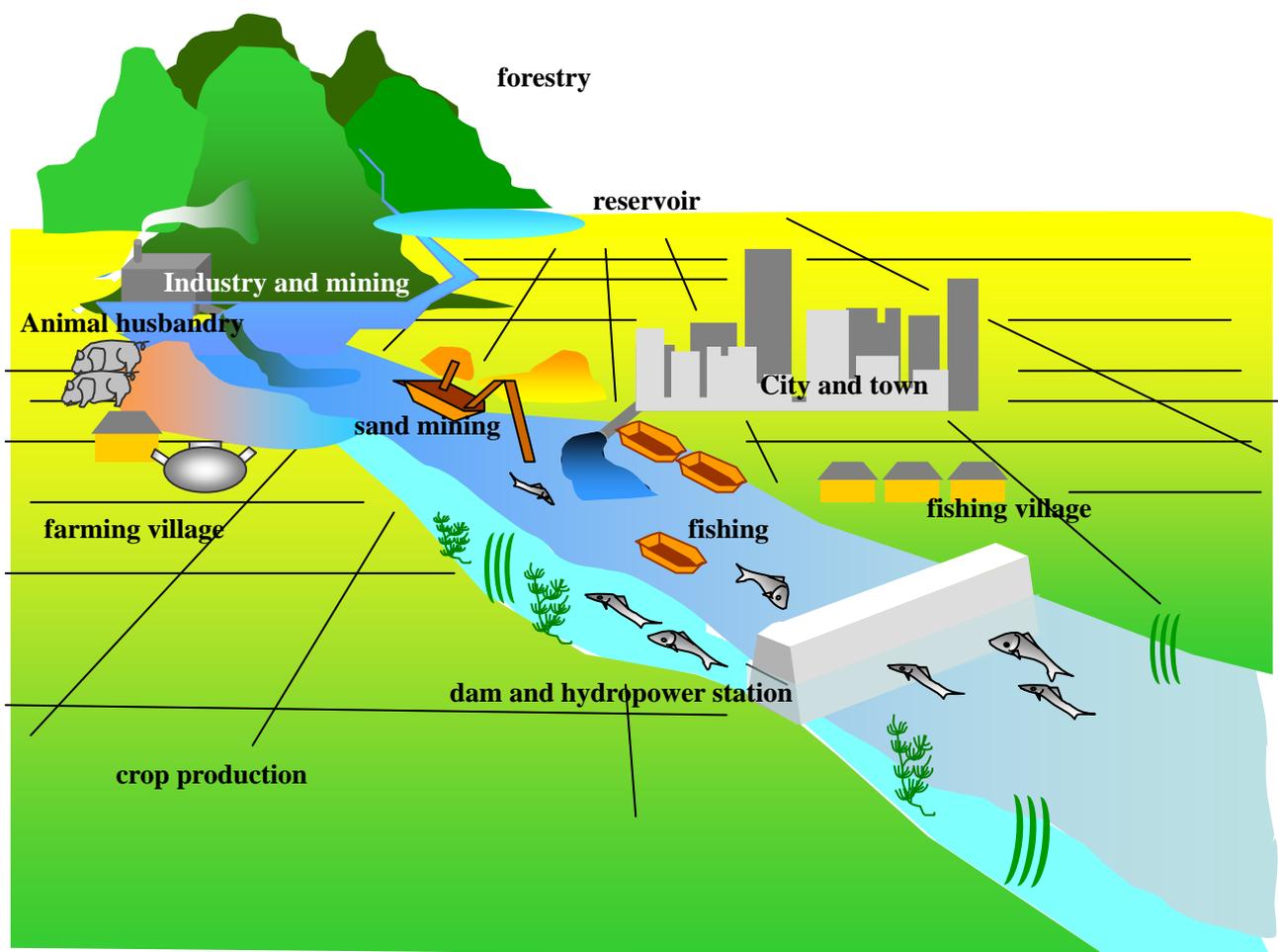


Fig.20 Watershed diagram shows the structure of Beijiang River Watershed and the influence of human activities along river ecosystem

(2) Forest ecosystem service

Forest ecosystem services refer to all the benefits and service functions that forest ecosystems offer human beings society. The forest ecosystem provides the functions of wood products, water saving, soil erosion, climatic regulation, oxygen release and carbon fixation, disaster reduction, biodiversity prevention and entertainment. (Qian F., Lu S. W., Yu X. X., et al.,2005, Zhao, T.Q., Ou Y. Z.Y., Zheng H.,2004)

In recent years, lots of trees have been planted and the area of forest is increasing. In the year 2008, the land area which can be used for forestry was 1.433 million ha. among which 1.162 million ha is covered by forest. The forest coverage rate was 66.1%. The standing forest stock was 65.235 million m³. The biomass of forest was 73.666 million tons, including 4.691 million tons of commercial forest biomass, 26.755 million tons of non-commercial forest biomass. The current gross energy stocked in forest vegetation is 14,150.5×10¹⁴ joules. The annual carbon dioxide absorption was 106 million tons. The annual amount of oxygen released was 78 million tons. The total carbon storage was 56 million tons. The forest water saving resources provided 2.16 billion tons of water. (Shaoguan Bureau of Forest, 2008)

According to the ecological service assessment methods, the ‘market value method’, ‘replace cost law’, and ‘shadow price law’, the forest ecosystem service benefit was 8.4737 billion RMB Yuan, including 2.3675 billion Yuan of forestry carbon assimilation, 2.5528 billion Yuan of forestry oxygen releasing, 1.998 billion Yuan of forest water saving and water control benefit, 300 million Yuan of atmospheric cleaning benefit, 0.3855 billion Yuan of forest soil erosion benefit, 0.1375 billion Yuan of forest wildlife protection benefit, 316 million Yuan of forest ecotourism benefit. Fig.21 shows the component ratio of forest ecosystem service functions. (Shaoguan Bureau of Forest, 2008)

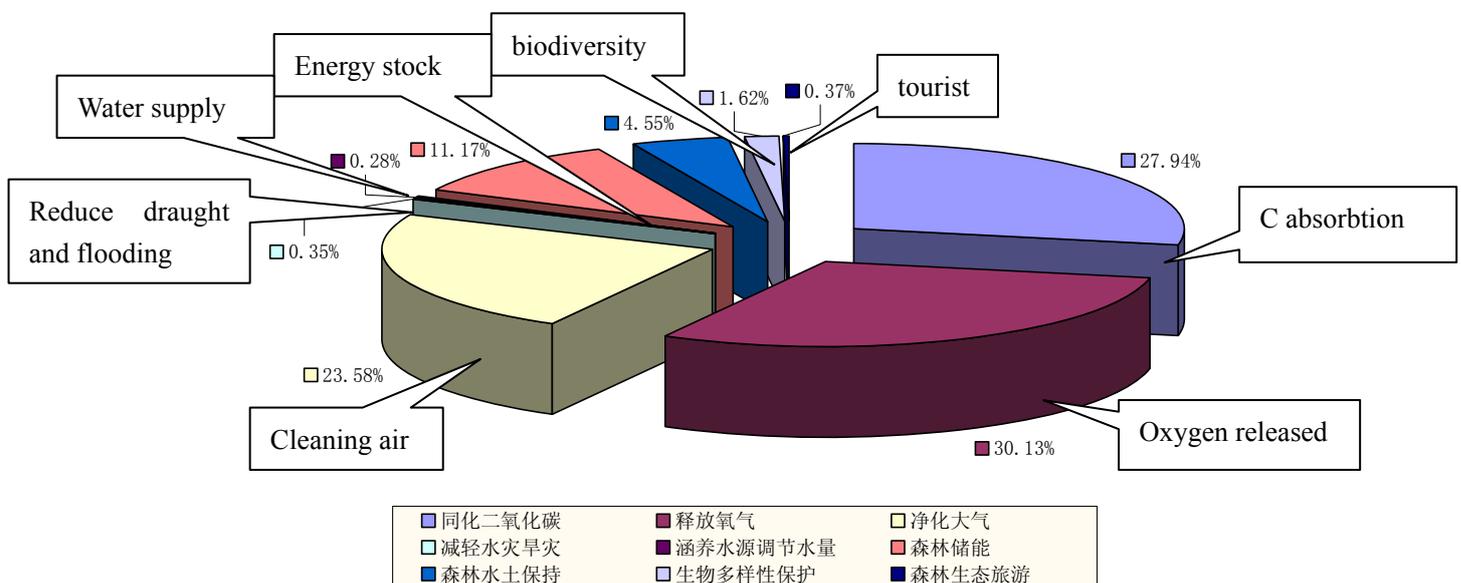


Fig.21 Functional classification of the river ecosystem service

(3) River ecosystem services

River ecosystem services refer to the benefit which humans derive from river ecosystem functions directly or indirectly. The river here refers to the stream ways in the river mouths, river banks, river courses and underground water, wetlands, offshore areas in the flooded area. According to the composition

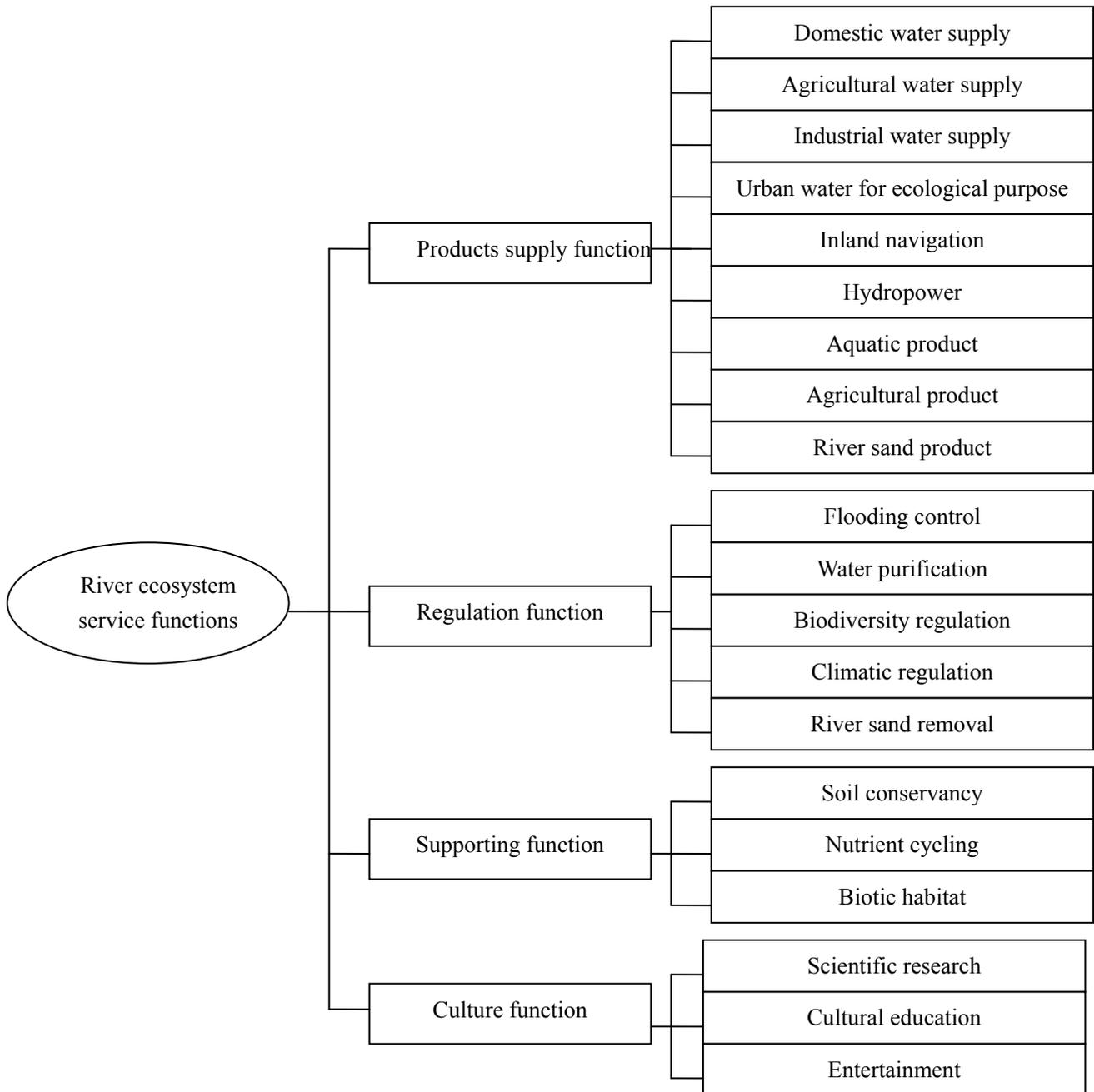


Fig.22 Functional classification of the river ecosystem service

feature, structure feature, ecological processes and efficiency, the river ecosystem service functions can be sorted into product supply function, regulation function, supporting function and culture function (Xiao, J.H., Shi G. Q.,

Mao C.M., 2008. Huang, H., Han X., Deng H. B., 2006). Fig.22 shows the specific functions.

① The effects on the river ecosystem service caused by the dams

The effects of the hydropower stations are potentially, long-term and tremendous (Fig.23). The different forms and effects of the river ecosystem functions make the influence caused by hydropower stations a complicated process. Firstly, hydroelectric development changes the ecological structure, such as hydrology, water quality, sediment, aquatic organisms etc. Secondly, the effects are passed on from the river to shore through the gradual change of the moisture gradient (Xiao, J.H., Shi G. Q., Mao C.M.,2006; Xiao J.H., Shi G.Q., Mao C.M.,2007; Mo C.R., Li X., Chen X.G.,2005) .Table 9 shows the effects on the river ecosystem services caused by dams.

Table 9 The effects of the dams on the river ecosystem service

Effects	Service functions	Index
Positive effects	Water supply	Adjusted storage capacity
	Hydropower	Annual generating capacity
	Inland navigation	Increase of transport
	Aquiculture output	Fish culture
	Flooding control	Country and field protection area
	Recreation and cultural	Tourism carrying capacity
Negative effects	Agricultural output	Inundated agricultural output, forests and grass biomass
	Environmental purification	Net primary productivity of inundated forests and grass
	Nutrient cycling	Net primary productivity of inundated forests and grass
	Aquiculture output	Fish capture
	Soil conservation	Soil erosion
	Water purification	Water environment capacity
	Soil and sand transfer	Accumulation of sediment of the dams
	Biodiversity maintain	Effects on the area of the habitats, fish species and migration

② The effects of sand quarrying on the river ecosystem service

Out of control sand quarrying can potentially change the structure of the river bed and water movement to a certain degree (Fig. 24). In the Pearl River basin, studies have shown that it makes the hydrological regime and sand silt characteristics change significantly. As a result, some river banks have collapsed, the water levels have dropped markedly in some channels, the fords were revealed, the channels have become narrow with insufficient depth of

water, and the movements of ships have been blocked (Han, L. X., Li W., Lu Y.J.,2005; Qian, Y.Q., 2004). There is therefore evidence that sand quarrying has also had an impact on flooding control, inland navigation, water storage, nutrient cycling, environment purification, soil erosion and so on. Table 10 shows the effects of the sand quarrying on the river ecosystem service.



Fig. 23 Hydraulic Power Station along Beijiang River

Table 10 The effects of the sand quarrying on the river ecosystem service

Effects	Service functions	Index
Positive effects	Sand supply	Annual sand quarrying
Negative effects	Agricultural output	Sand-pile occupancy on the river banks
	Environment purification	Collapse of the river banks
	Nutrient cycling	Collapse of the river banks
	Water storage and supply	River bed sinking, water level drops
	Inland navigation	River bed sinking, gradient changes
	Flood control	Embankment damage, part of river bed deteriorated
	Soil conservation	Soil erosion
	Water purification	Water environment capacity
	Soil and sand transfer	Accumulation of sediment of the reservoirs
	Biodiversity maintain	Effects on the area of habitats and fish species



Fig. 24 Sand mining in Beiji River

(3)The lake and reservoir ecosystem services

Wetland ecosystems have the highest biodiversity and ecological function of any natural environment. The artificial lake and reservoir ecosystem is one type of artificial wetland. It has significant effects on water supply, drought control, hydropower, aquaculture, irrigation, climatic regulation, and entertainment. It is very important for agriculture and national economy (Li, J. B., Liu C.P., Wang K.L., 2005; Zhang, J.S., Wang J., Wang H.L., 2008) (Table 11).

Table 11 The service functions of lake and reservoir ecosystem

Effects	Service functions	Index
Positive effects	Water storage and water supply	Capacity
	Flooding control and drought fighting	Irrigation area
	Aquatic output	Fish culture
	Climatic regulation	Total mass of the crops in the flooded area
	Nutrient cycling	Soil nutrient conservation
	Soil conservation	Modulo soil erosion in the flooded area
	Water purification	Water environment capacity
	Reduce the silt	Area of silt and reduction of fields
	Biodiversity maintain	Area of the habitats
Entertainment	Tourism carrying capacity	
Negative effects	Agricultural output	Reservoir inundation, earthquake risk

2.2.1.2 Ecosystem and Lives of fisherman

Because the current of water is interrupted by power plants, the water level is raised; the shoal and the barrier beach area are reduced along the river, so the protective aquatic animals such as *Pelochelys cantorii* and Wattle-necked soft-shell turtle are extremely rare in the Beijiang River. Particularly, *Pelochelys cantorii* has not been recorded for more than ten years.

At present, the Beijiang River's wild fish are mainly small, and are mostly non-jet streamed, coherent egg-ed or hideaway egg-ed, and have a short mature cycle, such as *Gobioninae* species and *Gobiobotia* species. The composition and the distribution of wild fish in Beijiang River have changed significantly when compared with historical data. The original precious fish and the important economic fish such as marbled eel, *Luciobrama macrocephalus*, *Semilabeo notabilis*, *Sinilabeo discognathoides*, *Sinilabeo decorus*, *Ptychio jordani* and *Xenocypris davidi bleeker* are already extinct or close to extinct in the Beijiang River. Some migratory or half-migratory, floating egg-ed, long-breeding-cycle wild fish are very difficult to be found in this river. Some fish which can adapt the jet-streamed life are also greatly reduced in terms of species number and population number. At present, the major type of wild fish that can be found are small, and the quantity is low. Now the most popular wild fish in Beijiang River are *Gobioninae* fish, the next is *Dactylogyrus* fish, carp, Crucian Carp, Chinese hoolsnout carp, and Yellow catfish. (Institute of Aquaculture of Shaoguan City. Investigation, 1991), (Pan, Q.H., 1985).

Moreover, as a result of the impediment created by the power plant, the slow water currents, the pollutant deposition, and the biological accumulation through the food chain, the quality of wild fish has declined. Fishermen complained that the fish captured in this river often had a diesel oil taste, so the price has fallen. It also suggests that petroleum pollutants are already quite a serious problem in the river.

2.2.2 Measures for ecosystem services enforcement

As one of the most important ecological buffering zone and a less developed part of Guangdong province, Shaoguan faces the sharp conflict between environmental protection and economic development. To fulfill a sustainable development, there is an urgent need to change the traditional development path not only in words but also in actions. In order to face various challenges, the scientific views on development and ecologically sound production and consumption patterns should be taken into account.

To protect water resources and improve the water quality of the Beijiang River, goals for 2010 were set up according to Zhujiang River Valley Pollution Remediation Project. The quality of surface water should reach the national standard according to its function. More than 80% of the check point data from Beijiang for water quality

must pass through the standard no matter how it is implemented at the national, provincial or city level. The water quality handed over to the next city in the border areas must be able to reach the standard of no less than 80%. More than 95% of the discharged water from industry will be treated and should reach this standard. The treatment rate of domestic wastewater should also reach more than 60%. (Government of Shaoguan City, 2003)

Monitoring data displays that water quality in 2008 was good in the upper reaches of Beijiang River (Shaoguan section) according to environmental quality standards for surface water (GB3838-2002). The total pass rate of water quality in major rivers and lakes is 93.50%. In four quality II zones, 100% of water quality samples in the river passed the standard. In six quality III zones, 97.2% water samples reached the standard. In three quality IV zones, 83.3% water samples passed the standard. Major excessive pollutant of quality-III and IV zones was colibacillus. Water quality of Wujiang River, Nanshui River, Jingjiang River, Mojiang River, Wengjiang River, Beijiang River (Shaoguan section), and Xinfengjiang River is still good, and the pass rate is 100%. (Bureau of Environment Protection of Shaoguan, 2009)

The local government (Shaoguan city) has taken many effective steps to protect water resources and to improve water quality of Beijiang River.

(1) To abandon industries which cause heavy water pollution.. Pollution producing small steel factories with up to 83 thousand tones of productivity, iron factories with up to 30 thousand tones of productivity and cement factories with up to 88 thousand tones of productivity has been eliminated. And the reduction of pulp and paper sludge, grain industry, dyeing industry and electroplating industry has been strengthened.

(2) To enforce the waste water treatment measures for major industries (listed in table 13) and to invest more in the infrastructure for environmental protection.

Through improving wastewater treatment techniques and optimizing the water circulation system, industrial wastewater released by Shaoguan Smelter reached the standard and water reuse rate reached 96.3%. The discharge of industrial wastewater was reduced from 2412 m³/h down to only 300 m³/h.

The Shaoguan Iron & Steel Group has invested 110 million Yuan for the reform of Meihua River and the establishment of a waste water treatment center. After that, 40% of the industrial wastewater discharged reached the environmental standards, and the other 60% has been recycled after further treatment. The industrial water circulation rate now reaches 98%.The decrease of COD discharged was up to 400 t.

Guangdong Dabaoshan Mining Industrial Co. Ltd. has also taken steps to improve environmental quality of it mining activity, such as the improvement of the drainage system of tailing, the conservation of water and soil, the increase of the holding capacity of the sediment detention reservoirs.

Restaurants on the river have also taken steps to reduce water pollution by for the simple removal of suspended solids and oil.

(3) Town sewage and waste treatment

Seven domestic wastewater treatment plants (WWTP) had been established as of 2007. The total treatment capability reached 140,000 t per day. The second phase of the second WWTP (50,000 t per day), the second phase of Qujiang WWTP (20,000 t per day), WWTP of Ruyuan county (15,000 t per day), WWTP of Wengyuan county (15,000 t per day), WWTP of Renhua county (10,000 t per day), WWTP of Pingshi town Lechang city (10,000 t per day) have been established in year 2008. The total domestic wastewater treatment capability of Shaoguan has reached 260,000 t per day. The industrial wastewater treatment rate has reached 80% (Fig.25). Moreover, 23.3 km waste pipes attached to wastewater treatment plants have also been established. (Bureau of Environment Protection of Shaoguan, 2009)

In 2008, 8,915,000 t of industrial solid wastes were produced in Shaoguan city. The treatment capacity was 1,371,100 t, and the amount of discharged industrial solid wastes was 19,500 t. The storage capacity was 958,400 t. The recycle rate of industry solid waste reached more than 80% (Fig.26) The first phase (600 t per day) of Hualazhai sanitary landfill for domestic wastes with investment of 0.12 billion RMB has been established and put into use. The goal of harmless disposal of domestic wastes has been achieved. (Bureau of Environment Protection of Shaoguan, 2009)

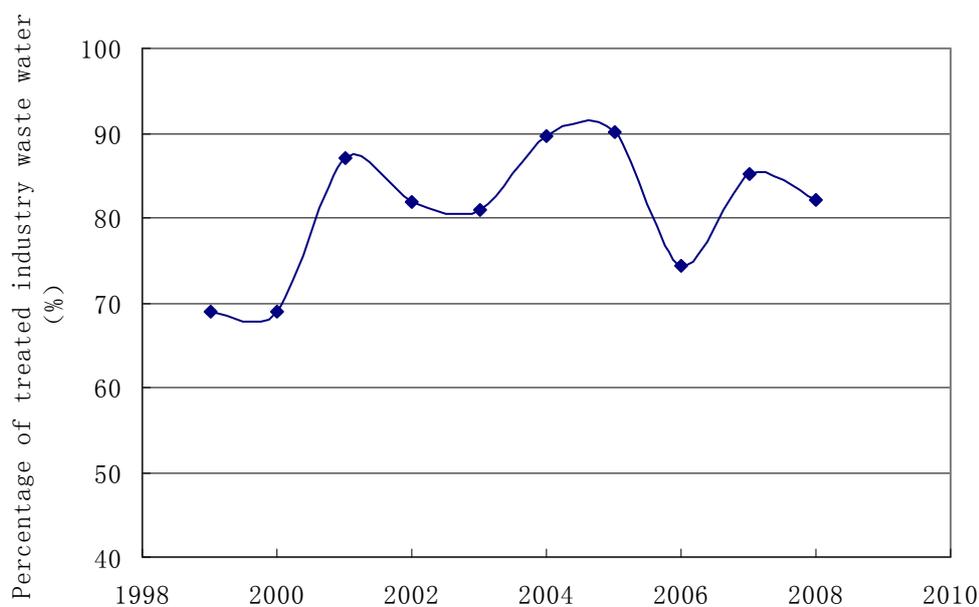


Fig.25 Percentage of industrial waste water discharged which reached the standard in Shaoguan

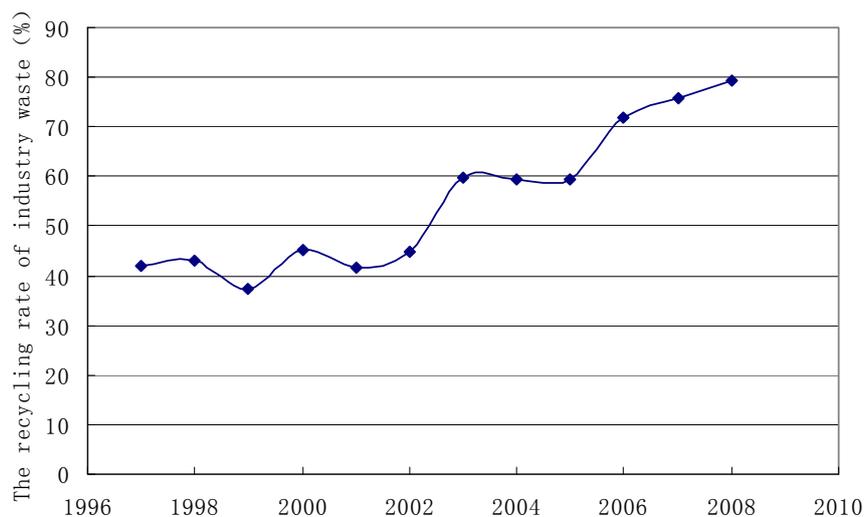


Fig. 26 The recycling rate of industrial solid waste in Shaoguan

(4) Environmental protection in rural area.

Major agricultural pollutant sources of the Beijiang River include animal husbandry, overuse of pesticides and fertilizers in non-scientific ways, and household sewage discharge. Strategies for water environmental protection in agriculture include: 1) Reinforcing the environmental management of animal raising farm and avoid pollution from animal excrement. 2) Developing eco-agriculture and extend biogas application. 175 thousand biogas pools will be established before 2010. 6566 t per year COD discharge will be cut off. 3). Reinforcing the management of agricultural chemicals. The amount of pesticide and fertilizer application will be reduced and bio-fertilizer, organic fertilizer, bio-pesticides, green feed and green feed additive will be more widely used. (Government of Shaoguan City, 2003)

Table 12 Waste discharge during 1980s to 2008

(Committee for Annals of Shaoguan, Guangdong Province, 2001)

	Total wastewater (10000 t)	Industrial wastewater rate (%)	Domestic sewage rate (%)	Total COD (t)	Industrial COD rate (%)	Domestic sewage COD rate (%)
1980s	12080	71.7	28.3			
2004	21678	68.1	31.9			
2005	22056	68.7	31.3	2.89	28.8	71.2
2006	19197	64.1	35.9	2.78	26.8	73.2
2007	18527	57.9	42.1	2.99	30.7	69.3
2008	18530	54.4	45.6	2.89	27.5	72.6

Table 13 Corporations of industrial waste discharge beyond 100000 t in 2008

(Bureau of Environment Protection of Shaoguan, 2009)

Corporate Name	Industrial use water (t)	Fresh use water (t)	Reuse water (t)	wastewater treated (t)	Wastewater discharge (t)
Shaoguan Iron & Steel Group Co., Ltd.	1882710	532316729	30084400	502232329	473647247
Shaoguan Smelter	620620	222162162	8220000	213942162	3095668
Topsearch Printed Circuits (QuJiang) Ltd.	67000	2559000	2559000		2405000
Guangdong Dabaoshan Mining Industrial Co., Ltd.	47000	1808200	459500	1348700	938889
Shao Guan Early Light International Co Ltd.	86192	1007905	985405	22500	837594
Shaoguan Tools Plant.	189752	189752		145919	145919
Limin pharmaceutical factory, Livzon Group.	513044	504948	8096	199200	398400
Shaoguan Jiahe Dyeing Co., Ltd	238600	238600		202811	202811
Shaoguan Jiqi Pharmaceutical Co., Ltd.	300000	300000		277973	277973
Shaoguan Fortune Creative Industries Co., Ltd.	119611	119611		119611	101669
Shaoguan Huahui Arts & Crafts Products Co., Ltd.	148401	148401		3500	126141
Bestone Int'l Co. Ltd.	114051	114051			96943
Shaoguan Konso Technology Co. Ltd.	209834	209834			178359
Brewery of Guangdong vigourbeer Co., Ltd.	174046	174046		151131	151131
Shaoguan Langqi Co., Ltd.	192461	126186	66275		89087
Shaoguan Yaoling Mining Industry Co.,Ltd.	150687	82880	67807	150687	82880
Shaoguan Zhenghua Dyeing & Finishing Co., Ltd.	436000	385000	51000	436000	336875

In general, the worst period of negative impact from pollution discharge has passed, although a lot of effort is still needed, especially for pollution control of major mining industries. However the negative effect from dam building seems difficult to overcome, even as fish fry releasing activity have been strengthened. Because the market demand for sand is still increasing, it is hard to encourage a reduction in sand mining in the river. These activities change the shape of the river bed dramatically, and the only hope lies in the controlled restriction of this activity in the fish protection zones and along river bank.

3. Socio-cultural systems

3.1 Gender and demographics

As of 2008, the total population of Shaoguan city was 3.23 million, out of which 1.67 million were male and 1.56 million are female. The gender ratio was 107.6. Within Shaoguan, 1.98 million people are countryside residents and 1.25 million people are urban residents. The natural growth rate was 0.686 % (Table 14).

Table 14 Population Statistics of Shaoguan City

(Guangdong Bureau of Statistics 2002-2009)

Year	Total population (million)	Classified by Gender		Classified by rural and city		Natural growth rate
		Male (million)	Female (million)	city population (million)	rural population (million)	%
1995	2.94	1.51	1.42	1.01	1.93	-
2005	3.19	1.65	1.54	1.26	1.93	0.64
2006	3.20	1.66	1.54	1.26	1.94	0.64
2007	3.21	1.67	1.54	1.26	1.95	0.677
2008	3.23	1.67	1.56	1.25	1.98	0.686

According to the second agricultural survey, the population living in the countryside was about 1.94 million in Shaoguan city at the end of 2006. The proportion of males was 51.62% and the females was 48.38%. Stable agricultural labor in the countryside was about 0.89 million in which the males comprise of about 50.89% and the female comprise of about 49.11%. Han Chinese is the majority ethnic group with a population of 2.6892 million, making up 98.32% of the entire population. There are 31 other ethnic groups, including Yao, She, Mandarin, Hui, Jing, Miao, Li, Bai, Dong, and Tujia.

In rural area, 0.29 million people (17.73%) are between 0 to 14 years old, 0.81 million people (55.0%) are between 15 to 40 years old, 0.26 million people (15.91 %) are between 45 to 60 years old, and 0.19 million people are above 60 years old (11.36%). As for people in rural area within working age, 12.73% laborers were under 20 year old, 37.11% are from 21 to 40, 25.76% are from 41 to 50 years old and 24.4% of the labors are above 50 years old.

3.2 Festivals and Customs (Committee for Annals of Shaoguan, 2001)

Shaoguan is a typical city of the Hakka people in Southeast China. Ancient seasonal customs still persist in mountainous areas. Businessmen carefully choose a lucky day to open their businesses, and people go to market on special local market days. Besides traditional Chinese festivals, such as Spring Festival, Lantern Festival, Tomb-sweeping Day, Dragon Boat Festival, Zhongyuan Festival, Mid-autumn Festival and Double-Ninth Festival, the New Harvest Festival and the Midwinter Day are also celebrated. For wedding ceremonies, the countryside of Shaoguan preserves ancient customs of weeping, seeing off and receiving the bride, give solute to parents, grand-parents and ancestors, and mischievous play in the new room for the new couple. Boys usually enjoy extra attentions from their parents for their roles in passing on the family line and parents generally depend on their children in their senior year. Families keep detailed records of their family tree. Ancestors are respected and worshiped on special occasions like Spring Festival and Tomb-sweeping Day. Children are encouraged to get enough education for a better future.

3.3 Religion and Cultural arts

Buddhism, Taoism, and Christianity all have their believers in Shaoguan, but Buddhism and Taoism are more common. Popular arts in Shaoguan include Tea-collecting Opera, Flowery Drum Opera, Flowery Lantern Opera, Folk Song Opera, Folks Songs, Story-telling, Allegretto, Guangdong Opera, Dragon and Lion Dance, woodcarving, knitting, embroidery and paper cutting.

3.4 Governmental and Non-governmental Organizations

Shaoguan City covers 3 districts, 5 counties, 1 autonomous county and 2 city where the municipal government located, in the District of Zhengjiang County. The 3 districts are further divided into 10-20 towns or sub-districts. Governments in municipal and county levels have set up departments such as the agricultural bureau (fishing agency included), environmental bureau, water conservancy bureau (water administration agency included), civil administration bureau, labor and social security bureau, forestry bureau, police bureau, education bureau and transportation bureau etc. Each town consists of several villages, groups or communities, with their own village committees or residential committees for the management of common affairs Economic cooperative societies include farmers' collectives (cooperatives), agricultural product associations, and professional cooperative societies. These organizations are responsible for implementing government policies and for the handling of social

and economic affairs among farmers.

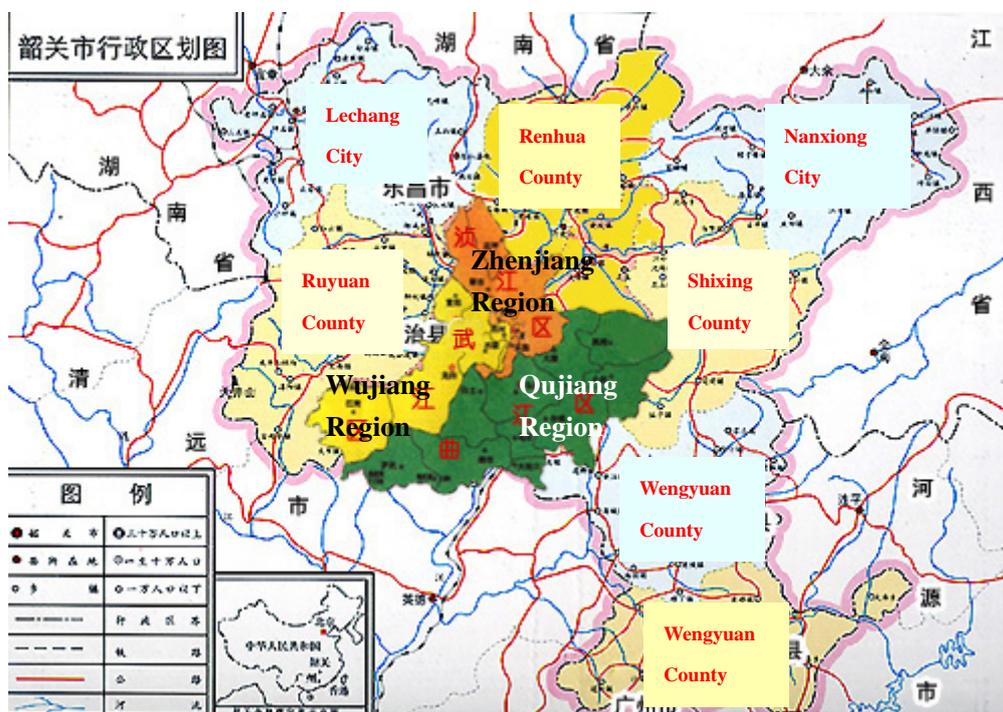


Fig. 27 The Administrative Division of Shaoguan City (River is in blue color. It is also showed in Fig.1-B)
 (Sources: <http://www.shaoguan.gov.cn/>)

4. Natural resource dependence and livelihood

4.1 Livelihoods and market networks

Aquatic resources in the North River play a key role in fishermen’s livelihoods in Shaoguan city. Most of the fishermen depend on these resources to maintain their livelihoods, particularly the older generation. Some fishermen are over 70 or 80 years old but are still fishing because they have only preliminary education and do not have a pension. The fishermen feel that the amount and species composition of aquatic resources have declined when compared with ten years ago. This decline has had a significant impact on their livelihoods. Almost all of the fishermen no longer want their children to depend on fishing for their livelihoods in the future. It is for this reason that most of the fishermen nowadays that do not go to the city to work are over 40 years old. Many remain in fishing because they have a very low education and worry about the prospects of finding urban employment. Those working in the city also worry that they may have to go back and continue fishing sooner or later. It is for this

reason that according to statistics, the number of fishermen in Shaoguan City has been declining over the last 20 years. A few fishermen consider that their livelihoods are better-off now when compared to 5 or 10 years ago, because some members of their family have jobs in the city and have more stable incomes as a result. However, the majority considered that there has not been too many changes to their present livelihoods and that the wealth among the fishermen also has not changed significantly over the last 20 years. (Guangdong Bureau of Statistics, 2002-2009)

4.1.1 Private assets and wealth

The livelihood resources of the households include human assets, social assets, natural assets, physical assets and financial assets. Fishermen have very limited access to these resources, restricting the diversification of their livelihoods. According to our investigation and from the statistic data from local government, the following situation can be identified.

(1) Human Assets

Generally, the education of fishermen is only up to junior secondary school or primary school and there many older fishermen. The health of most of the fishermen is good but for a few, it is insufficient for them to catch fish, particularly for the older generation. All knowledge of fishing has been learned through practice and passed on between generations, and is not related to any training offered by the government.

(2) Social Assets

There are no formal or informal organizations in Shaoguan City such as Fishermen's Association or Fishermen's Cooperatives for fishermen to participate in. There are also no organizations at the village level in fishing communities themselves. Fishermen are all fishing and marketing the fish separately at the household level. Restaurants or traders sometimes go to the fishing-boats to buy the fish directly, but there are no fixed cooperative relations between them. The fishermen who own fishing licenses all participate in the Farmers Credit Cooperative where they access subsidized diesel oil from the government. The fishers always seek help or borrow money from their relatives when they have difficulties.

Sometimes the neighbors may organize together to resolve problems such raising funds to build a wall along the river bank or the road in the community. Sometimes they may seek help from the local Resident Committee or the Department of Fish of the local government. The households with handicapped members can get allowances from the government. In general however, the fishermen are not well organized and their social assets are mainly limited to kinship or neighbor based relationships.

(4) Natural Assets

Fishermen can fish in the river section between the upstream and downstream dams, no matter whether they have a fishing license or not. The only difference is whether they can get diesel subsidies from government. If they want to fish across the dam, they have to wait for the opening times of the boat channel and also have to pay. Fishermen can collect firewood from the nearby mountains for cooking. Generally the firewood is composed of branches or bushes and therefore they do not need a license for collecting it. Sometimes households also collect drift wood from the river itself for use as fuel. Few of the fishermen have any land for farming and most of the daily regular consumption goods such as vegetables and rice are bought from the market. However in some households, fishermen plant vegetables in a small piece of land which is usually less than 10-20 m², around the house. They can also raise small number of chickens, ducks or geese around house or in a cage on the boat.

(5) Physical Assets

A few of the fishermen have their own houses. Some other families live in the houses provided by the government 30 to 40 years ago on the land which belongs to the fishing communities. Most of the fishermen do not have their own houses though, and they must rent accommodation from the local government or live on their boats.

Transportation between the fishing communities and outside is not convenient, especially for attending school, the health centre and the market. Some of the fishing communities are close to the school and health centre but some of the fishing communities are far away from the school and health centre. Most of the fishing communities have tap water but some communities still have to buy drinking water from the town. The sanitation situation in the communities is generally good. All the fishermen have their own fishing boats and tackles. Generally the old fishermen have non-motor boats and the young fishermen have motor boats. Most of the households have TV sets and a telephone; while some have a refrigerator, bike and mobile-phone. Few of the households however, have motorcycles or a drinking water dispenser.

(6) Financial Assets

The financial assets of fishermen are mainly composed of the households' income, government subsidizes, loans and savings. The households' incomes are mainly from fishing and the salaries of children who get a job in the town or city. The government provides a diesel oil subsidy and allowance for disabled household members. The diesel oil subsidy started from 2006 and each year the government provides the subsidy to the fishermen who own the fishing license according to the price of the diesel oil and the horsepower of the fishing boat. When the fishermen meet difficulties, such as schooling for the kids or medical treatment, they may borrow money from

their relatives but not from the bank because they do not have the mortgage assets for loan. The wealthy households with member working in town or city have savings

From the survey of three fishing communities, the wealthy households all have income from their children or relatives who have a permanent job in a town or the city. Most of the households' income depends on fishing and the poorest households are always the elderly who live alone, or the households with disabled members. The lives of the poorest households are very hard.

4.1.2 Household labour allocation to livelihood activities

Generally the wife and husband go fishing together. The husband tends to scatter the nets and draw the nets in. The wife is always responsible for sailing the boat and helping the husband draw the nets in. Most of the households go fishing in the evening and draw the nets in the morning because they can sell the fresh fish in the morning directly and the price of the fresh fish is higher. Commonly, the wife sells the fish but sometimes they may sell the fish together. In the daytime, men always arrange the fishing tackles, repair the nets and boats, and dig up earthworms for bait. Women then go shopping for regular daily consumption and take care of the children and the elderly people and do most of the housework. . Women then go shopping for regular daily consumption goods and take care of the children and the elders, doing much of the housework.

All the fishermen hope that their children will not be fishing in the future and do their best to let their children go to school so they will find a good job in town or city. The children therefore seldom participate in fishing activities.

4.1.3 Incomes

The main household incomes of fishermen are from the sale of fish. The mean catch per day is about 5 kg, although it can also be as high as 15kg or as low as 1kg. The price of most small fish is as low as 1-1.5yuan per kg. As it is small fish that are predominantly caught, the cash income is only around 20 to 30 Yuan per day and 1000 Yuan per month. The decline in fish species due to the construction of dams and sand mining have caused a significant decline in the per person income of fishermen over the last 5 years (see figure 28). (Department of Aquaculture of Shaoguan City. 2008)

Unfortunately, the fishermen do not have any other income source from agriculture because they do not own any land for farming. Some household may have extra income from their children or relatives who are working in the town or city but this depends on the stability of the job and the salary level. Some of the fishermen have a

part-time job, providing them a more secure source of income. Such households are generally better-off than those whose livelihoods are entirely based on fishing.

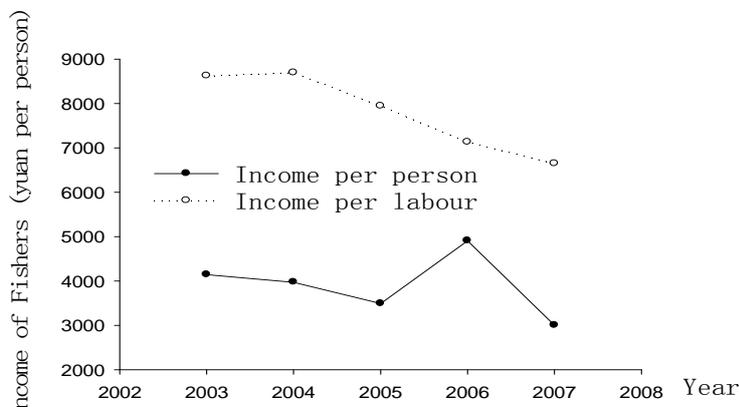


Figure 28 Income of Fishermen per Person and per Labor in Shaoguan City

(Department of Aquaculture of Shaoguan City, 2008)

4.1.4 Household budget and consumption

The fishermen have to buy most of their regular daily consumption goods from market, including rice, oil, salt, vegetable and meat, because they do not have any land for farming,. Commonly however, fishermen only consume the fish which can not be sold. A few of the fishermen grow vegetables around their houses. However, most of the household raise chickens for consumption during festivals in order to save money. Most of the households spend about 20 Yuan per day for their daily food consumption.

Because there are no collective economic organization and no public assets in the fishing communities, all the fishermen have their own fishing tackles including boats, different kind of nets and shrimp baskets and so on. The price of the fishing boats with high horsepower is about 10,000 Yuan and can be used for about 10 years. The price of the non-motor boats is about 3,000yuan and can be used for about 6-7 years. Each year fishermen may spend about 2,000-3,000 Yuan to buy the fishing tackles and about 1,000 Yuan to repair the boats and nets.

Most of the fishing income is used for daily consumption and productive consumption and therefore they have few savings. The fishermen who have extra income may have more savings. The better-off household may purchase medical insurance for the household members.

4.1.5 Perceived well-being and social support from government

Most of the fishermen consider that their social status is going down in the last 10 years and don't want their next

generation to fish anymore. However, the advantage of engaged in fishing are considered more freedom than working in the field or in factory. Social welfare becomes one of the important parts of their perception of life security.

There are a number of forms of social support provided by the government. For example, some of the fishermen benefit from the houses provided by the government. About 49 years ago, most of the fishermen lived in boats but at the end of 1960s the government had built houses on land for the fishermen. However, all of these houses are very old now and some of the houses have even collapsed in the floods over the years. If the fishermen want to build a new house there is no land for them. Additionally the government provides tap water and electricity for the fishermen who live in the boats within the section of the downtown city. The government is also planning to build houses for those fishermen there.

Aside from the provision of housing, households with disabled members can get 200 Yuan allowance per month from the government. Furthermore, all the children of the fishermen can enjoy free education from primary school to junior secondary school, alleviating the fishermen from the burden of education expenses. Additionally, the government offers subsidies for diesel, as stated above.

4.1.6 Dependency on different ecosystem services

The livelihoods of most fishermen depend on aquatic resources and fishing. The dependency of the fishermen on different ecosystem services is different which depends on the infrastructure conditions of each fishing communities. Some of the communities along the river bank have to use the water directly from the river and some of the communities depend on the firewood for cooking. The local fishermen do not consume aquatic plants in their daily dishes.

4.1.7 Market networks

There are several markets where fishers sell their produce in the early morning on their return from fishing excursions (Fig.29). Other sites where fish are sold include the terminal market, which is mainly for aquaculture products (Fig. 30). Fishermen are seldom there since the catch per day is small. Generally the fishermen go to the retail market or free market and sell their fish directly to the citizens. Sometimes the traders or the restaurateur may go to the boat to buy fish directly, but no formal or long-term system of cooperation exists. The fishermen consider that it is relatively convenient to sell the fish themselves directly to the end consumer. It does not require any permission, but only pay 1-2 Yuan for market management.



Fig. 29 Fishmen sell their fish by themselves in the morning



Fig. 30 The whole sale fish market in Shaoguan in early morning

4.2 Resource dependence, access and control

4.2.1 Legal rules concerning the property rights of natural resources

Rare and endangered wild animals ranked as class one and class two in the national protected animals list are legally owned by the state. The standards for class one and class two are similar to the IUCN red list category E (endangered), V (vulnerable), and R (rare). For those wild animals whose property rights have not been specified by law, the rule of “first caught, first owned” applies. The property rights of wild plants is to be stipulated as well,

but the collection and harvest of rare and endangered wild plants of class one and class two are forbidden. (Law of the People's Republic of China on the Protection of wildlife, 2004)

The property rights of forests (including bamboos) are vested in the state, various collectives and individuals (including companies) respectively. (Forest Law of the Peoples Republic of China, 1984)

Generally land which is categorized as city land belongs to the state, and those in rural areas and suburbs belong to collectives. Peasants may have access to agriculture land (including arable land, woodland, grassplots, and water land etc.), construction land (including residential land, infrastructure land, and industrial and mining land etc.) and undeveloped land via contracting after land use permits (including contracting management permits and forestry permit) are granted by government (The Law of Land Administration of the People's Republic of China, 1999).

Water resources belong to the state, but those in rural reservoirs and ponds are to be used by collectives and peasants. (Water Law of the People's Republic of China, 2002) Mining resources (including sand on riverbed) also belong to the state (Mineral Resources Law of the People's Republic of China, 2006).

4.2.2: Legal documentation required for natural resource harvesting:

Fisher folks and peasants have to apply for following permits to access to natural resources:

- Fishing permits for fishing with species which are not in the national protected list;
- Hunting permits for hunting animals not in the national protected list;
- Special fishing permits for fishing rare aquatic species defined by the Law of the People's Republic of China on the Protection of wildlife ;
- Special sale and transportation permit for selling and transporting rare aquatic species;
- Importation permits for importing fry and parent of aquatic animals;
- Special permit for hunting or fishing wild animals under national protection;
- Firearms license for armed hunting;
- Domesticating and breeding permit for domesticating and breeding wild animals under national protection;
- Lumbering permit for lumber trees other than those isolated ones in peasants' private plots and those surrounding their houses.
- Extra permits to be applied by fish folks include: sailors' basic training certificate, ownership certificate for fishing boats, inland river boat certificate.

- Mining licenses are required for mineral extraction, including sand mining.

Many fishermen do not have a license for fishing; hence they can not get the diesel oil subsidies. The fishermen pay a 105 Yuan annual fee for their fishing license. The license will be canceled if the fishermen do not pay for any reasons. For example, some fishermen went to the town or city for their job and did not pay the license and therefore lost their fishing license. The government refused to reissue the license. Because of the high price of diesel in recent years, it is very hard for those fishermen who do not have the license.

4.3 Community resilience and vulnerability

The fishers' livelihood security varies seasonally. This is because fishing harvests in the breeding seasons such as spring and summer is greater than in other seasons. In the winter, fishermen may collect firewood for one year and repair the boat. The capability of the fishermen to withstand stress and disaster is quite weak given this seasonality of production and the simple production methods. However, there are coping mechanisms. For example, when households face difficulties, such as those relating to children's schooling or medical treatment of household members, the fishermen always borrow money from their relatives. If they face difficulties for social-economic or environmental reasons, they may seek help from the local residential committee; and if they face difficulties in fishing itself, they may seek help from the Department of Fishery of the local government. Because the fishermen do not have their own organizations and their financial capability is low, it is very hard for them to resolve various difficulties that they may face.

After the interview with the fishermen from different fishing groups, we found that the main issues they face at present are as follows:

- The biodiversity of aquatic resources is declining because of the impact of sand mining and the construction of a dam and hydropower station. Although each year the government and society may throw fish fry into the Beijiang River and the total fish population is not declining significantly, the fishermen complain that the fish are too small and that big fish are rare. Most fish have a low price and no compensation for the fishermen from the sand mining companies and hydropower stations is available.
- Pollution on aquatic resources and fishing tackles has undermined livelihoods. Both pollution from the mineral mining companies on the Beijiang River and pollutant emission from residential areas have had an impact on the fisheries. The mineral mining industries not only impact the biodiversity of fish species but also the fishing tackles. Furthermore, low pH water may corrode the fishing boats.

- When the dam gate is suddenly opened by the hydropower station, the current caused by water discharge may break up the fishing tackles and sometimes even threaten the security of the fishermen. However there is no warning before the water discharge and no compensation when it causes damage for the fishermen.
- The older are hard to facing shocks, because the fishermen do not have the elderly insurance, or pension. The fishermen may have no income when they stop fishing, because they do not have any land for farming. At present the residents in the town or city pay one part of their elderly insurance and the working affiliation pay another part. But the fishing communities do not have any system to help them to pay for the insurance. The fishermen have to pay all by themselves if they want to have the insurance, something most fishers can not afford. It is good news for them that the government is going to extend the old people's insurance to every one in the whole country within a few years.
- Housing issues are important for fishers especially during the storm season or the cold season. While some fishermen live in the houses provided by the government, there are still a lot of fishermen who do not have their own house and have to rent a house or live in a boat. Most of the houses near river bank and the houses are easy to be inundated by flooding. The government is preparing to build new houses for the fishermen who are living in the boats within downtown section, but there are no plans for the fishermen who live in other sections so far.
- Medical care issues are also important for fishmen to deal with shock from disease. Only the better-off households buy health insurance for their household members. For poor households, they have to pay all the medical treatment costs themselves, and the economic situation of their livelihoods may become worse.
- Organization is important for farmer to help each other to overcome natural or social shocks. However, fishermen usually do not have their own organization, such as a Fisher's Association or Fisher's Cooperative. It is difficult to organize the fishermen when they encounter problems. They have a very weak bargaining power whenever they encounter other stakeholders. Additionally, leaders of farming villages usually get subsidies from the government or from the collective economic resources, but the leaders of the fishing community do not get this, hence nobody like to take the responsibility for the community.

5 Local planning and projects

5.1 Past and current projects

5.1.1 Utilization of water resources

The hydroelectric resources of the Beijiang River are plentiful with 3.19 million kilowatt of theoretical reserves, 2.365 million kilowatt of available installed capacity and 95.6 hundred million kilowatt-hour of annual generated energy. There are 16 water conservancy and hydro-electric projects along Beijiang River out of which there are 10 projects (both under construction and operational) with 0.5485 million kilowatts of total installed capacity, allowing 21.81 hundred million kilowatt-hours to be generated annually (<http://2004.chinawater.com.cn>). In addition, there are lots of local small-scale irrigation projects and hydroelectric stations. The key water control projects on the Beijiang River include the Feilaixia Water Control Project, Lechangxia Water Control Project and Nanshui Hydropower Station (<http://www.gdbjdd.com.cn>) (<http://2004.chinawater.com.cn>). Nowadays there are 1989 hydropower stations in Shaoguan City (Agricultural Statistical Yearbook of Guangdong, 2002-2009). These stations play a significant role in local economic development and flood control to some extent but also have a great impact on the fisheries, for there are now limited corridors for fish migration. Additionally the rising water level caused by dam construction has destroyed the growth of many aquatic plants within which fish like to spawn their eggs. The static water caused by dam construction reduces and even eliminates the fish species which like normal river flows. On the other hand, the sudden large currents caused by flood control may break up the fishing tackles and sometimes may threaten the safety of the fishermen.

There are 485 dams in Shaoguan city, out of which 454 dams are small scales, 27 dams are middle scale and 4 dams are big scale. Figure 29 and 30 shows that the numbers of dams have been increasing over the years, particularly in the 1990s, but the increase rate declined after 2000, only to significantly increase again in 2007. Most of the increased dams are small scale. The storage capacity of the reservoir has also increased, particularly in recent years. On the one hand, the construction of the dams and reservoir have increased the water supply capacity and flooding control capacity but at the same time they have had a detrimental impact on the fisheries resources of the river. The local fishermen usually complain that the amount of the fish have significantly decreased due to the change of the water flow and the block of fish migration.

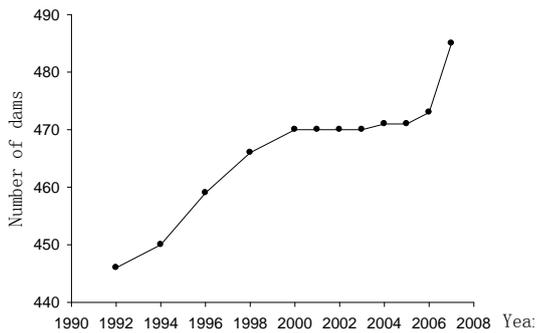


Figure 31 Number of dams over the years in Shaoguan City

(Guangdong Bureau of Statistics 2002-2009)

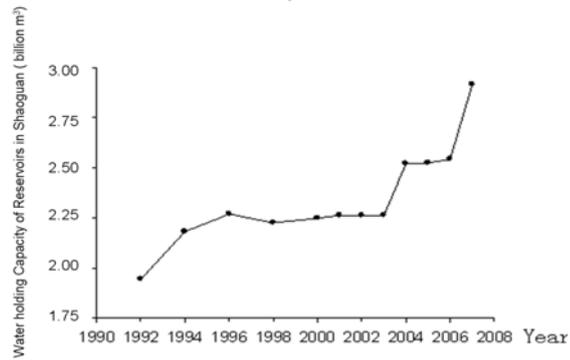


Figure 32 Storage capacity of the reservoirs in Shaoguan City

(Guangdong Bureau of Statistics 2002-2009)

5.1.2 Transportation construction

In recent years, the development of highways is rapid in Shaoguan city (see figure 31). The traffic mileage is about 13,050 km in 2008 and has increased 32% when compared to 2000. At present, 98.52% of the village is connected to the highway and 88.49% of communities are connecting to the highway. Only 6.33% of the main road within the rural communities have install road site lamps. Regarding the material used on road surfaces, cement roads represent about 38.57% and the macadam roads are about 48.19%. There are 4 villages and towns with train stations, 4 villages and towns with a wharf, 44 villages and towns connected to grade II highway, while 68.09% of the villages and towns can reach grade I highway system within 50 km. 82.98% of the villages and towns can reach the county government within one hour. There are 2 river ports with 300 tons of shipping capacity. Most of the fishing communities connect with the outside through the highways. The fishermen said that the cement roads within their community were built by themselves. There are no lamps on the road in the communities. Fishermen go to the market mainly by boat. Some of the communities are conveniently located to access schools or health centre facilities.

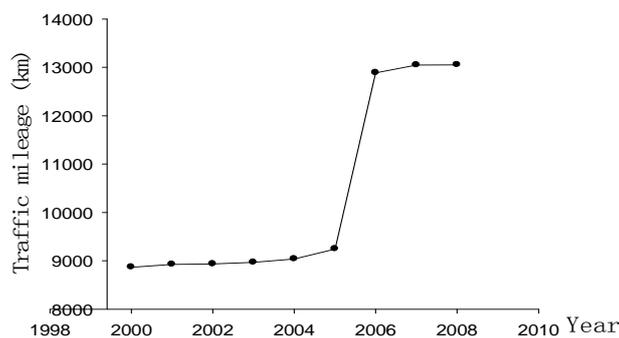


Figure 33 The traffic mileage of highways in Shaoguan city

(Guangdong Bureau of Statistics 2002-2009.)

5.1.3 Communication, television and information networks

89.36% of the villages and towns have finished the reform of the power supply system. 99.84% of the village and 93.43% of the community can access electricity. Most of the fishermen's household have electricity and TV sets.

There is one radio station, one TV station and 8 TV transmitters in Shaoguan city. 87.23% of the villages and towns have radio and TV station. 97.29% of the village and 95.07% of the community can receive TV programmes. 69.90% of the village and 56.92% of the community can access the cable television network. Most of the fishermen's household can receive TV programmes.

5.1.4 Market construction

80.85% of the villages and towns have their own comprehensive markets (120). 14.89% of the villages and town have markets specialized for certain goods (40) and 12.77% of the villages and town have specialized markets for agro-products (14). Fishermen usually sell fish in the retail or free markets.

5.1.5 Schools

At present, there are 176 secondary schools and 904 primary schools in Shaoguan city. However, over the last 10 years, the number of secondary and primary schools have declined due to the merge of small scale schools into larger schools (see Figure 34 and 35). All the villages and towns have primary schools and 95.74% of the villages and towns have secondary schools. Since 2006, the enrolment rate of primary and secondary schools have all increased, especially the enrolment of the secondary schools after the implementation of the policy for 9 years free education (see Figure 36). The teacher-student-ratio in primary and secondary schools has all decreased in recent

years (see Figure37). The fishermen' children can also enjoy this education policy and alleviate the household's burden but there are fees for senior secondary school and most of the children stop their education after junior secondary school and go out in search of work.

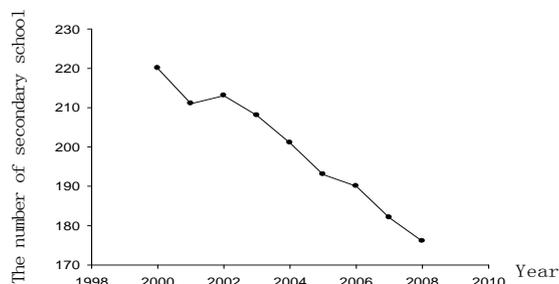


Figure 34 The number of secondary school in Shaoguan city

(Guangdong Bureau of Statistics2002-2009.)

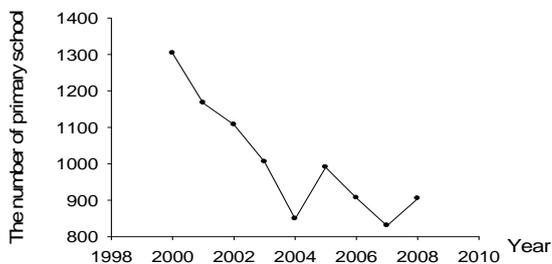


Figure 35 The number of primary school in Shaoguan city

(Guangdong Bureau of Statistics2002-2009.)

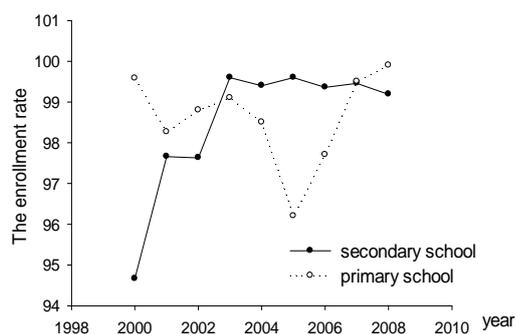


Figure 36 Enrolment rate in Shaoguan city

(Guangdong Bureau of Statistics2002-2009.)

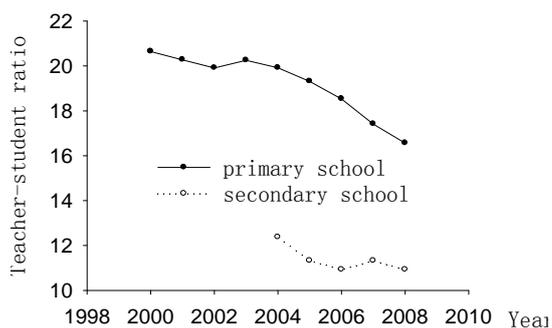


Figure 37 Teacher-student ratio in Shaoguan city

(Guangdong Bureau of Statistics2002-2009.)

5.1.6 Health system

There are 704 health institutions in Shaoguan city, among which there are 62 hospitals. 97.87% villages and towns have hospitals and 85.69% villages have health centres. The new cooperative health care plan covers about 63% of the villages. There are health centers near some of the fishing communities and it is convenient for health care but not for the other fishing communities.

5.1.7 Sanitation infrastructures

76.34% towns have a water supply system, but only 16.13% towns have a sewage treatment system and only 33.33% towns have garbage collecting systems. Some of the fishing communities have tap water and some do not, compelling them to buy drinking water. The sewage from the fishing communities is simply treated and emitted to the river directly.

5.2 Development and infrastructures plans

According to “the 11th Five Year Plan of Shaoguan Economic and Social Development” in 2006, major principles and targets of social and economic development in Shaoguan from 2006-2011 have been outlined. Some of the points are described as follow.

5.2.1 New Countryside Construction Plan

The New Countryside Construction Plan of Shaoguan includes the construction of infrastructure and the improvement of public affairs in rural areas. The construction of infrastructure includes tap water systems, road systems, sanitation systems, energy saving stoves, housing improvement, and garbage and sewage treatment systems including the promotion of biogas fuel. The improvement of public affairs focuses on the input of the government to education, sanitation, culture and security of the society and countryside. The 9-years-free-education will be improved and popularized. Senior secondary education is supported in the countryside and skill training is emphasized for the farmers. The social security system in countryside is set up especially for those who have lost their land or belong to the poorest groups. The new cooperative health system will be improved to integrate more farmers into the system. But not all the fishermen are residents of the countryside and some of the fishermen belong to the town and therefore neither can enjoy all the welfare provisions of the farmers, but also can not enjoy all the welfare services available to citizens.

5.2.2 Housing plan

The housing plan of the city and town includes the construction of low price housing and low rent housing to help the low-income households in urban areas. The project of reforming the old housing for the poorest in the countryside and the fishermen who live in the boat is being developed. The government is preparing to provide houses for 127 households who live on boats within the city area in 2012 and help them to find employment.

5.2.3 Ecological protection project

Forest resources will be protected and natural preserves will be strengthened to protect animals, plants and wetland

resources. Focus will be paid to the planting of forests for ecology and water conservation along the Beijiang River. High pollution activities will also be restricted. Biological and engineering measures will be taken for watershed management and erosion control. Ecological compensation system will also be set up.

5.2.4 Environmental protection project

More than 8 sewage treatment plants will be built or expanded. Water pollution and solid wastes will be controlled and treated. The treatment rate for waste water from city daily discharge will reach more than 60%, and from industrial discharges will reach more than 90% by the year 2010. More than 50% of the industrial solid waste will be reused, 50% of the garbage will be treated with harmless method. All hazard material will be treated safely.

5.2.5 Female and children

The lawful rights and interests of female and children will be secured. The employment of female and their participation into the society will be improved. The development of female and children in the mountainous area will be improved. Housing for the poor, health treatment and children' education will be improved.

6. Policy frameworks and stakeholders

6.1 National Laws and Policies

6.1.1 Comprehensive legal measures for environment protection

According to the Constitution of People's Republic of China and the "Environmental Law", the Chinese government is responsible for framing environment protection programs and establishing and managing nature reserves. Environment impact assessment is essential to all construction projects and governmental programs. Industrial projects and their environment protecting facilities are required to be designed, constructed and run simultaneously. Users of natural resources should pay special tax for the usage of natural resources and they should apply for special licenses. Action plan for emergency situation caused by pollution is required to be formulated. Alien species should be examined, quarantined and monitored for risk assessment. Alien invasive species should be recorded and efforts should be made to eliminate them. Any infringement of related laws should be punished.

6.1.2 Legal rules protecting key environmental elements

Legal rules protecting key wild animals: According to the “Law on the Protection of Wildlife”, key wild animals are put in a national protection list, and nature reserves are established to protect them. Hunting or fishing of wild animals is strictly under supervision, and all transactions of them should also be under supervision. Record of wild biotic resources should be kept for a long-term for monitoring. Users of wild biotic resources should pay extra tax for the sake of protection. Any wounded, grounded or stranded wild animals should be rescued, and those captured by accident should be freed. Anyone who is harmed by wild animals or any loss caused by the protection of them should be compensated.

Legal rules protecting water resources: According to the “Water Law”, plan for water supply and demand should be made. Activity of mass harvesting ground water or surface water should be permitted only by getting governmental license. Different functional zones of water resources should be set up. Resources for drinking water both from underground and surface will be protected. Pollutant discharging by enterprises and individuals alike should be strictly restricted in terms of quality, concentration and total discharge.

Legal rules protecting forestry: According to the “Forest Law”, forests should be classified for different protection measures. Records of forestry resources should be kept. Forestry development plan and forestry management plan should be made. A forestry development fund should be set up. Land reclamation, rock quarrying, sand quarrying, soil extracting and other activities with the result of deforestation should be forbidden. Forest protection troops and forest police are established to facilitate the forestry protection and the reduction of forestry fire and pests. Saplings should be quarantined for possible pests. Governments should encourage tree planting and adopt a quota and license system to control lumbering. Long-term loan should be granted for tree planting projects. Lumbering, mining and other construction projects should be taxed to collect fund for the restoration of forests. Returning slope farmland back to forests should be subsidized.

Legal rules protecting farmland resources: According to the “Law of Land Administration”, overall plans should be developed for farmland resources, in which basic farmland preservation areas should be marked. The transition of farmland into construction land should be strictly supervised. Related governmental agencies should conduct surveys on farmland resources and build a national farmland database. Anyone who damages farmland is liable for reclamation, and anyone who occupies farmland should be paid a farmland occupation tax.

6.1.3 Legal rules protecting women, children and senior citizens

According to the “Law of the People's Republic of China on the Protection of Rights and Interests of Women”,

“Law of the People's Republic of China on the Protection of Minors” and “Law of the People’s Republic of China on the protection of rights and interests of the aged”, women enjoy equal rights with men in politics, culture and education, labor, property and family matters. Maltreatment of women is totally forbidden.

The right to receive compulsory education for children of the appropriate age is protected by the law. Parents are liable to raise and care for their children, and maltreatment of children is totally forbidden.

Grownup children are liable to care for their parents. Senior citizens are entitled to help from the state and society. Respect and care to senior citizens should be encouraged. Endowment insurance and medical insurance system should be set up for senior citizens. Mistreatment of senior citizens is totally forbidden.

6.1.4 Social security policies in rural areas

The systems for rural basic life security, new rural medical care cooperation and rural medical relief are due to be established. Those rural residents without any family member or relatives are entitled to “five guarantees” (guarantees to food, clothing, residence, medical care and burial). Allowances for the relief from natural calamities should be set up.

6.1.5 Social security policies for fishing folks

Fishing folks are registered as urban citizens, but they don’t have any pension or basic life security. For them medical insurance is not compulsory, which means they have to pay 120 Yuan annually to buy it, and most of them think it is still too expensive. Those fishing families with fishing permits should be entitled to oil subsidy.

6.2 Local laws and policies

6.2.1 Laws and Policies of Guangdong Province

Measures taken in Beijiang Drainage Area: According to “Guangdong Management Ordinance of Water Resources of Dongjiang, Xijiang, Beijiang, and Hanjiang River Watershed” (2008) Overall planning as well as allocation schemes have been undertaken for the water resources in this area. Emergency preplans for water allocation will be carried out when there are serious droughts. Different function zones have also been designated in order to reserve a reasonable amount of water. The amount of pollution discharge is based on the cleaning capacity of the river. Water quality data should be able to be accessible to the public.

Measures taken to protect wetlands: According to “Guangdong Ordinance of Wetland Protection” (2006), an

overall plan should be formulated for the protection of wetlands according to their function. Survey and supervision of wetlands should be conducted to establish wetlands files for information exchange and the promotion of wetlands protection. Damages to wetlands are forbidden and should be compensated.

Measures taken to protect the fry and parent of rare aquatic animals: According to “Guangdong Management Ordinance for Fishery” (2003), fishing of the fry and parent of rare aquatic animals should be under strict supervision and control. Special licenses should be granted for the importation of alien species. When catching, buying, importing or exporting the fry of any rare aquatic species happens, a special fee should be paid for the multiplication and conservation activity of aquatic resources.

Control on sand mining: According to “Guangdong Management Ordinance for Sand Mining in River Bed” (2005), mining zones, non-mining zones as well as no-mining periods should be announced to the public. Licenses should be granted through public bidding for sand mining. Any such license should not last longer than one year. The amount and method of sand mining should be specified beforehand, and miners should pay river resources tax and compensation fee for the restoration of the river.

Measures taken to protect drinking water: According to “Guangdong Ordinance on Protection of Resources for Drinking Water and its Quality” (2007), overall planning for the protection of drinking water in both rural and urban areas should be undertaken to set up protection zones. Any loss caused by the setting up of these protection zones should be compensated. Construction projects that discharge pollution should be prohibited in drinking water zones. Governments should promote the application of ecological agriculture and pollution control facilities such as biogas system. Emergency preplans for contamination accidents on drinking water should be made.

6.2.2 Policies and measures of Shaoguan:

Activities which will be strengthened include the breeding and release of fish, surveying aquatic resources, stopping net-cage fish culture in some rivers and reservoirs, planting ecological forests, setting up biological fireproof zone and nature reserves, supervising bidding activity for sand mining by coordinating efforts from different law enforcement agencies such as departments of environment protection, water preservation, and land planning, making overall plans for the protection of ecology and resources, and improving law enforcement effort. Development Plan for Ecological agriculture in Shaoguan (2008-2015), Development Plan for Fishing in Shaoguan (2008-2015-2020) and Development Plan for Water Management Agency (2008-2010)) have been made. Investigating law infringement cases in large-and-medium reservoirs have been conducted.

6.3 Relations between stakeholders

Impact of hydropower stations on fishing communities: as water levels rise with the building of hydropower stations, the variety and amounts of fish in the river is decreasing, some lands along the riverbank have been submerged into the water, and the adjacent houses might end up collapsing. A slowing of the river current has also changed the essential environment condition for certain fish species, and has harmed the traditional fishing industry.

Impact of sand mining on fishing communities: the drinking water of fishing folks is contaminated; aquatic resources deteriorate when the oil and waste discharged in the process of sand mining polluted the water and ruined the spawning habitats of fish.

Impact of boat restaurants and other polluters on fishing communities: waste discharged by boat restaurants and other polluters contaminates the drinking water and bring damages to the fishing industry.

Relations between Shaoguan fishery monitoring team and fishing communities: the legal responsibilities of the fishery monitoring team include the issue of fishing permit, the supervision of the tool used for fishing, and the representation of government to relocate fishermen, to deliver subsidies, and to train fishermen.

Relations between Environmental Protection Bureau and hydropower stations, sand miners or boat restaurant: the legal responsibilities of Environmental Protection Bureau include reviewing environment impact assessment result, granting pollution discharge licenses, collection of pollution taxes, and monitoring pollution discharges from those industries.

Relations between Water Resources Bureau and Hydropower Stations: Bureau of Water Resources is in charge of reviewing applications for hydropower station projects and applications for water intake, collection of water resources taxes, and the monitoring of water storage and water discharge activities.

Relations between Water Resources Bureau and sand miners: Water Resources Bureau is in charge of the reviewing applications for sand mining and monitoring the mining process.

6.4 China's Involvement in Related International Treaties

6.4.1 Related international treaties that China already acceded to include:

Convention on Biological Diversity, International Plant Protection Convention, Convention on International Trade in Endangered Species of Wild Fauna and Flora, Convention on Wetlands of International Importance Especially as Waterfowl Habitat, International Convention for the Protection of New Varieties of Plants, United Nations

Convention on the Law of the Sea Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks.

6.4.2 International duties and obligations that China fulfilled

China introduced on-site (in situ) conservation and off-site (ex situ) preservation methods from the Convention on Biological Diversity, and has designated many off-site preservation locales. Strict legal rules have been promulgated to regulate construction activities to protect environment. Action plans like Action Plan for Aquatic Resources Preservation in China have also been framed to build various nature reserves such as Shaoguan Nature Reserve for Rare Fishes in Beijiang. Government conducted several surveys such as the one from year 2005 to 2009 on the fishing resources in Shaoguan, and has taken steps to prevent the introduction of alien invasive species and strengthen the protection of wildlife, grassland and fishing resources.

7. Logistics

7.1 Accessibility

7.1.1 Infrastructure

There are three lane highways which run between Guangzhou and Shaoguan. It takes 2 hours by train or nearly 3 hours by car from Guangzhou to Shaoguan. There is a plan to build an express rail way between the two cities which might cut travel time down to one hour. The infrastructure in rural regions is very good; most of the main roads entering the villages are well paved. Internal road networks are surfaced or gravel well and are easy to conduct field work even during the rainy season.

7.1.2 Accessibility and data availability

In general, the stakeholders are willing to disclose information regarding the aquatic resources. For example, the fishermen are willing to tell their livelihood status, such as their property ownership as well as their cash income and expenditure to allow the team to perform an economic analysis and species mapping. However, the team can only collect rough information about the distribution, amount and utilization of some aquatic species.

7.2 Existing data

Up to now, the team have collected 43 volumes related to economic statistics, history of the region, forestry, hydraulic power, soil, agriculture development, fishery, and environmental quality. The detailed data include:

- The basic statistic data about industry, agriculture and social status in Shaoguan;
- The amount of aquatic production;
- The number, distribution, area of fish villages and status of fishermen;
- The basic information about fish protection zone;
- The hydrogen power station, water reservoir and sand mining company status;
- The area of forestry land, rate of land covered by forestry;
- The water quality of Beijiang River and waste water treatment situation of companies along the river;
- Artificial fish releasing information in Beijiang River.

7.3 Pre-existing relationship to community/district

The research team have established a good relationship with the local government and community along the Beijiang River; there are many government officers who graduated from South China Agricultural University. It helps the investigation, evaluation and sustainable utilization of aquatic resources. .

7.4 Stakeholder commitment to the project

One of the objectives of this study is to identify important stakeholders who would be able to work with the research team to understand and find solutions to aquatic resource management issues. Stakeholders are those individuals or organizations that are involved in the subject. Their activities and influences are important in the solution to the problem. It is important that the activities and interests of these stakeholders are understood so that development strategies can be implemented effectively and efficiently in order to improve the situation. The important stakeholders involved in aquatic resource management or use in the study area include sand mining companies, hydroelectric power stations, boat restaurant owners, Shaoguan Fishery Monitoring Team, Environmental Protection Bureau, Water Resource Bureau, and of course the fishermen themselves (Fig. 38).. All the above stakeholders support the project, especially the fishers themselves and the Fishery Monitoring Team (Fig. 39, Fig.40). The former wants to increase the water resources, because they rely on the resources. The latter have

done a lot of work to increase the aquatic resource, such as fish fry releasing activity, and setting up fish resources protection area etc. However the sand mining companies have not shown their cooperation in the project so far.



Fig. 38 Discussion with different stakeholders in Shaoguan



Fig. 39 Fishman (second from right) like to talk with the research persons



Fig. 40 Research persons with the team leader of Fishery Monitory Team of Shaoguan City (middle with yellow shirt)

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