Freshwater ecosystem services and biodiversity values of the Beijiang River, China

Work Package 3 report:

Highland Aquatic Resources Conservation and Sustainable Development (HighARCS)

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1. Introduction

1.1. About this report

This report is a deliverable for an EC funded project called 'Highland Aquatic Resources Conservation and Sustainable use' (HighARCS - www.higharcs.org). This project is using an integrated approach of biodiversity, livelihoods, and policy framework surveys (following the IUCN Integrated Wetland Assessment Toolkit Springate-Baginsky *et al.* 2009) to value five wetland sites across Asia, and develop action plans to ensure aquatic resources are conserved and used sustainably. Here we present the findings of research taken to identify and value biodiversity and ecosystem services at one of these sites; three fishing villages along the Beijiang River, Guangdong Province, China. This report will be used alongside two others (one on livelihoods and one on policy and management) to formulate an Integrated Action Plan (IAP) to address sustainable use of aquatic resources at the site.

For this report the aquatic biodiversity at the three fishing villages has been identified through literature reviews, IUCN Red List assessments and field surveys. A participatory rural assessment method was adopted to identify the prioritisation of different ecosystem services and costs by different stakeholders. A total economic valuation of the ecosystem services provided by the Beijiang River has also been calculated using existing data. The policy and management framework that influences biodiversity and the provision of ecosystem services is also reviewed and discussed. The information in this report (WP3) together with the research results on the livelihoods of the fishers in the fishing villages (WP4) and the policy and management analysis (WP5) will provide a solid foundation for the integrated action plan (IAP).

1.2. Background

The Pearl River watershed is the third largest river in China. It is situated in southern China and extends from 21°31'N to 26°49'N and from 102°14'E to 115°53'E (Figure 1). The major tributaries of the Pearl River are the Xijiang River (West River), Beijiang River (North River), and the Dongjiang River (East River). After they merge together, they form the main stem of the Pearl River, which runs into the Pearl River Delta and to the South China Sea (Figure 2). The Beijiang River (North River), where the HighARCS project sites (fishing villages) are situated is the second largest sub-catchment in the Pearl River system and one of the most important rivers in Guangdong Province. The Beijiang River has been chosen as HighARCS project site is because of the highland areas within the catchment and the presence of fishing communities who depend heavily on aquatic resources.

Most of the Beijiang River watershed is mountainous or hilly and covered with evergreen vegetation typically a broad leaf seasonal forest containing high levels of biodiversity in a subtropical monsoon region. Due to the high rainfall in the region and steep topography, there are a lot of streams and rivers with high potential for power generation. Because of the rapid economic development in the region, especially mining and heavy industry activity, damming of rivers, pollution and habitat disturbance have become major threats to aquatic resources.

For detailed information on the Beijiang River site (natural environment, livelihood strategies etc. see

the WP1 report 'HighARCS situation analysis report – China site' SCAU 2010 available at www.higharcs.org).

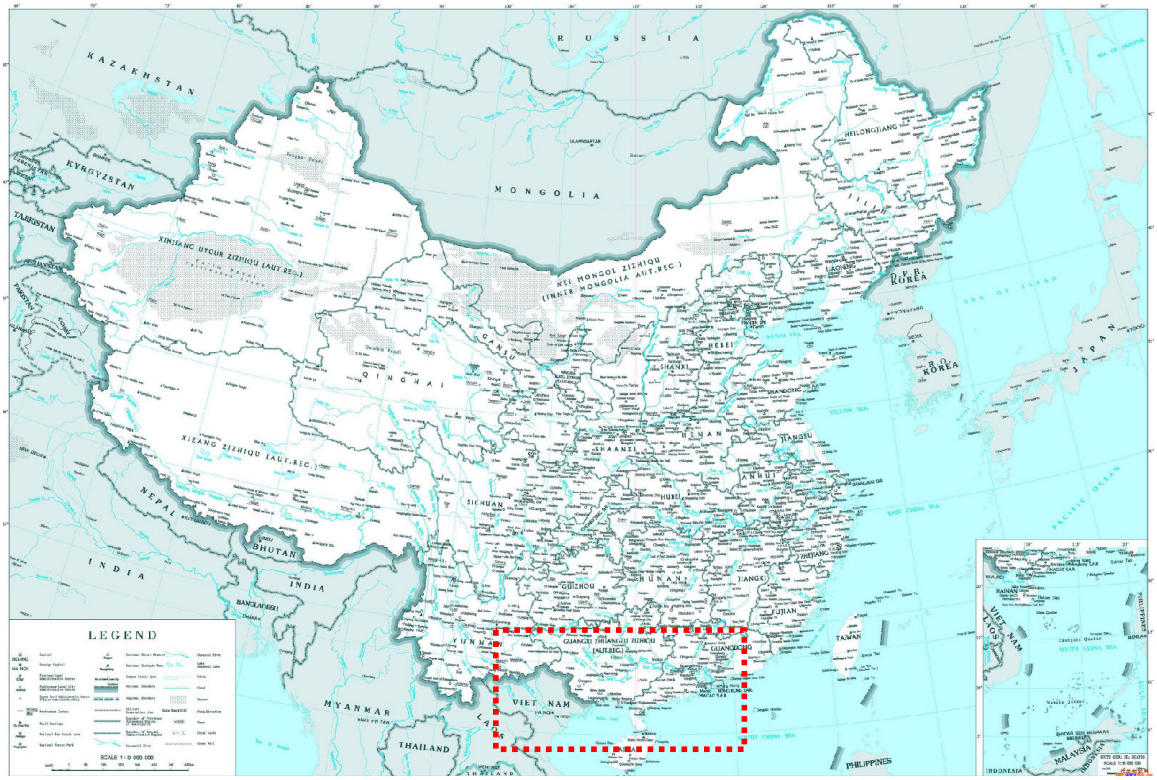


Figure1. The Pearl River watershed is within the red box (and is enlarged in Figure 2.)

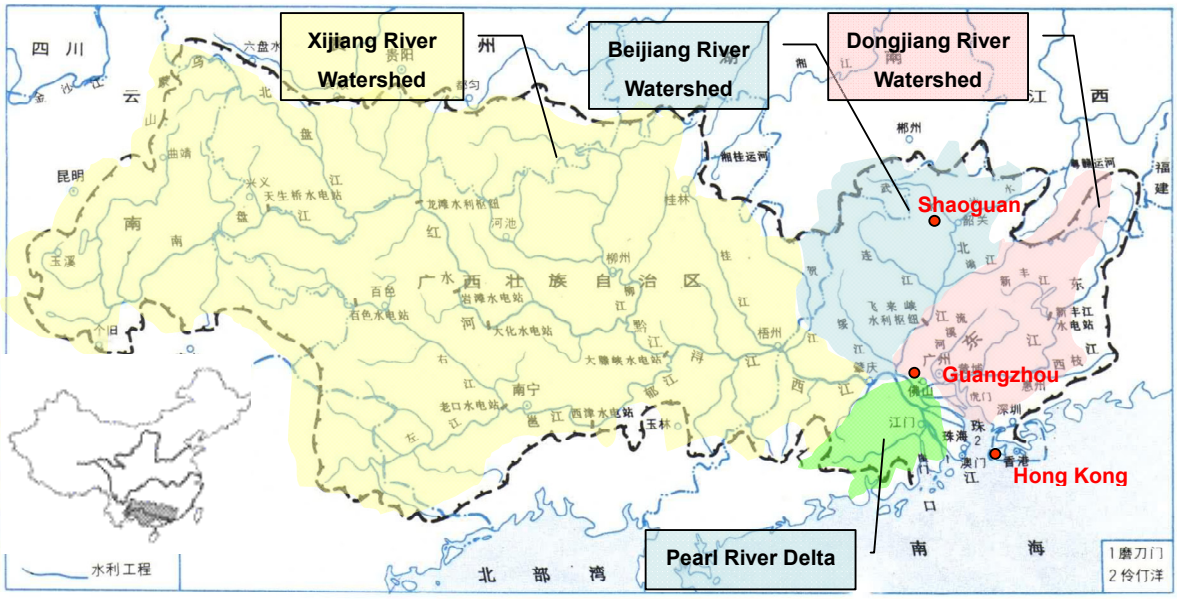


Figure 2. Position of Beijiang River (blue) in the Pearl River watershed

2. Site maps

The maps of the sites are important as they allow the results of this Work Package to be put into a geographic context. They will not only allow detailed information to be presented in an easy to understand format, but they will also be key in developing the IAP and identifying any potential indicators and monitoring plans. The maps of the field sites below were produced by initially digitizing satellite imagery using ESRI ArcInfo Geographic Information Software (GIS) by Dr. Fraser Sugden of Stirling University, and IUCN, whereas the catchment maps have been digitised by SCAU staff. Then through a mapping workshop held on 23-24 August, 2011 at the South China Agricultural University, Guangzhou, China the maps were reviewed, edited and land classifications were confirmed by SCAU staff based on their knowledge and field observations taken while at the site.

The Pearl River watershed (Figure 1) is found in the southern part of China draining into the South China Sea, and is China's third longest river. Figure 2 shows the three major branches of the Pearl River and the Pearl River Delta. The largest sub-catchment is the Xijiang (West River), which covers most of Guangxi Province and stretches into Yunnan, Guizhou and parts of northern Viet Nam. The Dongjiang (East River) and Beijiang (North River) are almost entirely found within Guangdong Province.

Figure 3 shows the upper Beijiang River where the three fishing villages are located. Two villages Lishi (24o 52'53.48''N, 113o 32'20.10"E) and Zhoutian (24o 58'57.77"N, 113o 51'36.75") are upstream of Shaoguan City on the Wujiang and Zhenjiang rivers respectively, and Kengkou village (24o 32'2.13"N, 113o 35'26.63"E) is downstream of Shaoguan on the Beijiang River after the Wujiang - Zhenjiang confluence. The major land cover within the Beijiang River watershed is forest, with farmland mainly found along the river valleys and flood plains. Some of the sensitive regions for biodiversity have been protected as national forests, natural reserves, or reserves for aquatic resources.

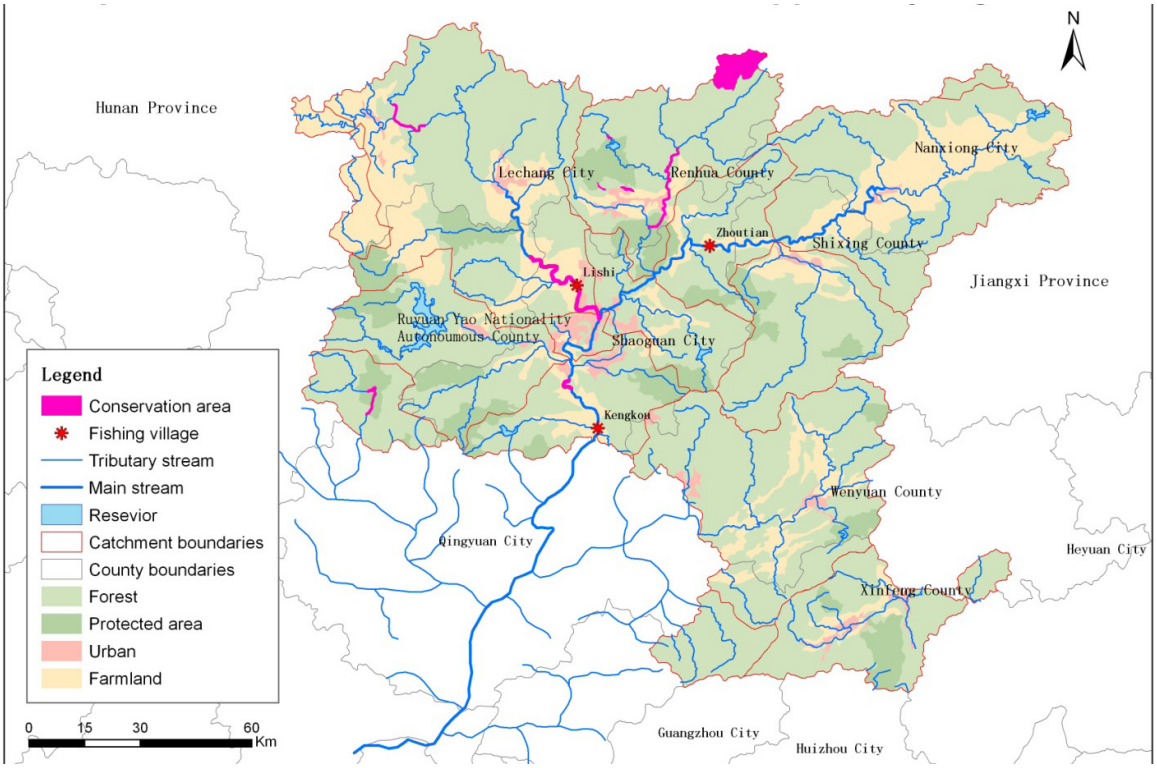


Figure 3. The major habitats in Beijiang River Watershed in Shaoguan

Figure 4 (top map) shows a detailed land cover classification map of the area that surrounds Zhoutian fishing village. The village is relatively far from built up areas and is surrounded mostly by agricultural land and forest. However, the village is situated just downstream of an active sand mine and a hydropower dam. Figure 5 (left) shows the land cover around Kengkou fishing village which is predominantly forest and plantations with little agricultural land. The village is situated downstream of a dam, sand mine and industrial areas. Also as the site is downstream of Shaoguan City, the river contains higher levels of pollution than the other sites. Figure 6 (top) shows the land cover around Lishi Fishing village. Lishi is very close to urban areas with Shaoguan city just downstream of the village and Lishi town is upstream. There are large areas of agricultural land on the opposite side of the river and is a dam downstream near Shaoguan City suburbs. Water is often pumped out from the river for agricultural irrigation and for urban usage which is released back into the river as waste water. Figures 4 (bottom map), 5 (right) and 6 (bottom) also show the locations of the field sites that relate to the different taxonomic groups that have been surveyed (see section 3 Biodiversity within the Beijiang River).

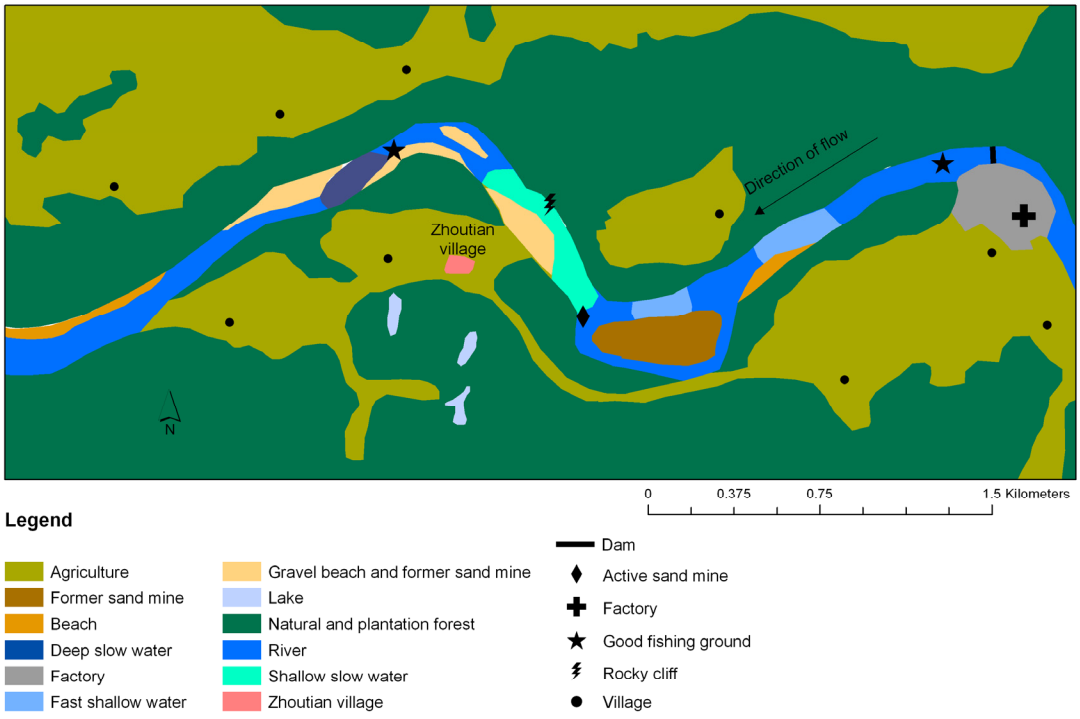


Figure 4. The site map of Zhoutian Fishing village (above) and the sampling sites for aquatic species (below)
In the lower map, the orange pins denote the sampling points for fish, yellow pins for dragonflies, green pins for aquatic plant species. Codes e.g. **Z-P4** mean **Z** for **Z**houtian fishing village, **P** is for aquatic **P**lants, and **4** is the sampling point number **4**. A full list of the sampling points can be found in Annex I.

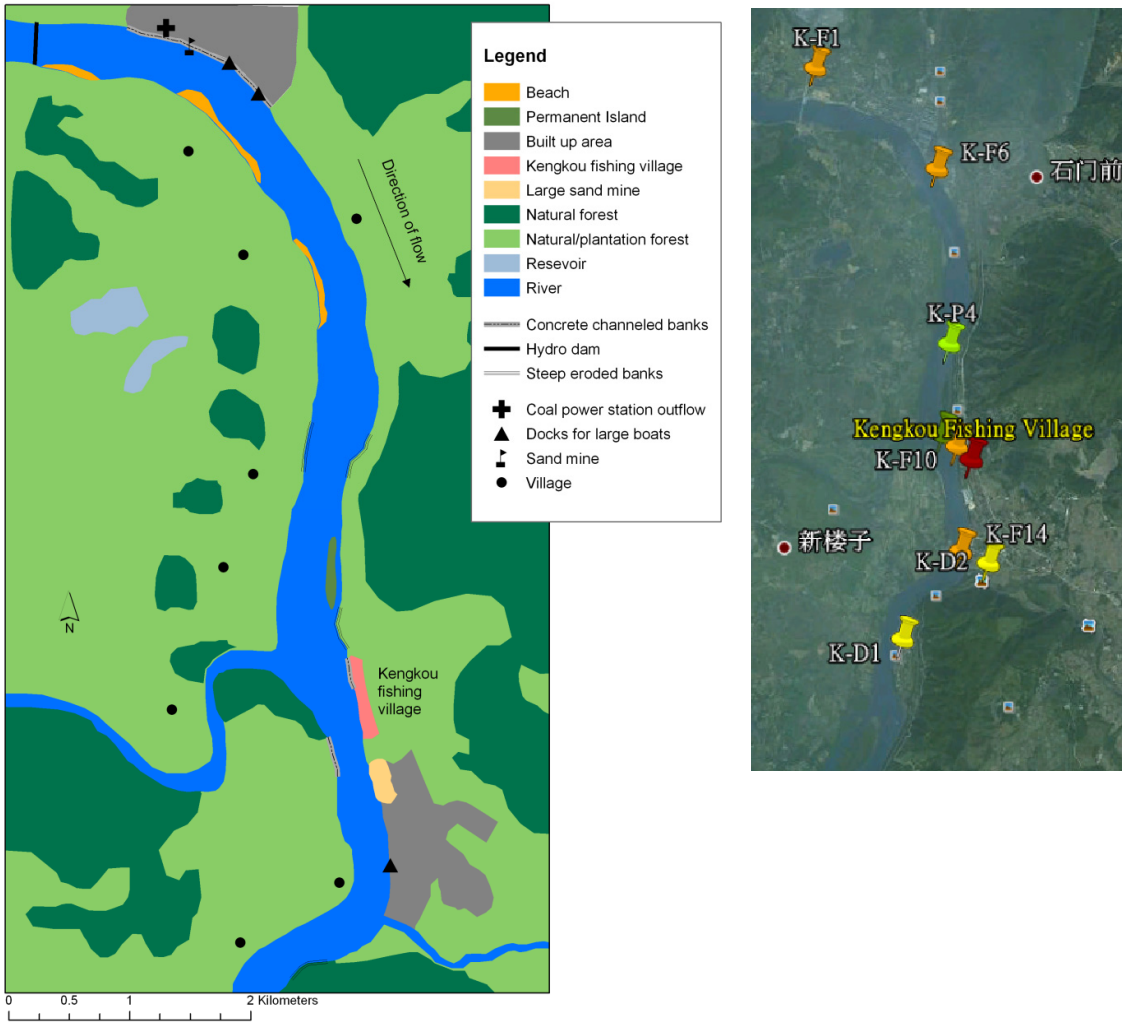
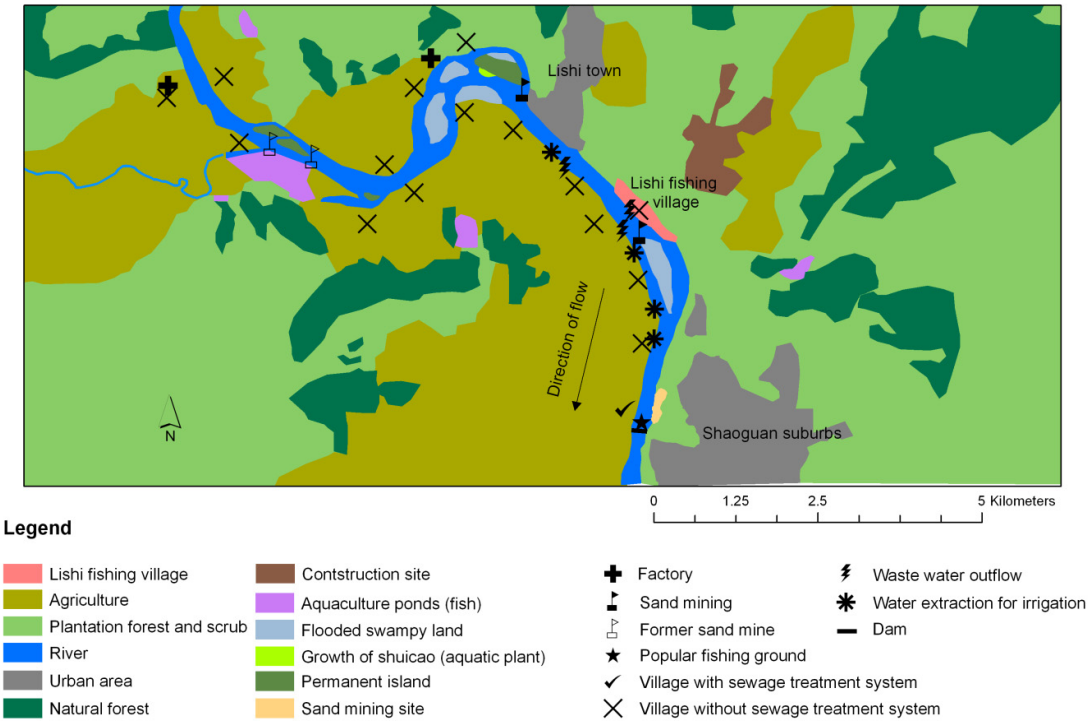


Figure 5. The site map of Kengkou fishing village (left) and the sampling sites for aquatic species (right)

In the right map, the orange pins denote the sampling points for fish, yellow pins for dragonflies, green pins for aquatic plant species. Codes e.g. **K-F10** mean **K** for **K**engkou fishing village, **F** is for aquatic **P**lants, and **10** is the sampling point number **10**. A full list of the sampling points can be found in Annex I.



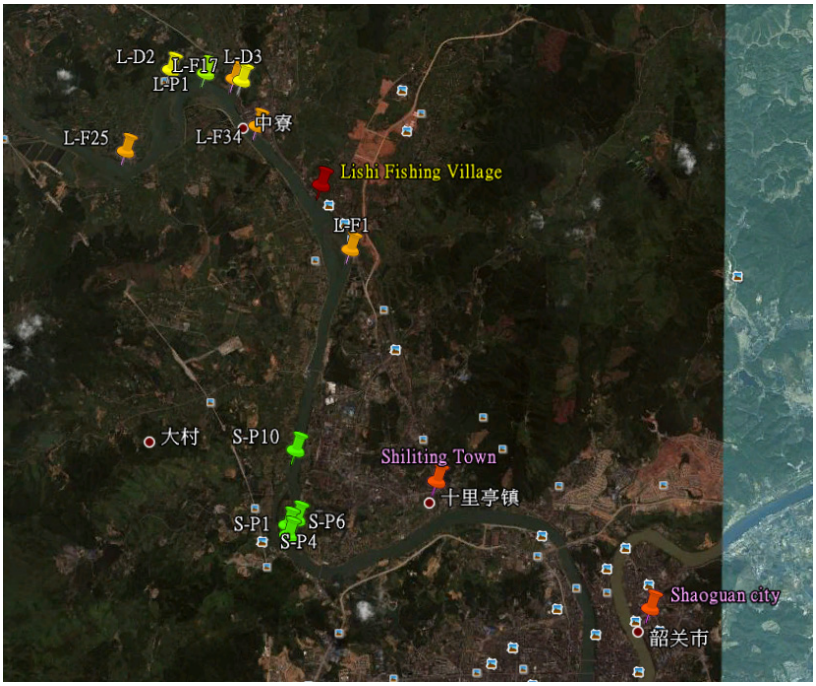


Figure 6. The site map of Lishi fishing village (left) and the sampling sites for aquatic species (right)

In the right map, the orange pins denote the sampling points for fish, yellow pins for dragonflies, green pins for aquatic plant species. Codes e.g. **L-D3** mean **L** for **L**ishi fishing village, **D** is for **D**ragonflies, and **3** is the sampling point number **3**. A full list of the sampling points can be found in Annex I.

3. Biodiversity within the Beijiang River

To inform the Integrated Action Plan (IAP) we need to know what aquatic species are present in the Beijiang River particularly at the 3 fishing villages, which species contribute to local livelihoods and what their conservation status are. Literature reviews, IUCN Red List assessments, field surveys, market investigation and household visits were undertaken to identify the aquatic species present within the three fishing villages along the Beijiang River.

3.1. Chosen taxonomic groups

The taxonomic groups chosen to be included in these analyses are fishes, molluscs, aquatic plants and dragonflies (odonates). Some fish and mollusc species are very important for the livelihood of fishers providing food and income, and molluscs, bivalves in particular (being sedentary filter feeders), odonates (rely on water for their juvenile life stage) and some aquatic plants are very sensitive to habitat quality and pollution. By identifying the presence and status of these species we will be able to recommend management actions to secure sustainable use and livelihoods and monitor environmental quality at the sites. This work will also allow us to identify any species that may not be important for livelihoods, but are of conservation concern, again allowing for suitable recommendations to be made in the IAPs.

3.2. Conservation status of biodiversity - IUCN Red List assessments

There are several methods of determining species conservation status and the most commonly used tool is the IUCN Red List Categories and Criteria (IUCN 2001), which allows consistency in approach across different taxonomic groups. It helps in determining the relative risk of extinction at a global scale and provides the basis for understanding if a species is Extinct, threatened (Critically Endangered, Endangered or Vulnerable), Near Threatened, of Least Concern, or lacking sufficient basic data for assessment (Data Deficient) (see Figure 7). The IUCN Red List of Threatened Species™ publishes the results of the global assessments (www.iucnredlist.org). The IUCN Red List also provides basic information on species taxonomy, distributions, habitat and ecology, threats, population trends, use and trade, livelihood information, ecosystem services provided, and research and conservation priorities.

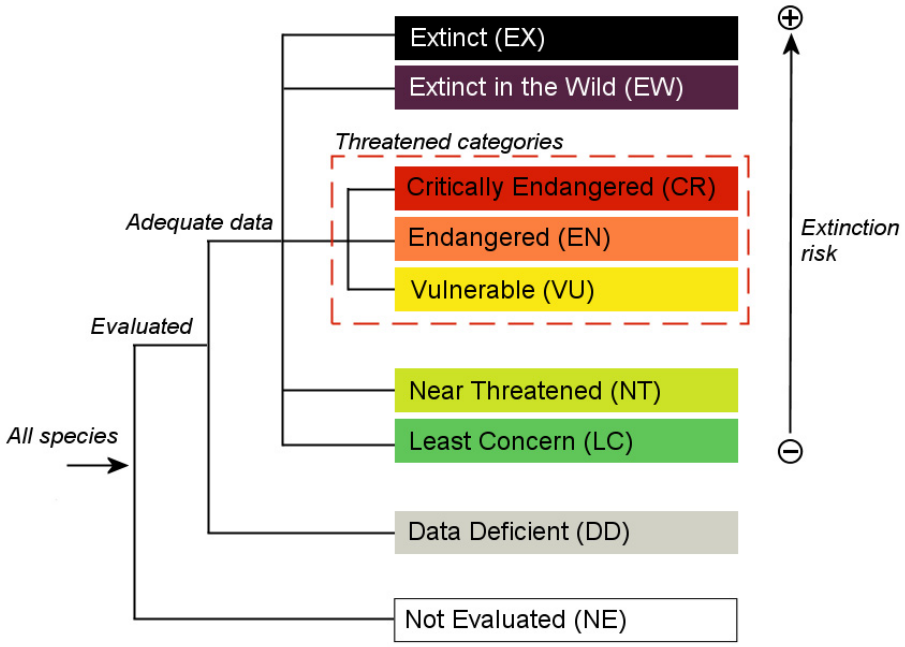


Figure 7. IUCN Red List Categories

Biodiversity experts from the HighARCS project partners, including from SCAU, were trained at a workshop (06-09 June 2009, Kolkata, India) in the use of the IUCN Species Information Service (SIS – the Red List species database), application of the IUCN Red List Categories and Criteria (IUCN 2001) (see Annex II for a summary of the IUCN Red List Criteria), and Geographic Information Systems (GIS) for digitally mapping species distributions. Following the training workshop, experts collated native species lists of freshwater fishes, dragonflies and damselflies (odonates), freshwater molluscs and aquatic plants for the Pearl River catchment (Figure 2), and input within the SIS, all available information on each species. The required data fields (with standard classification schemes) within SIS are species taxonomy, distribution, habitat and ecology, threats, population trends, use and trade, and research and conservation priorities, Red List Category and rationale. Data gaps were filled and corrections made to the data from another overlapping IUCN project (Freshwater biodiversity assessment of Indo-Burma) which is funded by the Critical Ecosystem Partnership Fund (www.cepf.org). These species were then reviewed at a second workshop (17-22 January 2011, Vientiane, Lao P.D.R.) and via email communications with other species experts after the workshop. The IUCN Indo-Burma project is due to be published in March 2012.

While these species will not all found at the fishing villages, it will allow the actions proposed through the IAP to take into consideration any globally threatened species within the wider catchment if necessary. It will also allow for all the species identified at the site, to be put into a global conservation context. For example a species may be stable and numerous at the site with no known threats and perceived locally as not being of conservation concern, but at a global scale the species may be threatened to impacts elsewhere within the species range, this would make the population at the site

of high conservation concern. Alternatively, global conservation status is not the only aspect to identify important species at the site. A species may be of Least Concern globally but may be undergoing severe declines at the site and may also be of economic and livelihood concern and would therefore potentially qualify as a species to be incorporated into the IAP.

The resulting dataset allows 238 fish species, 62 molluscs and 207 odonates, and 233 aquatic plants species to be identified as present in the Pearl River wider catchment as shown in Figure 2. A list of these species with their IUCN Red List Category can be found in Annex III. An extract of the globally threatened species from the Pearl River catchment can be found in Table 1. There are 2 Extinct (both fishes), 12 Critically Endangered, 9 Endangered, and 6 Vulnerable species (4 odonates, 20 fishes, 2 plants and 1 mollusc).

Table 1. Globally threatened (those listed as Critically Endangered, Endangered and Vulnerable) and Extinct species found within the Pearl River catchment.

The IUCN Red List categories are EX – Extinct; EW Extinct in the Wild; CR – Critically Endangered; EN – Endangered; VU – Vulnerable; NT – Near Threatened; LC – Least Concern; DD – Data Deficient; NA – Not assessed. The categories CR, EN and VU are classed as the 'threatened' categories. '*' indicates a draft Red List assessment, that still needs to be peer reviewed.

Order	Family	Binomial	IUCN Red List Category
Dragonflies & damselflies			
Odonata	Aeshnidae	*Cephalaeschna dinghuensis*	CR
Odonata	Gomphidae	*Gomphidia kelloggi*	EN
Odonata	Macromiidae	*Macromia katae*	VU
Odonata	Megapodagrionidae	*Philosina alba*	VU
Fishes			
Acipenseriformes	Acipenseridae	*Acipenser sinensis*	CR
Cypriniformes	Balitoridae	*Yunnanilus pleurotaenia*	VU
Cypriniformes	Cobitidae	*Paralepidocephalus yui*	EN
Cypriniformes	Cyprinidae	*Anabarilius andersoni*	CR
Cypriniformes	Cyprinidae	*Anabarilius liui yiliangensis*	EN*
Cypriniformes	Cyprinidae	*Anabarilius macrolepis*	EX
Cypriniformes	Cyprinidae	*Anabarilius qiluensis*	CR
Cypriniformes	Cyprinidae	*Anabarilius yangzonensis*	CR
Cypriniformes	Cyprinidae	*Bangana decorus*	CR
Cypriniformes	Cyprinidae	*Cyprinus chilia*	EN
Cypriniformes	Cyprinidae	*Cyprinus fuxianensis*	CR
Cypriniformes	Cyprinidae	*Cyprinus ilishaestomus*	CR
Cypriniformes	Cyprinidae	*Cyprinus yilongensis*	EX
Cypriniformes	Cyprinidae	*Cyprinus yunnanensis*	CR
Cypriniformes	Cyprinidae	*Parasinilabeo assimilis*	VU
Cypriniformes	Cyprinidae	*Poropuntius chonglingchungi*	CR

	Order	Family	Binomial	IUCN Red List Category
	Cypriniformes	Cyprinidae	*Pseudohemiculter dispar*	VU
	Cypriniformes	Cyprinidae	*Ptychidio jordani*	CR
	Cypriniformes	Cyprinidae	*Sinocyclocheilus tingi*	EN
	Cypriniformes	Cyprinidae	*Sinocyclocheilus yangzongensis*	CR
	Cypriniformes	Cyprinidae	*Tor yunnanensis*	EN
	Siluriformes	Cranoglanididae	*Cranoglanis bouderius*	VU
Molluscs				
	Architaenioglossa	Viviparidae	*Margarya mansuyi*	EN
Plants				
	Alismatales	Alismataceae	*Sagittaria lichuanensis*	EN
	Hydrocharitales	Hydrocharitaceae	*Ottelia acuminata*	EN*

Of these, only five species, all of them fish, are found within the Beijiang catchment. *Cranoglanis bouderius* (VU) is recorded from China in the Zhu Jiang River where it is distributed in Beijiang River at Yingde south of Shaoguan City, in the Xijiang River from Wuzhou to Longzhou, Liucheng and Zhaoping, at Funing County in Yunnan and at Anlong in Guizhou Province. The species was once common, but has declined drastically in the last twenty years, due to overfishing and increasing levels of pollution and habitat loss. *Parasinilabeo assimilis* (VU) is recorded from the Xijiang tributaries, Beijiang tributaries, and also from the Xiangjiang (a tributary of the Yangtze River). It is estimated that due to the impact of dams, overfishing, and pollution in recent years the species range has drastically reduced with recent surveys in Guangxi, Guangdong and other provinces not recording the species. *Bangana decorus* (CR) is known from Yunnan, Guangdong, and Guangxi Provinces in China. Dams impact the Beijiang, disrupting the species migration, and pollution from agriculture impacts all rivers. Recent surveys (2005-2009) in the Beijiang found only 10-20 specimens per year, and the population is estimated to have declined by 80% in 15 years (three generations). *Acipenser sinensis* (CR), the Chinese sturgeon is now extirpated from the Pearl River, and currently only occurs in the middle and lower reaches of the Yangtze river and close to shore in the Yellow and East China Sea, there is just one remaining spawning ground (a 4 km stretch of river), which is situated below the Gezhouba dam. The species has historically been overfished, its migrations have been blocked by dams and it is impacted by water pollution across its range. *Pseudohemiculter dispar* (VU) is usually found in the area to the south of Chang Jiang (Yangtze) River in China and is also known from the Mekong and Nam Ma basins in Lao PDR, central and northern Viet Nam. The species is impacted by high levels of pollution and major hydrological changes within the range of this species, in particular in the Mekong and Yangtze river basins and its population is suspected to have declined by more than 30% in the past 10 years.

The vast majority of the threatened species in the Pearl River catchment (17 fishes and 1 mollusc) are found far from the HighARCS project sites and are endemic to lakes in the very upper Xijiang catchment in Yunnan. *Cyprinus yilongensis* and *Anabarilius macrolepis* are now both extinct but were endemic to Yilong Lake are considered to have gone extinct when Yilong Lake dried up as a result of water abstraction for agriculture in 1981. Five species are assessed as Critically Endangered 'Possibly

Extinct'. *Anabarilius qiluensis, Cyprinus ilishaestomus* and *Cyprinus yunnanensis* which are all endemic to Qilu Lake and haven't been recorded in fisheries since the late 1970's early 1980's, it is thought that the introduction of non-native fishes in the 1960s caused their declines and possible extinction. *Anabarilius yangzonensis* (CR Possibly Extinct) is only recorded from Yangzong Lake. Recent surveys in 2008 did not find any specimens of the fish and it is suspected that the population has crashed as a result of pollution, as well as introduced fish species, and overexploitation. *Poropuntius chonglingchungi* (CR Possibly Extinct) is only known from Fuxian Lake and has been impacted by introduced species, the loss of spawning grounds (through the construction of aquaculture ponds and tourism development) and overfishing and has not been collected in surveys since the 1980s. The other threatened species from these lakes are the cyprinids; *Anabarilius andersoni* (CR), *Cyprinus chilia* (EN), *Cyprinus fuxianensis* (CR), *Sinocyclocheilus tingi* (EN), *Sinocyclocheilus yangzongensis* (CR) and *Tor yunnanensis* (EN) the loaches (Balitoridae and Cobitidae); *Yunnanilus pleurotaenia* (VU) and *Paralepidocephalus yui* (EN) and the mollusc (gastropod) *Margarya mansuyi* (EN). All these species are being impacted by pollution, introduced species (usually to improve fish catches), and overharvesting.

The four threatened odonate species are all found around the Pearl River delta and Hong Kong, where their terrestrial habitats have been lost due to development and their aquatic habitats polluted. The two threatened plant species may be found within the Beijiang catchment but specific locality data could not be found. *Sagittaria lichuanensis* (EN) is no longer found in Guangdong Province, and it is thought that the species now only occurs in small patches of swamps in Fujian, Jiangxi, Hubei, and Guizhou. The species has been impacted by overgrazing and agricultural chemical pollution. *Ottelia acuminata* (EN*) is widespread in southern China but has seen a significant decline in population (particularly in Yunnan) due to pollution.

3.3. Fishes

3.3.1. Literature review

The first step of undertaking a species survey was to undertake a comprehensive literature review to try and identify what species may have been recorded at the sites. Through the review of sixty one publications (see below), 119 species of fishes have identified as being previously recorded in the Pearl River system (Table 2). This is different to the figure generated through the Red List assessments (237 fish species) as the Red List assessments also use expert opinion and unpublished data to help generate species distributions.

All the globally threatened species identified through the literature survey are discussed above in section 3.2, apart from *Cyprinus barbatus* (from Erhai Lake, Yunnan) and *Yunnanilus nigromaculatus* (Dianchi Lake and Yangling Lake, Yunnan) as according to the Red List assessments are not found within the Pearl River Catchment. Out of the 118 species identified, only five species have been evaluated for the Chinese national Red List. Only two of these are not listed as threatened by IUCN *Atrilinea roulei* and *Siniperca roulei*. *Atrilinea roulei* (black striped minnow) is assessed as 'Rare' in the China National Red List and Least Concern by IUCN. It is endemic to China, known from the Qiantang Jiang (River) in Zhejiang Province, Guangxi (present in Tayaoshan nature reserve, and Shiwandashan) and Anhui Province, China. The China national Red List states the species population is extremely small and has been impacted by deforestation and soil erosion and destructive fishing methods but the IUCN

Red List states that the species may be naturally rare. *Siniperca roulei* (slender mandarin) is listed as VU on the China national Red List and Data Deficient by IUCN. The species population has declined mostly due to overfishing but also pollution. The IUCN DD listing states that it may qualify for a threatened category if further information on the level of exploitation and threat from habitat degradation becomes available, meaning more data is required to be able identify the threatened category. Forty of the 119 species have been identified through the literature review to have a declining population within the Pearl River catchment, and only three of these species have no economic or livelihood importance. *Anguilla marmorata* (marbled eel) is an economically important species that has seen a sharp decline within the Pear River. It has suffered primarily to dams and weirs blocking its migratory route from the ocean to the middle and upper stretches of the river where its spawning grounds are located. Only one species *Hypseleotris compressocephalus*, has a population that is increasing. The remaining 77 species have an unknown population trend.

The literature review also identifies that many species are important for livelihoods, either through providing food, income or used as medicine. Only 14 species (11% of all the species identified) have been identified as having no value. Species used as food (either commercial or local use) is the dominant use with 95 species (80%) being harvested for this purpose, and 12 species (10%) are utilised for the aquarium trade.

Table 2. Fish species identified from the Pearl River based on literature surveys.

The IUCN Red List categories are EX – Extinct; EW Extinct in the Wild; CR – Critically Endangered; EN – Endangered; VU – Vulnerable; NT – Near Threatened; LC – Least Concern; DD – Data Deficient; NA – Not assessed. The categories CR, EN and VU are classed as the 'threatened' categories. '*' indicates a draft Red List assessment, that still needs to be peer reviewed.

Species binomial	National Red List status	IUCN Red List	Economic or livelihood value	Population trend in catchment	Source
Acantopsis arenae	Not Evaluated	DD	None.	Unknown	Zheng 1989
Acheilognathus taenianalis	Not Evaluated	LC	None.	Unknown	Zheng 1989
Acrossocheilus beijiangensis	Not Evaluated	LC	Ornamental fish and a food fish.	Decline	Chen, X., J.-H. Pan, Z. Liu and D. Liang. 1991.
Acrossocheilus labiatus	Not Evaluated	NA	Ornamental fish and a food fish.	Unknown	Shen, S.C. (ed.). 1993
Acrossocheilus parallens	Not Evaluated	LC	Ornamental fish and a food fish.	Unknown	Chen, X., 1991
Acrossocheilus rendahli	Not Evaluated	NT	Ornamental fish and a food fish.	Unknown	Chen, X., 1991
Acrossocheilus wenchowensis	Not Evaluated	DD*	Ornamental fish and a food fish.	Unknown	Chen, X., 1991
Anabarilius liui ssp. Yiliangensis	Not Evaluated	EN*	Food fish.	Decline	Luo, Y. And Chen, Y. 1998.
Anabarilius macrolepis	Not Evaluated	EX	Food fish.	Considered to have gone extinct in the	Luo, Y. And Chen, Y. 1998.

Species binomial	National Red List status	IUCN Red List	Economic or livelihood value	Population trend in catchment	Source
				1970s	
Anabarilius maculatus	Not Evaluated	DD	Food fish.	Unknown	Zhou, W. And Cui, G.-H. 1992
Anabarilius qiluensis	Not Evaluated	CR	Food fish.	The species has not been recorded since the 1980's	Zhou, W. And Cui, G.-H. 1992
Anabarilius yangzonensis	Not Evaluated	CR	Food fish.	Considered to be almost extinct	Zhou, W. And Cui, G.-H. 1992
Anguilla marmorata	Not Evaluated	LC	Commercial fisheries.	Sharp declines	Shiao *et al.* 2003
Atrilinea roulei	Rare	LC	Food fish.	Unknown	Liu, K. And W. Zhou. 2009
Balitora longibarbata	Not Evaluated	LC	None.	Possibly a naturally scarce population	Chen, Y. And Tang, W. 2000
Bangana decorus	Not Evaluated	CR	Food fish.	Declined	Liu, K. And W. Zhou. 2009
Bangana wui	Not Evaluated	DD	Food fish.	Unknown	Zhang, E., Yue, P. And Chen, J. 2000
Beaufortia cyclica	Not Evaluated	LC	None	Unknown	Chen, Y. And Tang, W. 2000
Beaufortia kweichowensis ssp. Gracilicauda	Not Evaluated	NA	Food fish.	Unknown	Zheng, C.-Y. 1991
Beaufortia kweichowensis ssp. Kweichowensis	Not Evaluated	NA	Food fish.	Unknown	Zheng, C.-Y. 1991
Beaufortia pingi	Not Evaluated	LC	None	Unknown	Chen, Y. And Tang, W. 2000
Beaufortia polylepis	Not Evaluated	LC	Food	Unknown	Chen, Y. And W. Tang. 2000
Cranoglanis bouderius	Not Evaluated	VU	Food fish.	Decline	Zheng, C. 1989
Culter recurviceps	Not Evaluated	LC	Food fish.	Decline	Zheng, C. 1989
Cyprinus barbatus	Not Evaluated	CR	Previously important in fisheries	Possibly Extinct	Luo, Y. And Yue, P. 2000
Cyprinus chilia	Not Evaluated	EN	Commercial and local fisheries	Endange-red	Yang, J.-X. 1991

Species binomial	National Red List status	IUCN Red List	Economic or livelihood value	Population trend in catchment	Source
Cyprinus ilishaestomus	Endangered	CR	Commercial fisheries.	Possibly Extinct	Wang, S. 1998
Cyprinus longzhouensis	Not Evaluated	DD	Food fish.	Decline	Zhang, W. 1998
Cyprinus multitaeniata	Not Evaluated	NT	Commercial fisheries.	Near Threaten-ed	Huang, H.C. 1987
Cyprinus yilongensis	Extinct	EX	Food fish.	Extinct	Xiawuping. 1963
Cyprinus yunnanensis	Endangered	CR	Commercial fisheries.	Possibly Extinct	Zhou Wei. 1990
Discogobio tetrabarbatus	Not Evaluated	LC	Food fish.	Unknown	Cui, G.-H., W. Zhou and J.-H. Lan. 1993.
Discogobio yunnanensis	Not Evaluated	LC	Food fish.	Unknown	Zheng, L. And W. Zhou. 2008
Distoechodon tumirostris	Not Evaluated	LC	Food fish.	Unknown	Shen, S.C. (ed.). 1993
Formosania tinkhami	Not Evaluated	LC	Food fish.	Unknown	Zheng, C.-Y. 1991
Garra orientalis	Not Evaluated	LC	Food fish.	Unknown	Huang, H.C. 1987
Garra yiliangensis	Not Evaluated	DD	Food fish.	Possibly Extinct	CHU XIN-LUO CUI GUI-HUA. 1987
Glossogobius olivaceus	Not Evaluated	LC	Commercial fisheries.	Decline	Thi, N. N. And Quan, N. V. 2006
Glyptothorax fokiensis	Not Evaluated	LC	Food fish.	Decline	Zhengciyin. 1989
Glyptothorax pallozonus	Not Evaluated	NT	Ornamental fish.	Near Threaten-ed	Zhengciyin. 1989
Gnathopogon taeniellus	Not Evaluated	DD	None.	Unknown	Yue, P. 1998
Gobiobotia longibarba	Not Evaluated	DD*	Food fish.	Unknown	ZHANG E; LIU Huan-zhang. 1995
Gobiobotia tungi	Not Evaluated	NT	Food fish.	Near Threaten-ed	Y.Y. Chen.1998
Hemibagrus macropterus	Not Evaluated	LC	Commercial and local fisheries	Unknown	Nelson, J.S. 1994
Hemibarbus longirostris	Not Evaluated	NT	Commercial fisheries.	Decline	Matsuura, K. And T. Yoshino. 1984
Hemiculter lucidus	Not	LC	Commercial fisheries.	Unknown	Bogutskaya,

Species binomial	National Red List status	IUCN Red List	Economic or livelihood value	Population trend in catchment	Source
	Evaluated				N.G. and Naseka, A.M. 1996
Hemiculter tchangi	Not Evaluated	DD	Minor commercial fisheries.	Unknown	Luo, Y. And Y. Chen. 1998
Hemiculterella sauvagei	Not Evaluated	LC	Minor commercial fisheries.	Unknown	Lu, K. 1991
Hemimyzon macroptera	Not Evaluated	LC	Food fish.	Unknown	Zhengciyin. 1989
Huigobio chenhsienensis	Not Evaluated	LC	Minor commercial and local fisheries	Unknown	Yue, P. 1998
Hypophthalmichthys molitrix	Not Evaluated	NT	Food fish.	Decline	Skelton, P.H. 1993
Hypseleotris compressocephalus	Not Evaluated	LC	None.	Increase	Zhengciyin. 1989
Leptobotia guilinensis	Not Evaluated	LC	Food fish.	Unknown	Zhu, S.-Q. 1995
Leptobotia pellegrini	Not Evaluated	LC	Food fish.	Unknown	Ye, G. 1991
Liniparhomaloptera disparis ssp. disparis	Not Evaluated	NA	Food fish.	Unknown	Zhengciyin. 1989
Megalobrama amblycephala	Not Evaluated	LC	Food fish.	Unknown	Zhu, S.-Q. 1995
Micronemacheilus pulcher	Not Evaluated	LC	Ornamental species.	Unknown	Zhengciyin. 1989
Microphysogobio chinssuensis	Not Evaluated	LC	Food fish.	Unknown	Zhu, S.-Q. 1995
Microphysogobio fukiensis	Not Evaluated	LC	Food fish.	Unknown	Jin, X. 1991
Microphysogobio kiatingensis	Not Evaluated	LC	Food fish.	Unknown	Jin, X. 1991
Microphysogobio tafangensis	Not Evaluated	LC	Ornamental fish and a food fish.	Unknown	Yue, P. 1998
Microphysogobio tungtingensis	Not Evaluated	NT	None	Decline	Zhang, T. And Li, Z. 2007
Neosalanx tangkahkeii	Not Evaluated	LC	Commercial and local fisheries	Unknown	Froese, R. And Pauly, D. 2010
Odontobutis obscura	Not Evaluated	Introduced	Commercial and local fisheries.	Unknown	Shao, K.-T. And Lim, P.L. 1991
Onychostoma barbatum	Not Evaluated	DD	Minor commercial fisheries.	Decline	Shan, X., Lin, R., Yue, P. And Chu, X. 2000
Onychostoma rarum	Not	DD	Used in local fisheries	Decline	Shan, X., Lin,

Species binomial	National Red List status	IUCN Red List	Economic or livelihood value	Population trend in catchment	Source
	Evaluated				R., Yue, P. And Chu, X. 2000
Parabotia banarescui	Not Evaluated	DD	Food fish.	Unknown	Zhu, S.-Q. 1995
Parabotia lijiangensis	Not Evaluated	DD	Ornamental fish and a food fish.	Unknown	Zhu, S.-Q. 1995
Parabotia maculosa	Not Evaluated	LC	Food fish.	Unknown	Zhengciyin. 1989
Paracobitis variegatus ssp. variegatus	Not Evaluated	NA	Food fish.	Unknown	Wu, Y. And Wu, C. 1992
Paralepidocephalus yui	Not Evaluated	EN	Food fish.	Decline	Zhengciyin. 1989
Paranemachilus genilepis	Not Evaluated	DD	Ornamental fish.	Unknown	Zhengciyin. 1989
Parasinilabeo assimilis	Not Evaluated	VU	Commercial and local fisheries.	Decline	Kottelat, M. And E. Zhang. 2003
Pareuchiloglanis longicauda	Not Evaluated	LC	Food fish.	Unknown	Chu xin luo. 1999
Pelteobagrus argentivittatus	Not Evaluated	LC	Commercial and local fisheries.	Unknown	IUCN. 2010
Percocypris pingi	Not Evaluated	NT	Commercial fisheries and aquaculture.	Decline	Wu, Y. And C. Wu. 1992
Platysmacheilus exiguus	Not Evaluated	LC	Minor commercial and local fisheries	Unknown	Jin, X. 1991
Poropuntius chonglingchungi	Not Evaluated	CR	Minor commercial and local fisheries	Possibly Extinct	Zhang, E. And F. Fang. 2005
Pseudobagrus albomarginatus	Not Evaluated	DD*	Food fish.	Unknown	IUCN. 2010
Pseudobagrus ondon	Not Evaluated	LC	Food fish.	Unknown	IUCN. 2010
Pseudogastromyzon changtingensis ssp. changtingensis	Not Evaluated	NA	Food fish.	Unknown	Zhang, E., Yue, P. And Chen, J. 2000
Pseudogastromyzon fangi	Not Evaluated	LC	Food fish.	Unknown	Zheng, C. 1989
Pseudogastromyzon myersi	Not Evaluated	LC	None.	Unknown	Zheng, C. 1989
Pseudogobio vaillanti	Not Evaluated	LC	Commercial and local fisheries.	Unknown	Zhengciyin. 1989
Pseudogyrinocheilus prochilus	Not Evaluated	LC	Food fish.	Unknown	Zhengciyin. 1989
Pseudolaubuca engraulis	Not Evaluated	LC	Food fish.	Unknown	Y.Y. Chen, X.L. Chu, Y.L. Luo,

Species binomial	National Red List status	IUCN Red List	Economic or livelihood value	Population trend in catchment	Source
					Y.R. Chen, H.Z. Liu, M.G. He et al. 1998
Pseudorasbora elongata	Not Evaluated	LC	Minor ornamental fish	Unknown	Yue P.-Q. And Chen Y.-Y
Pterocryptis anomala	Not Evaluated	LC	Food fish.	Unknown	HEOK HEE NG and BOSCO P.-L. CHAN. 2005
Ptychidio jordani	Not Evaluated	CR	Food fish.	Endanger	Zhengciyin. 1989
Ptychidio macrops	Not Evaluated	DD	Food fish.	Unknown	Zhengciyin. 1989
Rectoris luxiensis	Not Evaluated	DD	Food fish.	Unknown	Zhengciyin. 1989
Rhodeus fangi	Not Evaluated	LC	Ornamental fish and livestock fodder.	Unknown	Zhengciyin. 1989
Rhodeus lighti	Not Evaluated	LC	Unknown.	Unknown	Y.Y. Chen, X.L. Chu, Y.L. Luo, Y.R. Chen, H.Z. Liu, M.G. He et al. 1998
Rhodeus sinensis	Not Evaluated	LC	Livestock fodder.	Unknown	Zhengciyin. 1989
Sarcocheilichthys kiangsiensis	Not Evaluated	DD*	None.	Unknown	Zhengciyin. 1989
Sarcocheilichthys parvus	Not Evaluated	LC	Potential ornamental fish.	Unknown	Zhengciyin. 1989
Sarcocheilichthys sinensis	Not Evaluated	LC	Commercial fisheries.	Decline	Zhengciyin. 1989
Schizothorax wangchiachii	Not Evaluated	NT	Food fish.	Unknown	Huang, H.C. 1987
Silurus meridionalis	Not Evaluated	LC	Aquaculture fish.	Unknown	Xie xiao jun. 1996
Sinibotia zebra	Not Evaluated	DD	Food fish.	Unknown	Kottelat, M. 2004
Sinibrama macrops	Not Evaluated	LC	Common commercial fisheries.	Decline	Zhengciyin. 1989
Siniperca fortis	Not Evaluated	DD	Food fish.	Unknown	Zhengciyin. 1989
Siniperca obscura	Not Evaluated	LC	Food fish.	Unknown	Zhengciyin. 1989
Siniperca roulei	Vulnerable	DD	Ornamental fish and food fish.	Decline	Zhengciyin. 1989

Species binomial	National Red List status	IUCN Red List	Economic or livelihood value	Population trend in catchment	Source
Siniperca undulata	Not Evaluated	NT	A highly prized commercial fish.	Unknown	Yue P.-Q. And Chen Y.-Y. 1998
Sinocyclocheilus guilinensis	Not Evaluated	NA	None.	Unknown	Yahui Zhao. 2009
Sinocyclocheilus tingi	Not Evaluated	EN	Food fish.	Decline	Xiong fei. 2006
Sinocyclocheilus yangzongensis	Not Evaluated	CR	Food fish.	Decline	Gao Li Cun. 1980
Sinogastromyzon sichangensis	Not Evaluated	LC	Commercial and local fisheries.	Unknown	Zheng, C. 1989
Sinogastromyzon szechuanensis	Not Evaluated	LC	Food fish.	Unknown	Zhengciyin. 1989
Sinogastromyzon wui	Not Evaluated	LC	Food fish.	Unknown	Zheng, C. 1989
Squalidus wolterstorffi	Not Evaluated	LC	Food fish.	Unknown	Hwang, H.C., Chen, I.Y. and Yueh, P.C. 1988
Tachysurus fulvidraco	Not Evaluated	LC	Important food fish, aquaculture.	Unknown	Zheng, b. And d. Dai 1999
Takifugu orbimaculatus	Not Evaluated	LC	Medicinal use.	Decline	Zhengciyin. 1989
Tor yunnanensis	Not Evaluated	EN	None.	Possibly extinct	Xiong fei. 2006
Vanmanenia pingchowensis	Not Evaluated	LC	Food fish.	Unknown	Zhengciyin. 1989
Onychostoma barbatulum	Not Evaluated	DD	Food fish.	Decline	Zhengciyin. 1989
Yaoshanicus arcus	Not Evaluated	LC	None.	Unknown	Zhengciyin. 1989
Yunnanilus nigromaculatus	Not Evaluated	EN	None .	Possibly extinct	Zheng, C. 1989

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3.3.2. Field survey methods

The information provided by the literature is not at a high enough resolution to allow us to identify the species at the three fishing villages and some of the information is out of date as the environmental conditions at the sites have changed significantly in recent years. Therefore we undertook a field survey, market survey and interviewed fishermen to identify what species are found at the sites.

Market surveys

Small local markets situated near the three sampling fishing villages (Lishi, Kengkou and Zhoutian) were visited 6 times in total, in 2009 and 2010. At each market the fish stall holders were surveyed and species were identified. Information on the location the species were harvested from, who the fishers are, catch trends (according to the stall holder) were noted, and the value of different fish species were recorded. Photographs of fishes were taken.

Field surveys

In August 2010, fishers were accompanied to their fishing sites and their catches and location (using a GPS) on where species were caught was recorded. The methods used by the fishers were:

Nets: Gillnets are versatile, low cost, and easy to operate. The size of the nets used was usually 1.5 meters high and 60-80 meters long (Figure 8).

Other methods: Traps come in a wide range of sizes and designs including net-trap (Figure 8), small 'basket traps' and 'fence traps' which direct the fish into baskets.

The locations of fish field surveys in the three fishing villages are shown in Figures 4, 5 and 6.


Figure 8. Nets (left) and net-trap (right) for fishing in Beijiang River, China

3.3.3. Field survey results

Distribution of fish resources along river

The richness of fish resources of each fishing ground of the three villages were differentiated into 3 types: low, normal or rich fish resources. Usually fish resources were rich behind the dams of hydropower stations with deep water, and poor in front of the dams or in certain sections of the river with shallow water (the areas of rich fish resources are noted in the site maps in Figures 4, 5 and 6).

Fish species composition

A total of 26 species of freshwater fishes, belonging to 23 genera, 7 families and 3 orders were found in the 3 fishing villages, 3 of which are non native species (Table 3 and 4). Among them, there are 20 species of cypriniformes, making up 76.9% of the total, 4 species of perciformes, or 15.4% of the total, 2 species of siluriformes, or 7.7% of the total (Table 4, Figures 9). Further information regarding the species economic importance, habitat, IUCN Red List status and population trends is provided in Table 5. Figure 10 shows some of the fish species photographed during the fish surveys.

Table 3. The proportion of species belonging to each order

Order	Family	Genus	Species	Percentage
Siluriformes	2	2	2	7.7%
Perciformes	3	3	4	15.4%
Cypriniformes	2	18	20	76.9%
total	7	23	26	100.0%

Table 4. Fish species from the survey in the 3 fishing villages and their higher taxonomy

Species	Family	Order	Location
Micronoemacheilus pulcher	Balitoridae	Cypriniformes	Zhoutian
Schistura fasciolata	Balitoridae	Cypriniformes	Zhoutian
Schistura incerta	Balitoridae	Cypriniformes	Lishi
Sinibotia robusta	Cobitidae	Cypriniformes	Lishi

Species	Family	Order	Location
Sinibotia pulchra	Cobitidae	Cypriniformes	Lishi
Cobitis sinensis	Cobitidae	Cypriniformes	Lishi, Zhoutian
Misgurnus anguillicaudatus	Cobitidae	Cypriniformes	Lishi, Zhoutian, Kengkou
Metzia formosae	Cyprinidae	Cypriniformes	Lishi
Pseudohemiculter dispar	Cyprinidae	Cypriniformes	Lishi, Zhoutian, Kengkou
Toxabramis houdemeri	Cyprinidae	Cypriniformes	Lishi, Zhoutian, Kengkou
Sarcocheilichthys parvus	Cyprinidae	Cypriniformes	Lishi, Zhoutian, Kengkou
Pseudogobio vaillanti	Cyprinidae	Cypriniformes	Lishi, Zhoutian, Kengkou
Abbottina rivularis	Cyprinidae	Cypriniformes	Lishi, Zhoutian, Kengkou
Microphysogobio fukiensis	Cyprinidae	Cypriniformes	Lishi
Saurogobio dabryi	Cyprinidae	Cypriniformes	Lishi, Zhoutian, Kengkou
Rhodeus lighti	Cyprinidae	Cypriniformes	Lishi, Zhoutian, Kengkou
Acheilognathus tonkinensis	Cyprinidae	Cypriniformes	Lishi, Zhoutian, Kengkou
Puntius semifasciolatus	Cyprinidae	Cypriniformes	Lishi, Zhoutian, Kengkou
Cyprinus carpio carpio	Cyprinidae	Cypriniformes	Lishi, Zhoutian, Kengkou
Carassius auratus auratus	Cyprinidae	Cypriniformes	Lishi, Zhoutian, Kengkou
Pterocryptis cochinchinensis	Siluridae	Siluriformes	Lishi, Zhoutian, Kengkou
Tachysurus fulvidraco	Bagridae	Siluriformes	Lishi, Zhoutian, Kengkou
Rhinogobius giurinus	Gobiidae	Perciformes	Lishi, Zhoutian, Kengkou
Macropodus opercularis	Osphronemidae	Perciformes	Lishi, Zhoutian, Kengkou
*Macrognathus aculeatus**	Mastacembelidae	Perciformes	Lishi
Mastacembelus armatus	Mastacembelidae	Perciformes	Lishi, Zhoutian, Kengkou

**Macrognathus aculeatus* – this record is probably misnamed as due to taxonomic revision this species is now only found in Indonesia.

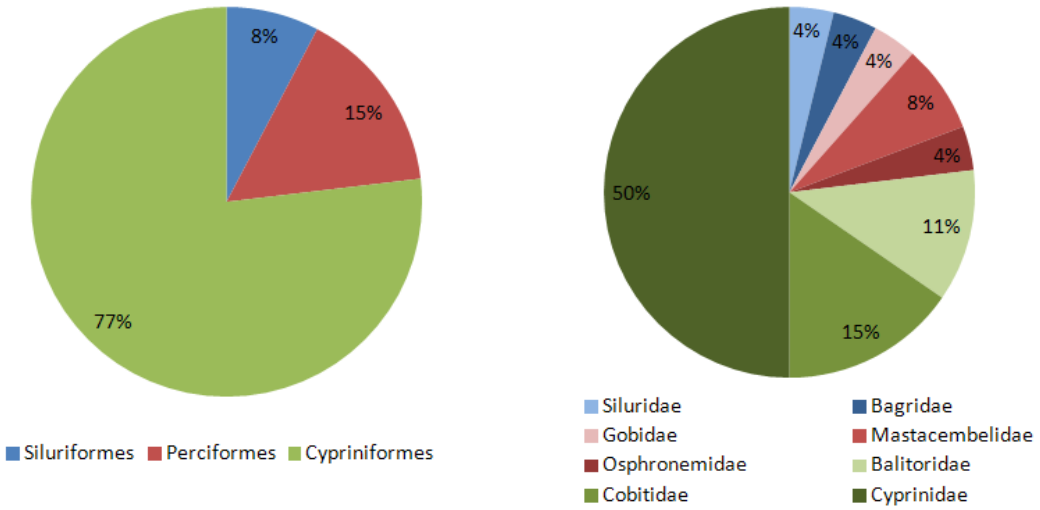

Figure 9. Proportion of species identified at the 3 fishing villages belonging to different orders (left) and families (right)

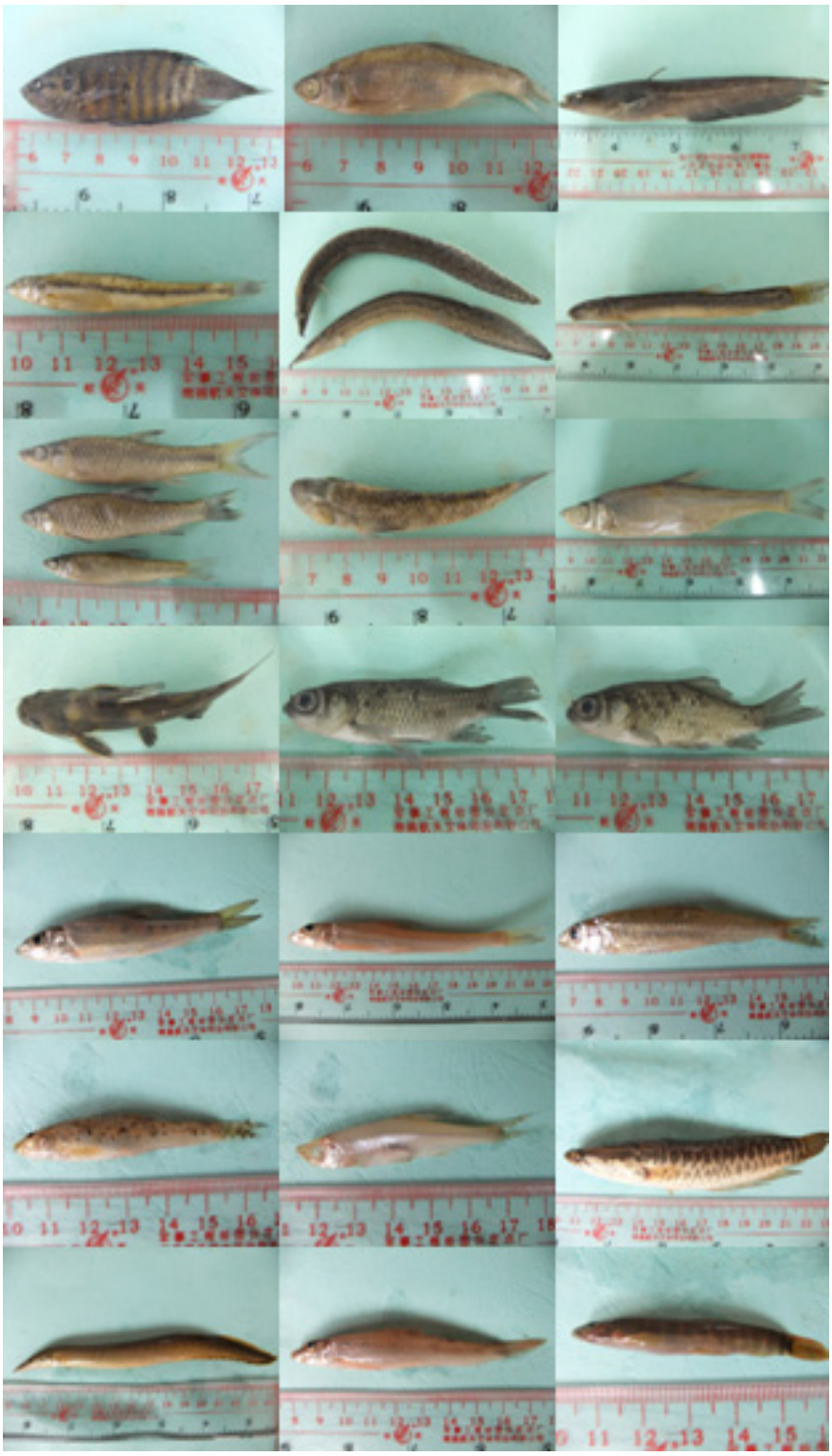

Figure 10. Photos of some of the fish specimens from Beijiang River

Table 5. Fish species identified from the three fishing villages through field and market surveys

The IUCN Red List categories are EX – Extinct; EW Extinct in the Wild; CR – Critically Endangered; EN – Endangered; VU – Vulnerable; NT – Near Threatened; LC – Least Concern; DD – Data Deficient; NA – Not assessed. The categories CR, EN and VU are classed as the 'threatened' categories. '*' indicates a draft Red List assessment, that still needs to be peer reviewed.

Species binomial	National Red List status	IUCN Red List	Economic importance	Population trends at the site	Habitat/sample site recorded from
Micronemacheilus pulcher	Not Evaluated	LC	None	Unknown	Streams on sand and gravel bottom.
Schistura fasciolata	Not Evaluated	DD	None	Unknown	Rapid current streams.
Schistura incerta	Not Evaluated	DD*	None	Unknown	Streams on the bottom.
Sinibotia robusta	Not Evaluated	DD	Commercial fisheries	Unknown	Inhabit in bottom parts of clear flowing water with sandy bottoms.
Sinibotia pulchra	Not Evaluated	DD*	None	Unknown	Inhabit in bottom parts of streams and main rivers in clear, moderately or slowly flowing water with some aquatic plants.
Cobitis sinensis	Not Evaluated	LC*	Subsistence fisheries	Unknown	Benthopelagic
Misgurnus anguillicaudatus	Not Evaluated	LC*	Commercial fisheries	It is a common but declining species in Beijiang River.	Found in rivers, lakes and ponds.
Metzia formosae	Vulnerable	LC	None	Unknown	Clear, still or slow moving waters of small rivers
Pseudohemiculter dispar	Not Evaluated	VU	Important commercial fisheries	It is a common but declining species in Beijiang River.	Benthopelagic
Toxabramis houdemeri	Not Evaluated	LC	None	Unknown	Benthopelagic
Sarcocheilichthys parvus	Not Evaluated	LC	None	Unknown	Bottom parts of clear flowing water with gravel bottoms.
Pseudogobio vaillanti	Not Evaluated	LC	Commercial fisheries	Unknown	Benthopelagic
Abbottina rivularis	Not Evaluated	Not Evaluated	Important commercial fisheries	Increasing	Inhabits shallow zones of lentic rivers and lakes with sandy or muddy bottoms.
Microphysogobio fukiensis	Not Evaluated	LC	None	Unknown	Benthopelagic

Species binomial	National Red List status	IUCN Red List	Economic importance	Population trends at the site	Habitat/sample site recorded from
Saurogobio dabryi	Not Evaluated	LC*	Low economic value	Unknown	Benthopelagic
Rhodeus lighti	Not Evaluated	LC	None	Unknown	Bottom parts of streams and main rivers.
Acheilognathus tonkinensis	Not Evaluated	DD	Likely to be found in local fisheries	Unknown	Inhabits bottom parts of streams and main rivers in clear, moderately or slowly flowing water with some aquatic plants.
Puntius semifasciolatus	Not Evaluated	DD*	None	Unknown	Benthopelagic
Cyprinus carpio	Not Evaluated	Introduced	Important commercial fisheries	Increasing	Inhabit warm, deep, slow-flowing and still waters
Carassius auratus	Not Evaluated	LC	Important commercial fisheries	Increasing	Benthopelagic
Pterocryptis cochinchinensis	Not Evaluated	LC	Commercial fisheries	Unknown	Benthopelagic
Tachysurus fulvidraco	Not Evaluated	LC	Commercial fisheries	Unknown	Benthopelagic
Rhinogobius giurinus	Not Evaluated	LC	Subsistence fisheries	Unknown	Inhabits bottom parts of streams and main rivers in clear flowing water with sandy or gravel bottoms.
Macropodus opercularis	Not Evaluated	LC	None	Unknown	Found in streams, paddy fields and ditches.
*Macrognathus aculeatus**	Not Evaluated	NA	Commercial fisheries and aquarium trade	Unknown	Benthopelagic
Mastacembelus armatus	Not Evaluated	LC	Commercial fisheries and aquarium trade	Unknown	Benthopelagic
Channa maculata	Not Evaluated	LC	Commercial fisheries	Unknown	The species inhabits silty and weedy bottoms of still water or slow-running river with lots of caves and aquatic vegetation to hide.

**Macrognathus aculeatus* – this record is probably a different species as due to taxonomic revision this species is now only found in Indonesia.

Of the species identified at the sites, only *Pseudohemiculter dispar* is globally threatened (discussed in section 3.2), and *Metzia formosae* is nationally threatened. *Metzia formosae* is a widespread species known from southeast Asia in southern China, Lao P.D.R. and Viet Nam and it is thought that the species may be impacted by pollution and dams. The majority of the species population trends at the site are unknown, but two species are known to be declining *Pseudohemiculter dispar* and *Misgurnus anguillicaudatus*. Three species have populations that are currently increasing at the sites *Abbottina rivularis*, *Carassius auratus* and the introduced *Cyprinus carpio*. Over half of the species have value to livelihoods, either through subsistence fisheries (4 species) or through commercial fisheries (12 species), 11 species have no direct livelihood value.

It is important to note that for the species where the populations trends are 'unknown', it should not be assumed that they are stable or increasing. Historically, the fish resources in Beijiang River were very rich with harvests reaching 8,000 tons annually in the 1950's. The species captured included eel (*Anguilla japonica*), grass carp (*Ctenopharyngodon idella*), black Chinese roach (*Mylopharyngodon piceus*), mud carp (*Cirrhinus molitorella*), triangular bream (*Megalobrama terminalis*), eastern barbell (*Squaliobarbus curriculus*), *Spinibarbus hollandi*, spotted long barbell catfish (*Hemibagrus guttatus*), and some local rare species, such as *Sinilabeo decorus*, *Sinilabeo discognathoides*, *Ptychidio jordani*, *Tor (Folifer) brevifilis*. However, fish resources have been decreasing, and the annual fishing production has not been more than 2,000 tons since 2000. Most of the fish species captured were of the low valued species such as *Saurogobio dabryi*. The traditionally high value economic species such as *Pseudohemiculter dispar* and *Misgurnus anguillicaudatus* are decreasing. The only species that are known to be increasing at the site are the non-native species *Cyprinus carpio* and the native *Carassius auratus*. Although the total aquatic production was continuously increasing since 1970, but the percentage from river fishing are decreasing. Species of conservation concern such as the Asian giant soft-shell turtle (*Pelochely bibroni*), marbled eel (*Anguilla marmorata*), hilsa herring (*Macrura reevesii* Richardson), wattle-necked soft-shell turtle (*Palea steindachneri*), *Luciobrama macrocephalus* (Lacépède, 1803) are very rare in north river today (Le, 1998).

3.4. Molluscs

3.4.1. Literature review

There is limited information available on the mollusc fauna of the Beijiang River. Only two publications have been identified, and are listed below. Through these publications 40 species of freshwater molluscs have been identified to occur in the Pearl River (Table 6). All of the species identified are globally assessed on the IUCN Red List as Least Concern or Data Deficient. However two species both gastropods, are classed as threatened on the Chinese national Red List, *Bellamya limnophila* (EN) and *Cipangopaludina ampulliformis* (VU). *Bellamya limnophila* is endemic to China and recorded from the lakes in Yunnan province and the eastern provinces and is threatened by water pollution, overharvesting and destructive fishing methods. IUCN classify this species as DD as the assessors question the validity of this species as a distinct species and state it needs taxonomic revision. *Cipangopaludina ampulliformis* is found in southern and eastern China and central Viet Nam, it has a small and fragmented population in China that is slowly declining due to overharvesting and water pollution (Sung and Yan 2005). Only four species have no direct livelihood value, with the vast majority

providing either food for humans or livestock, medicine or are even used for art and jewellery purposes (buttons or pearls).

Table 6. Mollusc species identified from Pearl River based on literature surveys.

The IUCN Red List categories are EX – Extinct; EW Extinct in the Wild; CR – Critically Endangered; EN – Endangered; VU – Vulnerable; NT – Near Threatened; LC – Least Concern; DD – Data Deficient. NA – Not assessed. The categories CR, EN and VU are classed as the 'threatened' categories. '*' indicates a draft Red List assessment, that still needs to be peer reviewed.

Species binomial	Common name	National Red List status	IUCN Red List	Economic importance	Population trends at the site/wider catchment	Source
Pila tischbeini	none	Not evaluated	NA	Food species.	Unkown	Yueying L. et al., 1979
Assiminea lutea	none	Not evaluated	LC*	None	Unkown	Yueying L. et al., 1979
Corbicula nitens	clam	Not evaluated	DD*	Used for food, animal feed and traditional Chinese medicine	Unkown	Yueying L. et al., 1979
Alocinma longicornis	Angle bean snail, B snail	Not evaluated	LC*	Used for animal feed	Unkown	Yueying L. et al., 1979
Parafossarulus striatulus	None	Not evaluated	LC*	Used for animal feed	Unkown	Yueying L. et al., 1979
Stenothyra glabra	None	Not evaluated	LC	Used for animal feed	Unkown	Yueying L. et al., 1979
Radix plicatula	Lymnaea, mark snail	Not evaluated	LC*	Used for animal feed	Unkown	Yueying L. et al., 1979
Limnoperna lacustris	none	Not evaluated	LC*	Important for local livelihoods (for food and animal feed)	Unkown	Yueying L. et al., 1979
Gyraulus chinensis	none	Not evaluated	LC	Used for feed	Unkown	Yueying L. et al., 1979
Tricula gregoriana	Ge's Tricula aperta	Not evaluated	DD*	None	Unkown	Yueying L. et al., 1979
Semisulcospira cancellata	none	Not evaluated	LC*	Used for animal feed	Unkown	Yueying L. et al., 1979
Acuticosta chinensis	clam	Not evaluated	LC	Used as raw material for making buttons and art ware, and also as animal feed	Unkown	Yueying L. et al., 1979
Acuticosta lanceolata	Banana clam	Not evaluated	NA	Some importance for local livelihoods (buttons, art ware and animal feed)	Unkown	Yueying L. et al., 1979
Acuticosta ovata	none	Not evaluated	LC	Used for buttons, art ware and animal	Unkown	Yueying L. et al., 1979

Species binomial	Common name	National Red List status	IUCN Red List	Economic importance	Population trends at the site/wider catchment	Source
				feed		
Anodonta fluminea	clam	Not evaluated	NA	Use for food, animal feed and traditional Chinese medicine	Unkown	Yueying L. et al., 1979
Anodonta globosula	Food clam	Not evaluated	NA	Little economic use	Unkown	Yueying L. et al., 1979
Cuneopsis capitata	Old duck lips	Not evaluated	LC	Use for food, animal feed and traditional Chinese medicine	Unkown	Yueying L. et al., 1979
Cuneopsis celtiformis	none	Not evaluated	LC	Use for food, animal feed and traditional Chinese medicine	Unkown	Yueying L. et al., 1979
Cuneopsis heudei	Lair thief, cone clam	Not evaluated	LC	Use for food, animal feed and traditional Chinese medicine	Unkown	Yueying L. et al., 1979
Cuneopsis pisciculus	Ox horn	Not evaluated	LC	Use for food, animal feed and traditional Chinese medicine	Unkown	Yueying L. et al., 1979
Hyriopsis cumingii	Trigonioid es	Not evaluated	LC	Commercial use for producing freshwater pearls, and used for food, animal feed, buttons and art ware	Declining in the catchment	Yueying L. et al., 1979
Lamprotula caveata	none	Not evaluated	LC	Use for buttons and art ware	Unkown	Yueying L. et al., 1979
Lamprotula fibrosa	Old wozi	Not evaluated	LC	Important use buttons and art ware	Unkown	Yueying L. et al., 1979
Lamprotula leai	Pig ears clam	Not evaluated	LC	Important use buttons and art ware	Declining in the catchment	Yueying L. et al., 1979
Lamprotula mansuyi	Buddha ears clam, White jade clam	Not evaluated	NA	Use for food, animal feed, buttons and traditional Chinese medicine	Declining in the catchment	Yueying L. et al., 1979
Lamprotula tientsinensis	White jade clam	Not evaluated	DD	Important use for buttons and art	Unkown	Yueying L. et al., 1979

Species binomial	Common name	National Red List status	IUCN Red List	Economic importance	Population trends at the site/wider catchment	Source
				ware		
Lamprotula zonata	none	Not evaluated	DD	Use for buttons and art ware	Unkown	Yueying L. et al., 1979
Lanceolaria gladiola	Salt note, Long clam	Not evaluated	LC	Used for food, animal feed and buttons	Unkown	Yueying L. et al., 1979
Lanceolaria triformis	Salt note	Not evaluated	DD	Used for food, animal feed and buttons	Unkown	Yueying L. et al., 1979
Lepidodesma languilati	Green shell clam	Not evaluated	DD	Used for food and animal feed	Unkown	Yueying L. et al., 1979
Schistodesmus lampreyanus	Gold and silver bread，lake clam	Not evaluated	LC	Used for food, animal feed, buttons and traditional Chinese medicine	Unkown	Yueying L. et al., 1979
Schistodesmus spinosus	Gold and silver bread	Not evaluated	LC	Little economic use	Unkown	Yueying L. et al., 1979
Angulyagra polyzonata	none	LC	LC	Used for food and animal feed	Distribute widely	Yueying L. et al., 1979
Bellamya aeruginosa	stone clam	LC	LC*	Used for food and animal feed	Distribute widely	Yueying L. et al., 1979
Bellamya limnophila	snail	EN	DD	Used for food	Population is small	Wangsong et al., 2004
Bellamya purificata	snail	LC	LC	Used for food, animal feed and traditional Chinese medicine	Distribute widely	Yueying L. et al., 1979
Bellamya quadrata	snail, stone clam	LC	LC	Important use for food, animal feed and traditional Chinese medicine	Distribute widely	Yueying L. et al., 1979
Cipangopaludina ampulliformis	field clam	VU	LC	Very important use for food and animal feed	The population is small	Yueying L. et al., 1979, Wangsong et al., 2004
Cipangopaludina cathayensis	snail	LC	LC	Very important use for food and animal feed	Distribute widely	Yueying L. et al., 1979
Cipangopaludina chinensis	snail	LC	LC	Important use for food, animal feed and traditional Chinese medicine	Distribute widely	Yueying L. et al., 1979

Reference used for molluscs literature review:

1. Yueying, L., Wenzhen, Z., Yuexian, W. and Enyi, W. 1979. Economic animal fauna of China (Freshwater molluscs) [M]. Beijing. Science Press.
2. Sung, W and Yan, X. 2005. China Species Red List. Volume 3 Invertebrates. Biodiversity Working Group of China Council for International Cooperation on Environment and Development. Higer Education Press.

3.4.2. Field survey methods

A field species survey along with fishermen interviews were undertaken as the information provided by the literature was not at a high enough resolution to allow us to identify the species at the three fishing villages, also the information could be out of date as the environmental conditions at the site have changed significantly in recent years.

The mollusc field surveys were carried out in August 2010 and the locations were the same as for the fish surveys (see Figures 4, 5 and 6). The sampling methods used were as follows.
1 - Hand-sampling - This is only feasible in the shallow margins or bank of rivers.
2 - Using a hand-net (triangle net see Figure 11) - Used in shallow and easily accessible water.
3 - Fishing nets - Fishermen often catch molluscs along with fish using fish nets.

Figure 11. Hand-net (triangle net) used for sampling molluscs

3.4.3. Field survey results

Eight species of freshwater mollusc were recorded at the three fishing villages, one of which is a non-native introduced species (Table 7). All of the species are either Least Concern or Data Deficient according to their global IUCN Red List status, but one species *Cipangopaludina ampulliformis* is classed as Vulnerable by the Chinese national Red List (discussed in 3.4.1.). All the species have some form of livelihood value as all are harvested either for animal feed or human use as medicine or food.

Table 7. Molluscs species from the three sites in Beijiang River through field surveys.

The IUCN Red List categories are EX – Extinct; EW Extinct in the Wild; CR – Critically Endangered; EN – Endangered; VU – Vulnerable; NT – Near Threatened; LC – Least Concern; DD – Data Deficient. The categories CR, EN and VU are classed as the 'threatened' categories. '*' indicates a draft Red List assessment, that still needs to be peer reviewed.

Species binomial	**Common name *(local name)***	**National Red List status**	**IUCN Red List**	**Economic importance**	**Population trends at the site**	**Habitat/sample site recorded from**
Corbicula fluminea	Gold clam, yellow clam	Not Evaluated	LC	Important as food, animal feed, and traditional Chinese medicine. It can also be used for calcined lime CaO	Unknown	Lishi, Kengkou and Zhoutian.
Semisulcospira libertina	Chuan quan snail	Not Evaluated	LC	Used for animal feed	Common	Lishi, Kengkou and Zhoutian.
Melanoides tuberculatus	Chuan quan snail	Not Evaluated	LC	Used for animal feed	Unknown	Lishi
Semisulcospira sp.	None	Not Evaluated	DD	Used for animal feed	Unknown	Lishi, Kengkou and Zhoutian.
Cipangopaludina chinensis	snail	LC	LC	Important use for food, animal feed and traditional Chinese medicine	Distributed widely	Lishi, Kengkou and Zhoutian.
Cipangopaludina ampulliformis	field snail	VU	DD	Very important use for food and animal feed	Small population and sensitive to declines in habitat quality	Lishi, Kengkou and Zhoutian.
Angulyagra polyzonata	none	LC	LC	Used for food and animal feed	Distributed widely	Lishi
Ampullaria gigas	Fu Shou snail	Not Evaluated	Introduced species	Used for animal feed	Common	Lishi, Kengkou and Zhoutian.

Indicator species

Benthic organisms (such as molluscs) are valuable bio-indicators for water quality, especially for the quality of water and sediment. For example, *Cipangopaludina chinensis* is very sensitive to polluted water, and *Semisulcospira libertina* is very sensitive to even slightly polluted water (Deng *et al*. 2007). Since a lot of *Semisulcospira libertina* can be caught from the three sampling sites, it indicates that the water and sediment of the investigated water was not seriously polluted at present. Both these species can be used as indicators to monitor water quality through regular field surveys.

Threats to molluscs

There are very few surveys on mollusc resources in the Beijiang in recent years. Through interviews with fishermen, the number of species and numbers individuals has been found reducing gradually. The main reasons are as follows: (1) The habitats of many mollusc species have been destroyed by dams and dredging etc; (2) Water pollution is increasing with pyrite, and oil; (3) Major floods, the last in 2006, which bring large levels of sand and sediment which cover the molluscs and their habitats (4) Over-harvesting, also there is no artificial breeding or stocking; (5) The invasion of the introduced *Ampullariua gigas* (native specie of Amazon River basin, and introduced into China in 1981). A large number of apple snail (*Ampullarius gigas*) was found in the water surveyed. Due to its rapid growth, amphibious nature, strong reproduction ability and adaptability, it has spread and formed populations in most parts of south China, and now threatens biodiversity and ecosystems where it is found (Yang et al, 2010). Therefore, some preventive and control measures should be taken, again without having a negative impact to the native mollusc fauna.

Economic significance and human disease control

Some large molluscs such as *Corbicula fluminea, Cipangopaludina chinensis* and *Cipangopaludina ampulliformis* provide good prospects for market development. For example, *Corbicula fluminea* has great aquaculture development prospects (nutritious and popular). It can be processed into dry clam or even processed in to canned product (Deng and Tang, 2007). However, of the 8 species of mollusc listed in Table 8, most of them are an intermediate host of human and livestock parasites (Liu *et al.,* 1979; Li *et al.,* 2009). It is important that the prevention and control of parasites (or the molluscs) is undertaken without harming the sustainable utilisation of the mollusc species.

3.5. Decapods (shrimps and crabs)

In addition to the groups that were specifically targeted for surveys, shrimps and crabs deserve a brief discussion as they are popular species caught by fishermen. Common species caught are *Procambarus clarkii* (Louisiana crayfish**)**, *Macrobranchium nipponense* (Giant Freshwater Prawn) and *Eriocheir sinensis* (Chinese mitten crab). However, *Procambarus clarkii* is an invasive alien species native to south-eastern United States, and holds a competitive advantage over native species and may damage the native ecology.

3.6. Aquatic plants

Aquatic plants are essential elements in aquatic ecosystems. They play an important role in food chains, energy flow, and the ecological succession of the aquatic ecosystems. Many species are also sensitive to pollution from urbanization and industrialization. Therefore, the aquatic plants have been chosen to be surveyed at the sites. The information obtained can reveal the potential impact of the economic development and urbanization on the aquatic resources in the Pearl River.

3.6.1. Literature review

According to Yu *et al.* (1998) there are 2 Extinct, 16 Endangered, 31 Vulnerable, 22 Rare and 44 Uncertain species of aquatic plants in China. Through reviewing the published literature and national and regional botanical monographs, a total of 233 aquatic plants were recorded in the Pearl River region – these are the species that had their IUCN Red List assessments undertaken

(see section 3.2 and Annex III). For Guangdong Province, 101 vascular aquatic plant species have been identified, 8 are submerged plants, 16 are emergent, and 5 are floating and 72 are classed as wetland (surviving in wet or water logged ground) (Table 8) (Yan 1989).

Table 8. Aquatic plants and their growth form present in Guangdong Province (Yan 1989).

	Submerged plants	Floating plants	Emergent plants	Wetland plant
Families	20	7	37	111
Genera	5	3	13	22
Species	8	5	16	72

There was very little information available on the aquatic plants of the Beijiang River. Based on literature available, only 17 aquatic plant species from 5 families and 11 genera have been identified as present in the Beijiang River, this is likely to be a large underestimate of the true number. Hydrocharitaceae and Potamogetonaceae have the most species present, the former having 6 genera and 8 species while the latter has 2 genera and 5 species (Table 9). Most aquatic plant species recorded in Beijiang River are widespread and categorized as Least Concern in the IUCN list.

Table 9. Aquatic plant species identified from Beijiang River based on literature surveys.

The IUCN Red List categories are EX – Extinct; EW Extinct in the Wild; CR – Critically Endangered; EN – Endangered; VU – Vulnerable; NT – Near Threatened; LC – Least Concern; DD – Data Deficient. The categories CR, EN and VU are classed as the 'threatened' categories.

Species binomial	National Red List status	IUCN Red List	Economic importance	Population trends at the site/wider catchment	Source
Blyxa aubertii	Not in the list	LC	unknown	No information	Ye *et al.* 2006
Blyxa octandra	Not in the list	LC	unknown	No information	Ye *et al.* 2006
Ceratophyllum demersum	Not in the list	LC	Ornamental plant; used for ecological restoration	No information	Ye *et al.* 2006
Hydrilla verticillata	Not in the list	LC	Fodder for fish and water purifying	No information	Ye *et al.* 2006
Myriophyllum spicatum	Not in the list	LC	Ornamental plant	No information	Ye *et al.* 2006
Myriophyllum verticillatum	Not in the list	Introduced	Ornamental plant	No information	Ye *et al.* 2006
Najas marina	Not in the list	LC	Fodder for fish	No information	Ye *et al.* 2006
Nechamandra alternifolia	Not in the list	LC	unknown	No information	Ye *et al.* 2006
Ottelia alismoises(*O. dioecia*)	Not in the list	LC	Chinese medicine	No information	Ye *et al.* 2006

Species binomial	National Red List status	IUCN Red List	Economic importance	Population trends at the site/wider catchment	Source
Potamogeton crispus	Not in the list	LC	Fodder for fish	No information	Ye *et al.* 2006
Potamogeton distinctus	Not in the list	LC	Fodder for fish	No information	Wu *et al.* 1992
Potamogeton pusillus	Not in the list	LC	Fodder for fish	No information	Ye *et al.* 2006
Potamogeton wrightii (*Potamogeton malaianus*)	Not in the list	LC	Fodder for fish	No information	Ye *et al.* 2006
Stuckenia pectinata (Potamogeton pectinatus)	Not in the list	LC	unknown	No information	Yan 1989; Ye *et al.* 2006
Utricularia aurea	Not in the list	LC	Ornamental plant	No information	Ye *et al.* 2006
Vallisneria denseserrulata	Not in the list	NA	Fodder for fish	No information	Yan 1989; Ye *et al.* 2006
Vallisneria natans	Not in the list	LC	Fodder for fish	No information	Ye *et al.* 2006

The references used in the aquatic plant review are listed below.

1 - Bao, B., Clemants, S.E., Thomas, B. 2003. In Wu Zhengyi. Flora of China. Vol. 9. Beijing: Science Press. 415-429

2 - Bingtao, L., Huaxing, Q. and Jinshuang, M. 2009. In Wu Zhengyi. Flora of China. Vol. 11. Beijing: Science Press. 197

3 - Chien, G. 1994. Flora bryyophytarum sinicorum. Vol. 1. Beijing: Science Press. 2-55

4 - Chi-ming, H. and Kelso, S. 2001. In Wu Zhengyi. Flora of China. Vol.15. Beijing: Science Press. 39-189

5 - Dan, Y., Yunxiao, Z. and Manghui, T. 1998. Study on the threatened aquatic higher plant species of China. Chinese Biodiverrsity. 6(1): 13-21

6 - Deyuan, H. and DeFilipps, R.A. 2006. In Wu Zhengyi. Flora of China. Vol.24. Beijing: Science Press. 19-39.

7 - Deyuan, H., Hanbi, Y. and Cunli, J. 2010. In Wu Zhengyi. Flora of China. Vol.18. Beijing: Science Press. 1-212

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3.6.2. Field survey methods

The aquatic plant surveys were conducted at the three sites within the Beijiang River watershed between 2009 and 2010 (see Figure 4, 5 and 6 for survey site locations). Line-transects were used to estimate the species composition and distribution of the submerged plant communities. A quadrat with an area of 1m X 1m was set up at a distance of 2m. In each quadrat, water depth, species composition, coverage, and heights of the submerged plants were recorded.

At Lishi the field surveys were undertaken between July and December in 2010. The submerged plant communities are located in the middle of the river covering an area of about 1,000 m^2 at a depth of about 1-2m (see Figures 12 and 13). At Kengkou Fishing Village the surveys were conducted in October 2009 and September 2010 and no submerged plant community was observed, but some specimens of floating plants were found in the water near the banks (invasive water hyacinth) (Figures 14). The third site Rujiang River near the town of Rucheng, was surveyed in October 2009. The river banks have been paved with concrete (Figure 15) and the water is clear and clean and the depth is 2-3.5m. The most common submerged plant identified was *Potamogeton wrightii* (Figure 16).

Figure 12. The river section along Lishi fishing village that is wide and deep

Figure 13. Aquatic plants found near Lishi fishing village.

Figure 14. River section along Kengkou Fishing Village with water hyacinth

Figure 15. Rujiang river section along Rucheng, which is clear and clean

Figure 16. *Potamogeton wrightii* in the Rujiang river section along Rucheng

3.6.3. Field survey results

A total of 11 species belonging to 4 families and 6 genera of submerged vascular plant species were found in our study sites, including 5 species of Potamogetonaceae and 4 species of Hydrocharitaceae (Table 10, Figure 17). Rujiang and Lishi had 9 and 8 species recorded respectively, 5 species were recorded in Kengkou and only 1 species in Zhoutian. Only one species, *Vallisneria natans*, was found in all four sites. *Hydrilla verticillata*, *Myriophyllum spicatum*, and *Potamogeton wrightii* were seen in all sites apart from Zhoutian. *Ceratophyllum demersum* and *Potamogeton crispus* were each found in two sites. *Potamogeton maackianus*, *P. pusillus*, and 2 species of Najas were all confined to one site, Lishi.

Table 10. Submerged plant species identified from site Beijiang through field surveys.

The IUCN Red List categories are EX – Extinct; EW Extinct in the Wild; CR – Critically Endangered; EN – Endangered; VU – Vulnerable; NT – Near Threatened; LC – Least Concern; DD – Data Deficient; NA – Not Assessed. The categories CR, EN and VU are classed as the 'threatened' categories. '*' indicates a draft Red List assessment, that still needs to be peer reviewed.

S1：Lishi；S2：Kengkou；S3：Zhoutian；S4：Rujiang.

Species binomial	National Red List status	IUCN Red List	Economic importance	Population trends at the site	Habitat/sample site recorded from	Habitat/sample site recorded from			
						S1	S2	S3	S4
Ceratophyllum demersum	Not assessed	LC	Ornamental plant for home decoration, used for ecological restoration	Declining due to habitat degradation. Rare or locally common.	Shallow areas with water depth between 0.3-2 m.	+	-	-	+
Hydrilla verticillata	Not assessed	LC	Used for raising pond fish and water purifying	Locally common, but declining due to habitat degradation	Intermediate areas between muddy and sandy sediments with water depth between 0.2-1.2 m.	++ +	++	-	+
Myriophyllum spicatum	Not assessed	NA	Ornamental plant for home decoration and wetland planting in parks; fodder for raising livestock; used as medicinal plant and water purifying	Locally common, but declining due to habitat degradation	Shallow areas with water depth between 0.3-2.8 m.	+	+	-	+
Najas marina	Not assessed	LC	Used as fodder for fish ponds	Declining due to habitat degradation. Rare or locally	Only found in the shallow sediment river sections with	++ +	-	-	-

Species binomial	National Red List	IUCN Red List	Economic importance	Population trends at the site	Habitat/sample site recorded	Habitat/sample site recorded from			
				common.	water depth between 0.3-1 m.				
Najas minor	Not assessed	LC	Used as fodder for fish ponds	A rare species declining due to habitat degradation	Growing in the habitats same to *Najas marina.*	++	-	-	-
Potamogeton crispus	Not assessed	NA	Used for water purifying	A rare species declining due to habitat degradation	Shallow or deep river sections with water depth between 0.2-1.8 m.	-	+	-	+
Potamogeton distinctus	Not assessed	LC	Used as fodder for livestock and as a fertilizer	A rare species declining due to habitat degradation	Shallow muddy beds near river banks with water depth between 0.3-1.3 m.	-	-	-	+
Potamogeton maackianus	Not assessed	LC	Used as fodder for livestock and as a fertilizer	A rare species declining due to habitat degradation	Central river sections with water depth between1-2.3 m.	-	-	-	++
Potamogeton pusillus	Not assessed	NA	Used as fodder for livestock and as a fertilizer	A rare species declining due to habitat degradation	Shallow muddy beds near river banks with water depth between 0.2-1.2 m.	-	-	-	++
Potamogeton wrightii	Not assessed	LC	Used as fodder for fish ponds and livestock, as a medicine, and for water purifying	Locally common, but declining due to habitat degradation	Muddy or sandy river sections with water depth between 0.2-3 m. Adapted to varied water flows.	++	++	-	+++

Species binomial	National Red List	IUCN Red List	Economic importance	Population trends at the site	Habitat/sample site recorded	Habitat/sample site recorded from			
Vallisneria natans	Not assessed	LC	Used as fodder for fish ponds; used for fertilizer and medicine; also used as raw materials of biogas, and as a food.	Declining due to habitat degradation. Rare or locally common.	Shallow muddy areas with water depth between 0.3-1 m.	++ +	++ +	++	+

a

b

c

d

e

f

g

h

i

j

a: *Potamogeton wrightii*; b. *P. crispus*; c. *Najas marina*; d. *N. graminea*; e. *Ceratophyllum demersum*; f. *Hydrilla verticillata*; g. *Myriophyllum verticillata*; h. *Vallisneria natans*; i. *Potamogeton pusillus*; j. *Chara* sp.

Figure 17. Photos of aquatic plant species collected from the three sites in the Beijiang River

3.6.4. Indicator species

Most aquatic plants in the sites are globally widespread and adaptive plants, all assessed as Least Concern. However, their distributions in our research sites are uneven. This implies that they are sensitive to the environment and have specific habitat needs. Some species could be used as indicators for water pollution and changes in natural flow regimes. For example, *Vallisneria natans* prefers muddy river beds (also found by You *et al.* 1994), *Potamogeton wrightii* is more likely found on sandy beds, while *Hydrilla verticillata* was commonly found in the intermediate areas between muddy and sandy sites. *Hydrilla verticillata* and *Vallisneria natans* are potential indicator species for long-term monitoring (see f. and h. in Figure 17) as they are found at all three sites though the populations were generally small and sparsely distributed, they are key food for fish and crabs (Xiong and Yao 2000, Lin *et al.* 2005) and therefore have great impacts on aquaculture success. Currently, the information on their ecological and phonological characteristics is still lacking and the impact of the local environment on their population development needs to be further studied.

3.6.5. Threats to aquatic plants at the sites

Based on our field surveys and discussions with the locals at the fishing villages, aquatic plant communities in Beijiang River have drastically declined in the past few decades. The major threats to aquatic plants in Lishi, Zhoutian and Kengkou are the dams (hydropower stations), sand mining, and industrial pollution. The dams have altered the water level and water flow regime of the river which has greatly affected the growth and distributions of the aquatic plants. Frequent and severe sand mining has also destroyed river bed habitats and added large amounts of sand in to the water impacting and covering submerged plants. Water pollution from industrial sources and domestic, have also threatened aquatic plants. In Rujiang, which has the highest species richness, the major threats to aquatic plants are the regular cutting for fodder and the artificially draining of wetlands. Rujiang has the best because water quality, then Lishi and Zhoutian, with the worst being Kengkou. The number of species at these sites partly reflects this difference in water quality, with Rujiang having 9 species, Lishi 8, Kengkou 5 and Zhoutian 1.

3.7. Odonata (dragonflies and damselflies)

Guangdong Province has been regarded as one of biodiversity hotspots for Odonata in China (Wilson and Xu 2007, 2008) but the overwhelming majority of the information comes from headwater streams at remote mountain areas in Guangdong Province. Like other Chinese large rivers, the Odonata fauna in the Beijiang River is poorly known. Not being a popular species, for most local people, all Odonata species are regarded as one name, i.e. 'Qingting' (means dragonfly). Therefore a literature survey was not possible and a field survey was necessary to identify the Odonata fauna in the Beijiang River.

3.7.1. Field survey methods

Odonata surveys were conducted at three sites in the Beijiang River on the 28 and 29 October 2010 (see Figures 4, 5 and 6). The survey methods included observation of species on the wing and while resting using binoculars, netting to capture adults and kick sampling in streams and other aquatic habitats for sampling for larvae.

Lishi Site (Figure 6): Location near Lishi Town, Shaoguan. Three sites were investigated along the Wujiang River, a main tributary of the Beijiang River at altitudes between 63-72m. Site L-D1 (24.8766N, 113.5447E) has deep water near a highway and can be navigated by ferry and ships (Figures 19 and 20). Site L-D2 (24.9012N, 113.5103E) is located on a river bend at a pool where the current is very slow (Figures 21 and 22). Site L-D3 (24.8993N, 113.5236E) is located at a dredging sand site where dredging vessels and fishing boats can be found (Figures 23 and 24).

Zhoutian Site (Figure 4): Location near Zhoutian Town, Shaoguan. Two sites were surveyed along the Zhenjiang River, a main tributary of the Beijiang River at altitudes between 69-78m. Site Z-D1 (24.9267N, 113.8356E) the habitat is damaged by dredging sand (Figures 25 and 26) and site Z-D2 (24.9820N, 113.8846E) is located downstream of a hydropower station at a riffle area near the confluence the Zhenjiang River with a small stream (Figures 27, 28 and 29).

Kengkou Site (Figure 5): Location near Dakengkou Town, Shaoguan. Two sites were sampled along Wushi-Kengkou reach in the Beijiang River. This section is difficult to survey the river bank because it is separated by a railway system between the road and river bank. Site K-D1 (24.5099N, 113.5808E) is located near a village where the river width is about 250 m (Figures 30 and 31). Site K-D2 (24.5200N, 113.5933E) is located by a small tributary of the Beijiang River (Figure 32).

Figure 19. Site 1 in Lishi (Wujiang River)

Figure 20. Site 2 in Lishi (Wujiang River)

Figure 21. Site 2 in Lishi (Wujiang River)

Figure 22. Electric fishing at Site 2 in Lishi

Figure 23. Dragonflies survey at site 3 in Lishi

Figure 24. Dredging sand vessels at site 3 in Lishi

Figure 25. Dredging sand site at site 1 in Zhoutian (Zhenjiang River)

Figure 26. Dredging sand at site 1 in Zhoutian (Zhenjiang River)

Figure 27. Upriver of Site 2 in Zhoutian at a hydropower station (Zhenjiang River)

Figure 28. Downriver of Site 2 in Zhoutian

Figure 29. Kick sampling for larvae at Site 2 in Zhoutian (Zhenjiang River)

Figure 30. Site 1 in Kengkou (Beijiang River)

Figure 31. Site 1 in Kengkou (Beijiang River)

Figure 32. Site 2 of Kengkou (tributary of Beijiang River)

3.7.2. Field survey results

Twenty five Odonata species were identified during the survey (Table 11). All the species are very common and widely distributed in all kinds of freshwater habitat, although their population trends at the sites are not known. All species are assessed as Least Concern on the IUCN Red List. Their photos are shown in Figure 33. Lishi had 23 species recorded, Zhoutian 11 and Kengkou only 1 species. Of all the species recorded only two species were not found in Lishi *Matrona basilaris* and *Onychothemis testacea*, both of which are only found in Zhoutian. The only species found in Kengkou, *Orthetrum sabinam*, is also found in the two other sites.

Table 11. Odonata species identified from Beijiang River through field surveys

The IUCN Red List categories are EX – Extinct; EW Extinct in the Wild; CR – Critically Endangered; EN – Endangered; VU – Vulnerable; NT – Near Threatened; LC – Least Concern; DD – Data Deficient; NA – Not assessed. The categories CR, EN and VU are classed as the 'threatened' categories. '*' indicates a draft Red List assessment, that still needs to be peer reviewed.

Species binomial	National Red List status	IUCN Red List	Economic importance	Population trends at the site	Habitat/sample site recorded from		
					Lishi	KengKou	Zhoutian
Anax parthenope julis	NA	LC	No direct importance	unclear	site 1 site 2		site 2
Epophthalmia elegans	NA	LC	No direct importance	unclear	site 2		
Ictinogomphus	NA	LC	No direct	unclear	site 2		

Species binomial	National Red List status	IUCN Red List	Economic importance	Population trends at the site	Habitat/sample site recorded from		
pertinax			importance				
Brachythemis contaminata	NA	LC	No direct importance	unclear	site 2 site 3		
Orthetrum pruinosum neglectum	NA	LC	No direct importance	unclear	site 2		Site 2
Orthetrum sabina sabina	NA	LC	No direct importance	unclear	site 2	Site 2	
Orthetrum glaucum	NA	LC	No direct importance	unclear	site 2		Site 2
Sympetrum darwinianum Selys	NA	LC	No direct importance	unclear	site 2		
Sympetrum eroticum ardens	NA	LC	No direct importance	unclear	site 2		Site 2
Sympetrum risi risi Bartenev	NA	NA	No direct importance	unclear	site 2		
Tholymis tillarga	NA	LC	No direct importance	unclear	site 2		
Tramea virginia Rambur	NA	LC	No direct importance	unclear	site 2		
Trithemis aurora	NA	LC	No direct importance	unclear	site 2 site 3		Site 2
Libellago lineata	NA	LC	No direct importance	unclear	site 2 site 3		
Copera marginipes	NA	LC	No direct importance	unclear	site 2		Site 2
Ceriagrion auranticum ryukyuanum Asahina	NA	LC	No direct importance	unclear	site 2 site 3		Site 2
Ischnura senegalensis	NA	LC	No direct importance	unclear	site 2		
Pseudagrion pruinosum fraseri Schmidt	NA	LC	No direct importance	unclear	site 2		
Pseudagrion rubriceps rubriceps Selys	NA	LC	No direct importance	unclear	site 2		
Pseudagrion spencei Fraser	NA	LC	No direct importance	unclear	site 2 site 3		
Prodasineura autumnalis	NA	LC	No direct importance	unclear	site 2		
Crocothemis servilia servilia	NA	LC	No direct importance	unclear	Site 3		Site 1 Site 2

Species binomial	National Red List status	IUCN Red List	Economic importance	Population trends at the site	Habitat/sample site recorded from		
Pantala flavescens	NA	LC	No direct importance	unclear	Site 3		Site 2
Matrona basilaris Selys	NA	LC	No direct importance	unclear			Site 2
Onychothemis testacea *tonkinensis* Martin	NA	LC	No direct importance	unclear			Site 2

Ictinogomphus pertinax (Hagen in Selys, 1854)
(Location: Lishi)

Sympetrum darwinianum Selys, 1883
(Location: Lishi)

Orthetrum sabina sabina (Drury, 1770)
(Location: Lishi, Kengkou)

Orthetrum pruinosum neglectum (Rambur, 1842)
(Location: Lishi, Zhoutian)

Sympetrum eroticum ardens (McLachlan, 1854)
(Location: Lishi, Zhoutian)

Sympetrum risi risi Bartenev, 1914
(Location: Lishi)

Matrona basilaris
(Location: Zhoutian)

Pseudagrion rubriceps rubriceps Selys, 1876
(Location: Lishi)

Neurobasis chinensis(Location: Lishi)

Pseudagrion spencei Fraser, 1922 (Location: Lishi)

Figure 33 Photos of some Odonata species found during the field surveys (All photos by Tong Xiaoli)

3.7.3. Indicator species

Dragonflies (Odonata) have been widely used as indicators of environmental quality in freshwater ecosystems (Samways 1993, Chovanec and Waringer 2001). They live in a wide range of aquatic habitats, are easy to record and identify at the species level, and they respond clearly to environmental variation. However, there is debate over which is the best, adult or larvae, as the suitable stage to monitor as the indicator. Adults may not respond well to changes in water quality due to being predominantly aerial, their mobility might also limit their value in indicating local habitat quality because adults can occur at sites where they do not breed (Corbet 1993). Odonata larvae are more directly dependent on the aquatic environment, and have the added advantage of occurring over a more prolonged period than adults (Corbet 1993; Osborn and Samways 1996). Even though none of the species have been identified as being particularly habitat specific, the number of species declined in polluted areas. Kengkou for example is the most polluted of the sites (it receives water after the river has flowed through Shaoguan City) has only one odonate species recorded. Also in recent years, SCAU Odonata team have studied the dragonfly larvae taxonomy in southern China (Zhang & Tong, 2009a, 2009b, 2010; Zhang et al., 2010a, 2010b). Therefore the SCAU team have the capacity to use dragonfly larvae as indicators to assess the change of aquatic environment in the Beijiang River.

3.8. Inclusion of data in online databases

Data collated through this research will be included in two online species databases; the IUCN Red List (www.iucnredlist.org) and Fishbase (www.fishbase.org).

Through Work Package 1 of this project the fish, odontata, molluscs and selected aquatic plant species of the Beijiang River basin were assessed against the IUCN Red List categories and criteria and have been published on the Red List website (see section 3.2). Information on the species identified through this workpackage such as new information on species distributions, threats but in particular their utilisation by humans will be added to their Red List assessment and published online with the next IUCN Red List update in 2012. If the information provided is significant it may require the species to be reassessed, changing the species Red List Category.

The information on the fish species utilisation will also be added to the Fishbase online database, under the 'Human Uses' tag. For example, the species will be tagged as being 'Fisheries: minor commercial' or 'aquarium: potential'.

4. Threat surveys

The major threats to aquatic biodiversity and ecosystem services in Beijiang River come from (1) water pollution caused by waste water from industry and urban areas, (2) sand mining activity along the river which destroys the habitat of aquatic species, and (3) dams of hydropower stations which cut off natural flow of the river and block the migration route of many fish species.

4.1. Water pollution

Due to the rapid economic development and population growth in Guangdong, large amount of waste water is generated each year (Table 12). Although great effort has been made to reduce waste water and to increase waste water treatment capacity, the water in the Beijiang River becomes polluted as it flows through big cities like Shaoguan (Figure 34). This impacts biodiversity as can be seen through the field surveys as only one dragonfly species was sampled in Kengkou Fishing Village, which is just downstream of Shaoguan City. Whereas the number of dragonfly species in Lishi was 23 and 11 in Zhoutian, both of which are upstream of Shaoguan which is the major source of water pollution in the Beijiang river.

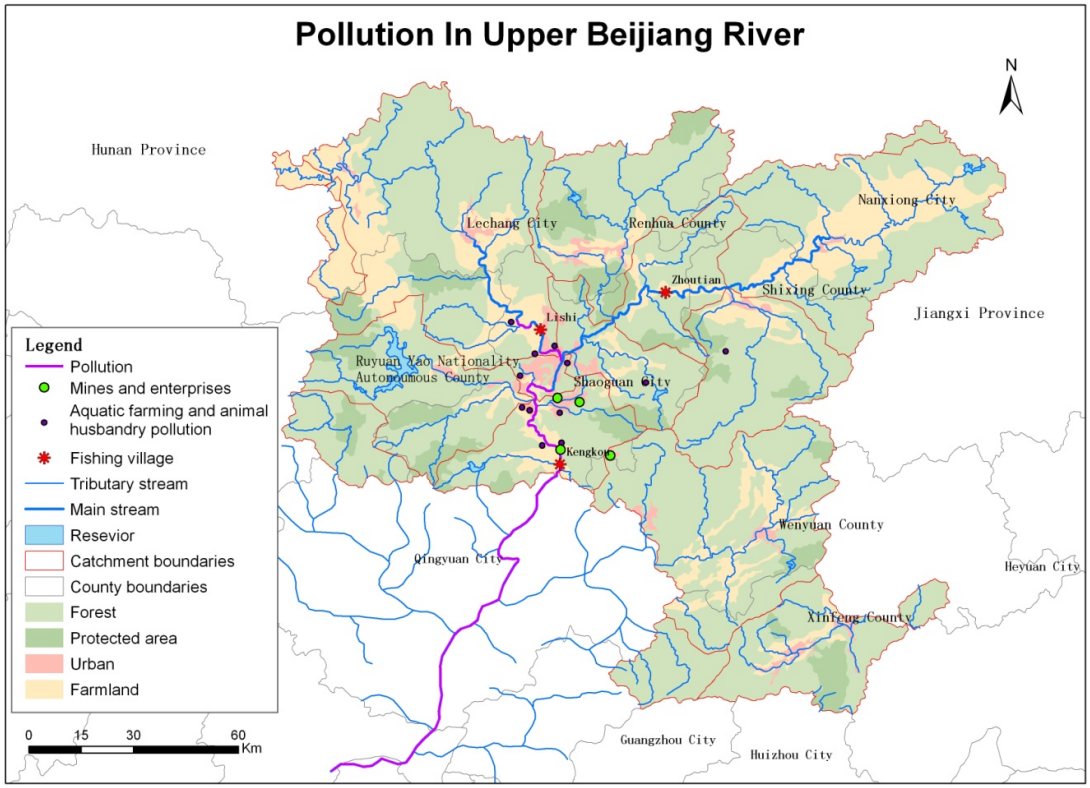

Figure 34. Water pollution along the Beijiang River

Table 12 Waste discharge into the Beijiang River 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

4.2. Sand mining

Due to large amounts of construction work such as high ways, buildings, and factories the demand for sand as a building material has rapidly increased. Large scale sand mining operations have appeared in many sections of the Beijiang River (Figures 35 and 36). This mining activity not only destroys the habitat of aquatic species, but also impacts many of the aquatic ecosystem services provided by the river (Table 13).

Figure 35. Sand mining in Beijiang River

Table 13. The effects of the sand mining on the river ecosystem services

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

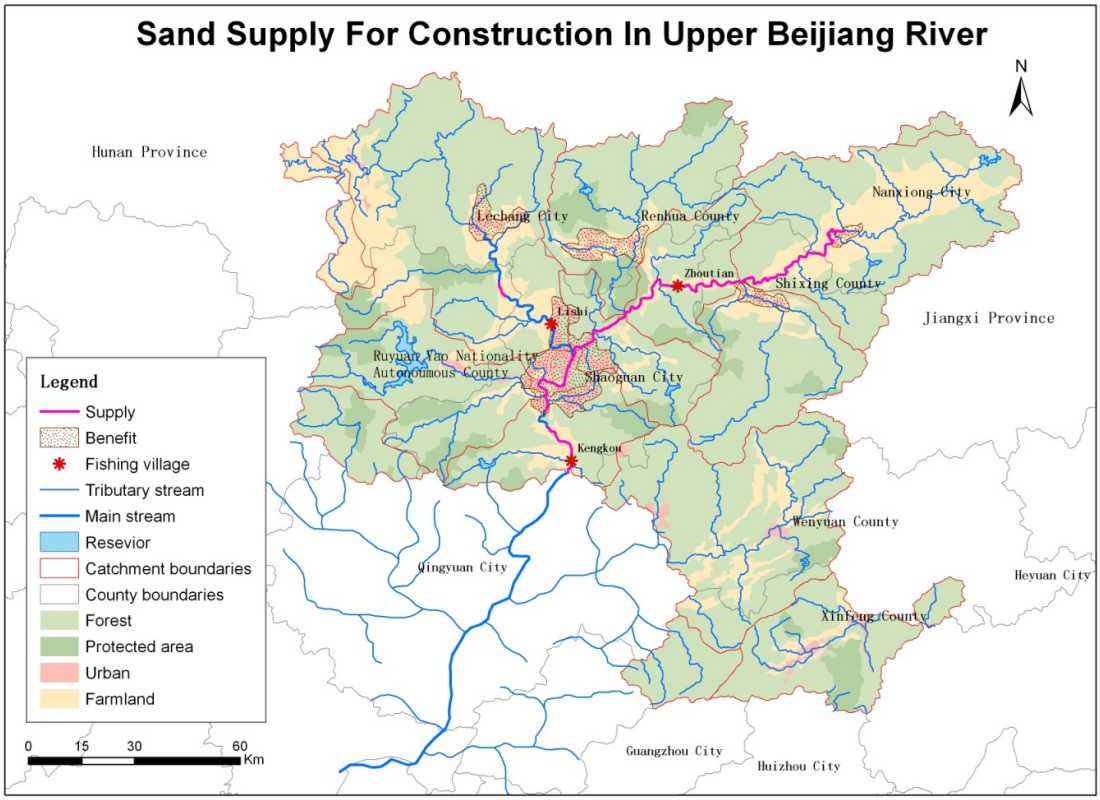

Figure 36. Sand mining sites along the Beijiang river and the areas 'benefiting' from the sand for construction

4.3. Hydropower dams

There are 485 dams in Shaoguan city, out of which 454 dams are small, 27 dams are medium sized and 4 dams are large scale (Figures 37 and 38). Figure 39 shows that the numbers of dams have been increasing over the past 20 years, particularly in the 1990s, which declined after 2000 only to significantly increase again after 2007. Most of the increase is due to the construction of small dams. The storage capacity of reservoirs has also increased, particularly in recent years (Figure 40). The construction of the dams and reservoirs have increased the water supply capacity and flooding control capacity but they have had a detrimental impact on the fisheries resources of the river. The local fishermen complain that the amount of fish has significantly decreased due to the change of the water flow and the blocking of fish migration routes (Table 14).

Figure 37. Hydropower dam (large scale) across the Beijiang River

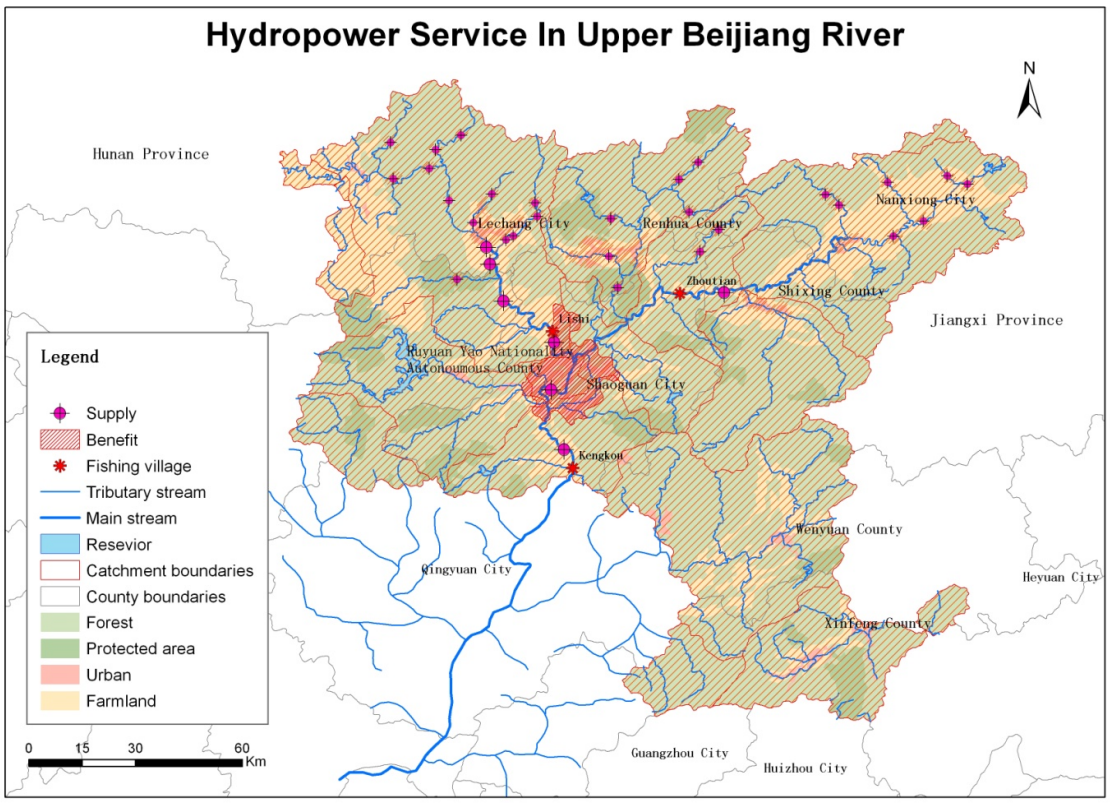

Figure 38. The distribution of dams in Beijiang River and the areas benefiting from the power produced

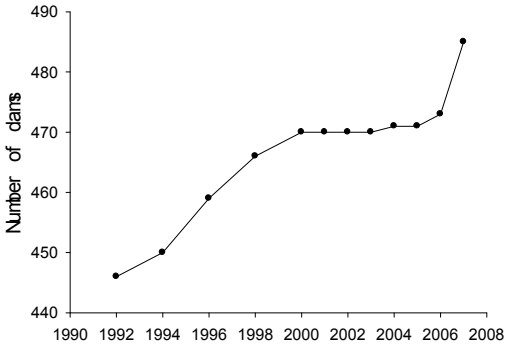

Figure 39. Number of dams over the years in Shaoguan City (Guangdong Bureau of Statistics 2002-2009)

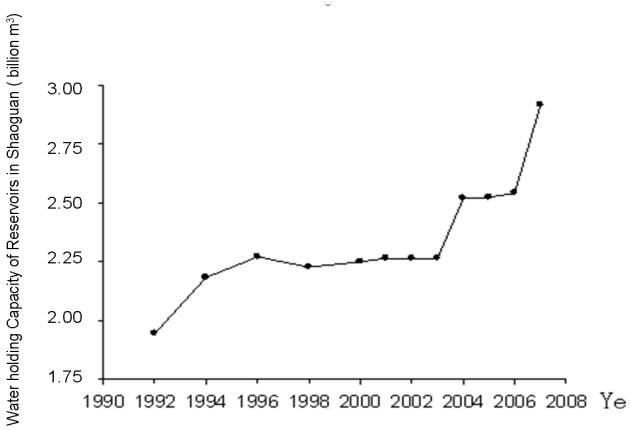

Figure 40. Storage capacity of the reservoirs in Shaoguan City (Guangdong Bureau of Statistics 2002-2009)

Table 14 The effects of dams on the river ecosystem services

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

5. Ecosystem services

Ecosystem services are the conditions and processes through which natural ecosystems and the biodiversity that make them sustain and fulfil human life (Daily 1997). They provide many goods, such as food, timber, fuel, natural fibber, and many pharmaceuticals, industrial products, and their precursors. The American ecologists (Costanza *et al.* 1997) called the products and services provided by ecosystems as "ecosystem services" and divided it into 17 different types. We have divided ecosystem services into 4 major types; provisioning, regulating, cultural and supporting services (Figure 41) (following the Millennium Ecosystem Assessment (MEA) as shown in Springate-Baginski *et al.* 2009). The value derived from these ecosystem services can be categorised as direct use values (from provisioning services), indirect use values (from supporting and regulating services) and existence values (from cultural services) and option values can come from all types of services. Different types of services need different assessment methods (Figure 42).

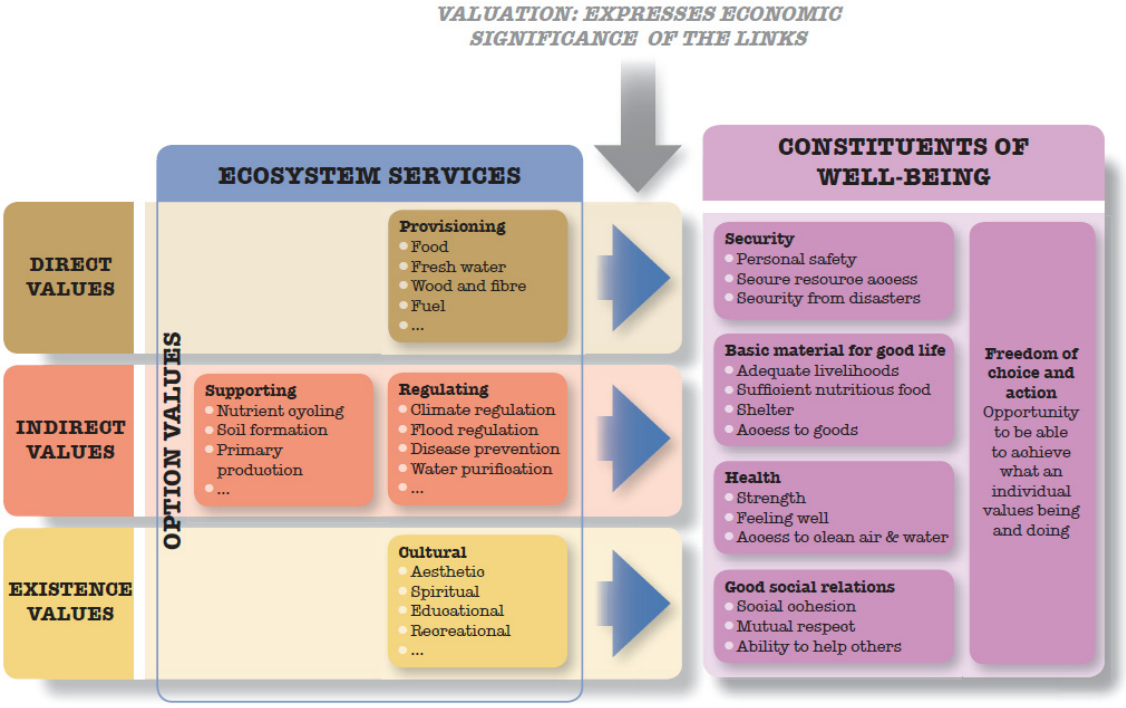

Figure 41. Types of ecosystem services and how they relate to human well-being (adapted from MEA Springate-Baginski *et al.* 2009)

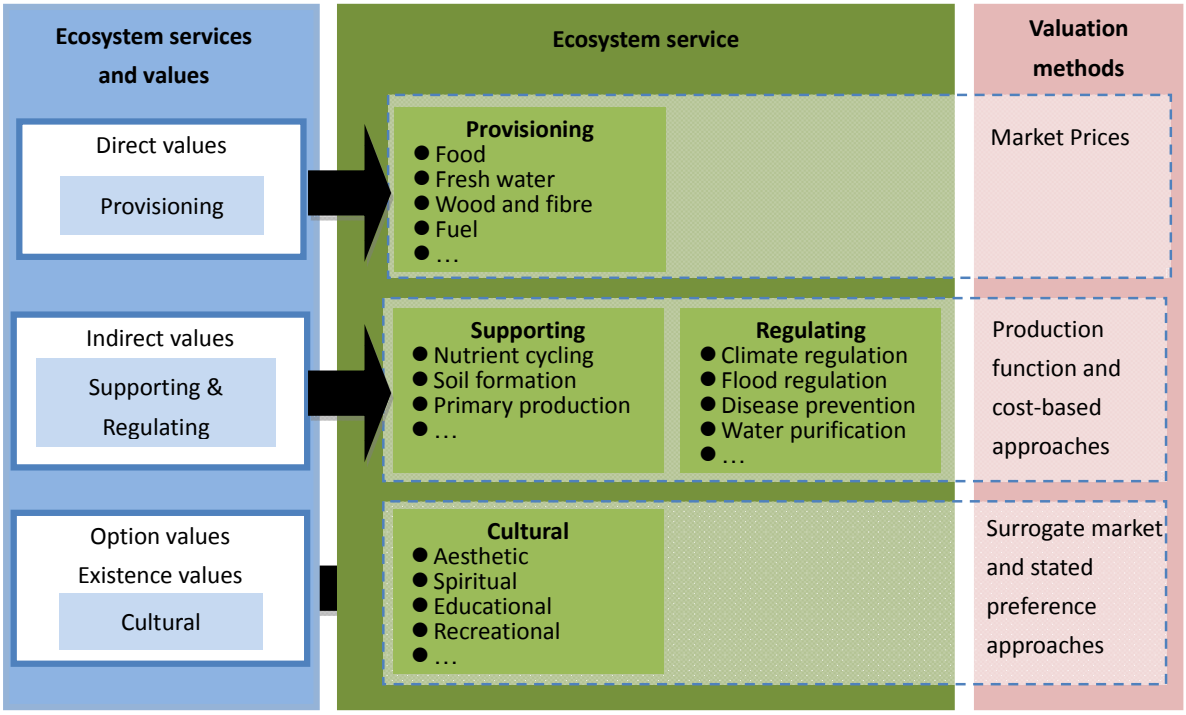

Figure 42. Ecosystem values, services and evaluation methods

5.1. Types of ecosystem services provided by the Beijiang River watershed

5.1.1. Provisioning services

In the upper Beijiang River, the ecosystem products mainly include wood from the forest ecosystem, fishes for food, industrial water supply, domestic water supply, sand supply for building, hydropower supply, and transportation across the river, reservoirs and lakes; and grain products from irrigated farmland. Provisioning services can often be valued by the price they are sold for known as the market value method.

(1) Wood

In recent years, many trees have been planted within the Beijiang catchment, increasing forest cover to 1.162 million ha (1.433 million ha used for forestry) by 2008. The standing forest stock was 65.235 million m^3, with the biomass of forest being 73.666 million tons, including 46.91 million tons of commercial forest biomass and 26.755 million tons of non-commercial forest biomass. (Shaoguan Bureau of Forest 2009)

(2) Aquatic products

In 2007, the aquaculture production of Shaoguan City was 60,395 tons, including 59,612 tons of fish, 393 tons of shellfish, and 202 tons of shrimps and crabs (Table 15). In 2007, the total aquaculture production value was 431.87 million Yuan (~40 million Euros in 2007). It was 3.93% of the total agricultural output value.

Table 15. The aquaculture output of Shaoguan City in 2007

(Statistical Bureau of Shaoguan, 2008)

	Yield (tons)
Total aquaculture output	**60395**
1. Fish	**59612**
(1) High value fish	**18420**
Channa argus	166
Siniperca chuatsi	130
Micropterus salmoides	526
Piaractus brachypomus	2009
Oreochromis niloticus	5118
Carassius auratus	3809
(2) Other fish	**41192**
*Ctenopharyngodon idell*a	14781
Hypophthalmichthys nobilis	9194
Hypophthalmichthys molitrix	10126
Cyprinus carpio	4853
2. Shellfish	**393**
3. Shrimps and crabs	**202**

In spring, a typical amount of catch per day by a small fishing boat operated by two people is 15 kg of common carp (*Cyprinus carpio*) (at 5 Yuan/kg), or 0.25 kg of yellow horn fish (*Pelteobagrus fulvidraco*) (18 Yuan/kg). In April to September, 2 kg of shrimp (14 Yuan/kg) can be captured per day. According to our research in the three villages, a third of the fishermen's families are completely reliant upon fishing for their income. About one fifth of fishing families partly rely on fishing and partly on income from working outside or from children working outside. For example, in Lishi Fishing Village, there are 11 families that totally rely upon fishing, and 3 families that totally rely on income from working outside the village, 2 families are totally dependant on the support from their children working outside, and the income of the remaining 7 households are 50-90% from fishing, 10-50% from other sources.

(3) Water for productive use

Water for productive use includes agricultural water supply and industrial water supply. For agricultural irrigation, there are 1,567,200 hectares of cultivated land and 1,433,000 hectares of forest land in Shaoguan City in 2008. Most of the agricultural irrigation is provided by the water stored in dams or reservoirs while some is provided directly by the springs from the forest. Industrial water supply is very important for many companies in Shaoguan City, including the Shaoguan Iron Steel Group Limited Company of Guangdong Province, Shaoguan Smelter, Dabaoshan Mining Limited Company of Guangdong, etc. The industrial water consumption was 5.49×10^6 tons in 2008 (Shaoguan Bureau of Forest, 2009).

(4) Domestic Water Supply

The urban and rural domestic water is mostly supplied by the large reservoirs such as the Nanshui reservoir in Ru Yuan County. Some of the rural domestic water is supplied directly from the river and underground water (wells).

(5) Sand Supply for Construction

The main sand digging activity to provide construction sand, takes place in the river beds of the major streams. An example is the Water Management Bureau of Shaoguan who have allowed a 5.3 km section of the river near Zhoutian Village to opened for sand mining at a quota of 0.35 million cubic metres per year. It also permitted a 4.6 km river section near Lishi village for sand mining and the quota was 25 million cubic meters per year. The depth for sand mining usually reaches 1-1.3 m on average. (Sources: Contract between Shaoguan local government and sand mining company)

(6) Hydropower Supply

The Beijiang River is abundant in its hydropower resources, with a theoretical potential of 1,744,900 kW (kilowatt) (Committee for Annals of Shaoguan 2009). The annual hydropower generated can reach 55.8 billion kWh (Kilowatt hours). By the end of 2008, there were 485 reservoirs in Shaoguan, including 4 large, 29 medium and 454 small scale dams and 1989 small scale hydropower stations. The total installed capacity of power generation reaches 1,519,200 kW and the power generated in 2008 was 45.56 billion kWh (Annual Report of Shaoguan, 2009). All the hydropower supplies are incorporated into the national electricity network and supply to domestic, commercial and industrial usage.

(7) River Transportation

Shaoguan water transportation channels include rivers such as Beijiang, Wujiang, Zhenjiang, Wengjiang, Xinfengjiang, and the Longguihe. The Beijiang River can be accessed by hundred tonnage ships between Shaoguan and Guangzhou (a port city in the Pear River Delta). In 2008, there were 698 km of water transportation channel in Shaoguan and the shipping capacity reached 15 million tons, with the actual port throughput reaching 200 million tons (Committee for Annals of Shaoguan, 2009). The 184 km long Shaoguan-Qingyuan river channel is wide enough for cargo ship transportation (Guangdong Shaoguan city ecological civilization construction planning, 2008) and on October 14, 2008, the container shipping voyage from Beijiang Xingang Port, Shaoguan to Hong Kong was officially opened. It diversified the channels for importation and exportation from the mountainous area of north Guangdong (see http://www.yicang.com/html/news/view/awv).

(8) Food products

Shaoguan is suited to agricultural production in owing to its warm and humid subtropical climate resources. The arable land area per capita in Shaoguan is the largest in Guangdong Province and it relies heavily upon irrigation from the water stored in reservoirs. In recent years, the infrastructure in agricultural and rural areas has been improved and agricultural output value has increased. The seven major agricultural products in the region are vegetables, rice, livestock, fish, fruit, bamboo, and tobacco. Many rice, livestock and fish are well known for their quality and have high market values. In 2009, the grain growing area was 1,567,266 ha with a total production of 9,010,000 tons. The growing area of high-quality rice was 564,933 ha with a total production of 3,894,000 tons. The production of meat was 148,000 tons which included 117,000 tons of pork and 66,000 tons of fish.

5.1.2. Regulating services

Regulating services include climate regulation, water regulation, water purification, soil conservancy, natural disaster/flood control, etc. and they usually can not be valued directly by market prices (as is the case also for cultural and supporting services). In this case, other methods must be adopted for

evaluation. The following methods can be used for the evaluation of regulating ecosystem services:

- Replacement cost method: If an ecosystem service is not provided by nature, the cost which must be used to generate this service artificially is called a replacement cost. For example, the value of water storage capacity of forest can be estimated by the cost of building a reservoir with similar capacity.
- Shadow price method: Values of some services can be estimated by the value given for a change in an ecosystem services. The value changed can be estimated indirectly by the price which visitor agree to pay, e.g. the pollution treatment cost which society has to pay, or the price increase of land property etc.

(1) Forest ecosystem's regulating services

In 2008 the land area used for forestry was 1.433 million ha. This area provided annual carbon dioxide absorption of 106 million tons, released 78 million tons of oxygen, stored 56 million tons of carbon and provided 2.16 billion tons of fresh water downstream (Shaoguan Bureau of Forest, 2008). According to the ecological service assessment methods which include the replacement cost method, and shadow price method, the value of forest ecosystem service was 8.4737 billion RMB Yuan. This includes 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 flood control, 300 million Yuan for cleaning atmosphere, 0.3855 billion Yuan of forest soil erosion control, and 0.1375 billion Yuan for wildlife protection benefit (Shaoguan Bureau of Forest, 2008).

(2) River ecosystem's regulating services

Shaoguan City covers many different sub-catchments of the Beijiang River, including the Mojiang, Jinjiang, Wujiang, Nanshui, and Wenjiang all of which are larger than 1,000 km^2. The river ecosystem regulating services, as shown in Table 16, includes: flooding control; water resource storage; environmental purification; providing wildlife habitat; and CO_2 fixation (Xiao *et al.* 2006, 2008; Wang 2006).

Table 16. Regulation services provided by river ecosystem

Regulating service	Description
Flooding control	Vegetation along the river ecosystem, floodplains and downstream wetlands, swamps, etc. with water storage capacity, can reduce flood peaks, delay flood flows and reduce the economic losses caused by floods.
Regulation of soil, sand and nutrients transferred through river ecosystem	River transportation of sediment allows nutrients to be passed downstream, including carbon, nitrogen, phosphorus and others, and is one of the world's most important biogeochemical cycles.
Water resource storage	Floodplains, wetlands and marshes accumulate and store large amounts of water. In the dry season they supplement the supply of water and can improve regional stability of water supply.
Water purification and climate regulation	Wetlands and their biodiversity help water purification (e.g. through the absorption of nitrogen and phosphorous) and help regulate local climate (by absorbing heat in the day and releasing heat at night).
Providing wildlife habitat	The river ecosystem provides important breeding, migration and nursery habitats for birds, mammals, fish, invertebrates, amphibians, plankton and aquatic plants.

5.1.3. Supporting services

Supporting services provided by the Beijiang river includes soil development and nutrient cycling. Soil is an important part of national wealth and is formed through a slow process taking thousands of years (Ou Yang Zhi Yun 2000). Freshwater systems support soil development through the transfer of sediment and soil particles to wetlands, swamps and river estuaries creating new land, and during floods by depositing sediment to flood plains (which are often used as agricultural land during the dry season).

Freshwaters also play a key role in nutrient storage and cycling for example soil organic matter balance, and nitrogen, phosphorus, potassium, carbon and sulphur cycling. It is estimated that soil carbon storage is 118 times larger than all plant carbon storage while soil nitrogen storage is 19 times larger than plants nitrogen storage (Schlesinger 1991). The organisms within freshwater systems supply, store and absorb nutrients and promote the exchange of nutrients between living organisms and their environment.

5.1.4. Cultural services

Cultural services include the spiritual enjoyment, inspiration, entertainment, recreational opportunities, aesthetic and educational values. In the Beijiang basin, sightseeing, fishing, boating and swimming are the major cultural services provided. The natural tourism resources of Shaoguan City are mainly geological features, forest waterfalls, rivers and valleys, lakes and hot springs. There are 10 forest parks, (including 3 state forest parks, 2 provincial forest parks, 5 county forest parks) and 22 nature reserves (including 3 state nature reserves, 12 provincial nature reserves, and 2 county nature reserves).

5.2. Ecosystem costs

In the “Integrated Wetland Assessment Toolkit” published by IUCN (Springate-Baginski *et al.* 2009), the costs of ecosystem services are defined into four categories (Figure 43): **Management costs**: the direct physical expenditures on the equipment, infrastructure and human resources required to manage wetlands; **Opportunity costs**: alternative uses of time, land, money or other resources required for wetland conservation which could have generated income and profits had they been used or allocated elsewhere; **Costs to other activities**: damage and interference to human and economic activities caused by wetlands resources and species, including human and livestock disease and injury, crop pests and sources of competition over resources.

5.2.1. Management cost

In Beijiang River, the management costs include waste water treatment and pollution control, maintenance of river channels (such as river dike construction, channel clearance, floating garbage collection), biodiversity protection, fishery management, and reforestation and water conservation.

5.2.2. Opportunity cost

The opportunity costs in the Beijiang River include the cost for losing the opportunity to develop heavy industry and chemical industry because of the water quality requirements, and the opportunity to develop more wood harvesting forest and fruit orchard in hilly areas because of the water and soil erosion controls.

5.2.3 Costs for other activities

The other costs that can be identified include the transmission of water born diseases such as schistosomiasis, and the damage caused by flooding during the rainy season.

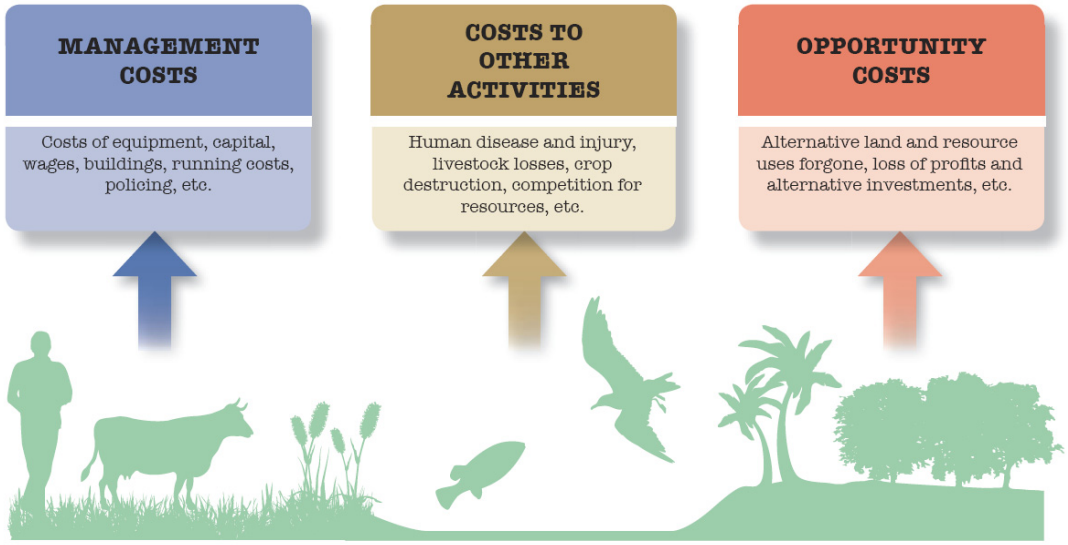

Figure 43. The total economic cost of an ecosystem (Springate-Baginski *et al.* 2009)

5.3. Ecosystem prioritisation

A participatory assessment to identify the priority ecosystem services and costs of the Beijiang River, according to different stakeholders has been undertaken. This will provide the relevant information for the integrated action planning process to help ensure that these services are given full recognition by all stakeholders, and also allow potential indictors to be developed that can be used to monitor any actions proposed through the IAP.

5.3.1. Methods

Referring to Springate-Baginski *et al.* (2009) Table 17 was designed to question different stakeholder groups to identify their prioritisation of the identified ecosystem services and costs provided by the Beijiang River.

On May 21, 2010, an evaluation meeting was held in the meeting room of Shaoguan City Government where the evaluation table and methodology was presented to government officers (morning meeting), and leaders from enterprises (afternoon meeting). After a short discussion, each individual filled in their own form with or without their name on it although a mark on each table was used to identify the type of stakeholder. On May 22, and July 2, 2010, three teams visited the different fishing villages and farming villages to conduct the same surveys with fishermen and farmers.

Table 17. Evaluation Sheet for Ecosystem Service and Cost of Beijiang River

Affiliation_____Location_____Date_____No._____

Draw a circle 'o' in the cell where you think the level of importance is right. The bigger the number, the more important it is. You can add other items at the end of the table (no. 24/12).

Ecosystem services		5	4	3	2	1
Provisioning	1 irrigation					
	2 daily water use					
	3 industrial water supply					
	4 aquatic products					
	5 sand for construction					
	6 transportation					
	7 hydro-electricity					
	8 game fishing					
	9 boating					
	10 tourism					
	11 swimming					
Regulating and supporting	12 air humidity					
	13 stable air temperature					
	14 clean environment					
	15 reduce flooding					
	16 delete pollution					
	17 reduce diseases					
	18 biodiversity					
	19 residential value					
Cultural	20 beautiful environment					
	21 spiritual home					
	22 education					
	23 research					
	24					
Ecosystem Cost		5	4	3	2	1
Cost for other reasons	-1flooding					
	-2 drought					
	-3 transmit diseases					
	-4 carrying pollutants					
Management cost	-5 dike building					
	-6 river bed clearance					
	-7 fishing management					
	-8 planting tree					
	-9 river pollution control					
	-10 water hyacinth					
	-11 picking up river garbage					
	-12					

One hundred and eight people participated in the investigation. Among them 15 from government offices including the Bureau of Agriculture, the Bureau of Water Management, the Bureau of Forestry, the Bureau of Environmental Protection, the Bureau of Industry and Commerce, the Bureau of Aquatic Product, the Department of Development and Reform, the Department of Security, Research Institute of Aquatic Products, Secretary of City Government, City Hospital, and Xihe Township Government. Fourteen came from enterprises including sand mining, river transportation, agricultural, steel and iron manufacturing, mining, hydropower station, hotel and food. There were 62 fishers who came from the three site villages of this project (Kengkou, Lishi and Zhoutian), and Shangping fishing village and 17 farmers from near by villages (Kengkou village in Kengkou, Qunlai village in Lishi, and Pingfu village in Zhoutian). In total, there were 29 women, 71 men and 8 who did not record their sex. All 28 women, except one, were from fishing or farming villages. Software SPSS was used for data statistic analysis.

5.3.2. Result and analysis

5.3.2.1. The general result of variation analysis

In order to understand if true differences exited within the data collected, the statistical method for ANalysis Of VAriation (ANOVA) using SPSS was applied. The results of an ANOVA (Table 18) show that there are significant differences existing among different ecosystem services or costs, between the different stakeholders, and between the different sex groups. However, further analysis shows that there are no significant different between men and women because the significant difference was caused by the group without sex record (Table 19). Therefore further analysis is focused on the difference between the different stakeholders and different ecosystem services/costs.

Table 18. Result of Univariate Analysis of Variance for ecosystem services provided by Beijiang River, China

Tests of Between-Subjects Effects Dependent Variable: evaluation value

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	37739.983(a)	204	185.000	88.334	.000
ecosystem services	727.631	33	22.049	10.528	.000
types of stakeholder	481.071	3	160.357	76.567	.000
Sex group	251.110	2	125.555	59.950	.000
ecosystem services X types of stakeholder	552.443	99	5.580	2.664	.000
ecosystem services X sex group	172.562	66	2.615	1.248	.086
Error	7261.017	3467	2.094		
Total	45001.000	3671			

a R Squared = .839 (Adjusted R Squared = .829)

Table 19. Duncan's multi-range analysis result for sex group effects

Sex group	Average score	Duncan's Multi-range test result
Men	3.126	b
Women	3.144	b
No sex record	2.669	a

5.3.2.2. Differences between different ecosystem services and costs

The most important ecosystem services ranked included aquatic products; daily water supply, reducing flooding, hydro-power supply and deletion of pollutants by Beijiang River (services in red in Table 20). For this group, the average importance achieved is more than 3.61 (in our 1-5 point system). These services impact almost everyone (from all the stakeholder groups) living within the Beijiang River area.

Table 20. Analysis of the results given for ecosystem services and costs

	Service Item	Average	SD	Duncan's multi-range test*								
Ecosystem Service provided by Beijiang River	11 swimming	1.71	1.22	a								
	9 boating	2.06	1.36	a								
	8 game fishing	2.07	1.37	a								
	10 tourism	2.08	1.28	a								
	6 transportation	2.56	1.38		b							
	23 research	2.58	1.55		b	c						
	1 irrigation	2.87	1.77		b	c	d					
	12 air humidity	2.94	1.56		b	c	d	e				
	20 beautiful environment	2.98	1.54		b	c	d	e				
	3 industrial water supply	2.99	1.63		b	c	d	e				
	13 stable air temperature	3.00	1.5		b	c	d	e				
	19 residential value	3.03	1.63		b	c	d	e				
	18 biodiversity	3.04	1.48			c	d	e				
	5 sand for construction	3.16	1.57				d	e	f	g		
	22 education	3.32	1.58					e	f	g	h	
	17 reduce diseases	3.34	1.58					e	f	g	h	
	14 clean environment	3.53	1.54						f	g	h	i
	21 spiritual home	3.55	1.34						f	g	h	i
	16 delete pollution	3.61	1.55							g	h	i
	7 hydro-electricity	3.62	1.48							g	h	i
	15 reduce flooding	3.71	1.58								h	i
	2 daily water use	3.77	1.74								h	i
	4 aquatic products	3.98	1.34									i
Ecosystem cost caused by Beijiang River	-2 drought	2.15	1.55	a								
	-3 transmit diseases	2.75	1.61		b	c	d					
	-10 water hyacinth	2.88	1.66		b	c	d	e				
	-8 planting tree	3.09	1.63				d	e	f			
	-11 picking up river garbage	3.21	1.67				d	e	f	g		
	-7 fishing management	3.24	1.56					e	f	g		
	-4 pollutant diffusion	3.52	1.49						f	g	h	i
	-6 river bed clearance	3.6	1.49							g	h	i
	-5 dike building	3.62	1.52							g	h	i
	-9 river pollution control	3.83	1.57									i
	-1flooding	3.86	1.73									i

* Factors with the same character did not significantly different within 5% significant level; they can be assigned to the same group. The numbers in front of the service items are the same as in table 15. Negative number indicates ecosystem cost.

The second most important 'group' of ecosystem services (an average score of 3.16-3.55 points) include the spiritual function, clean environment provided, reduction of diseases, educational function, and sand production for construction (services in orange in Table 20). The third most important 'group' of ecosystem services (2.56-3.04 points) ranked by the stakeholders include biodiversity, scientific research, stable air temperature and humidity, industrial and agricultural water supply, beautiful environment, residential value, and river transportation (services in yellow in Table 20). The least important 'group' of ecosystem services (1.71-2.08 points) ranked by the stakeholders includes tourism, fishing for sport, boating for sport and swimming. Although tourism is developing very quickly, the number of people benefiting from these services is still very limited.

The most important ecosystem costs ranked by the stakeholders include the damage caused by flooding and pollution, the expenditure used in waste water treatment; dike building and dredging of river bed for transportation (ecosystem costs in red in Table 20). These costs are very relevant to the most important category of ecosystem services (the stakeholders considered that the reduction of flooding and pollution are very important ecosystem services) as they considered that the money spent in waste water treatment, dike building and dredging is very important. The second most important 'group' of ecosystem costs include expenditure used for fishing management, picking up river garbage, and tree planting (costs in orange in Table 20). The third most important 'group' of ecosystem costs include the expenditure induced by diseases spreading along rivers and the picking of water hyacinth, an invasive species that grows very quickly in rivers and lakes (costs in yellow in Table 20). The least important 'group' of ecosystem costs include the loss caused by drought such as crop failure and lack of drinking water supply. Many people recognize that the river itself is not the reason of drought costs (costs in white in Table 20).

5.3.2.3. The differences between different stakeholder groups

There is no significant difference in the prioritisation made by men and women. This is likely due to the equal status of men and women in their daily life in this region. They often work together and share their life together without significant sexual work separation.

The higher the average ranking given by a stakeholder group, the more important they considered the ecosystem services provided by freshwater. The average ranking value for ecosystem services is in this order: government officers (3.54) > leaders of enterprises (3.42)> farmers (3.28) > fishers (2.87) (Table 21, line 1). Surprisingly the fishers have the lowest average, even though they rely the most directly upon the services provided by the river. This may be due to the concept of ecosystem services being quite abstract and that some groups of fishers and farmers needed more explanation, whereas the government officers and leaders of enterprises are usually more educated. The slide explanation for government officers and leaders of enterprises in a meeting room was more easily understood than oral explanation by different researchers for farmers and fishers in their houses.

Fishermen score aquatic products highly (Table 21, item 4), but surprisingly flooding is given a comparatively low score (Table 21, item 15). Government officers and leaders of enterprises give more priority to daily water supply than farmers and fishermen, the reason may be that many farmers and fishermen rely on well water rather than tap water from reservoirs (Table 21, item 2). The function for clean [aquatic] environment was considered less important by farmers than by the other stakeholders,

possibly a result of farmers activity being confined on land (Table 21, item 14).

Table 21. The influence of Stakeholder to the evaluation of ecosystem services

	Average score for the evaluation of the importance				Result of Duncan's multi-range test*			
Stakeholders / Ecosystem service/cost	Gov.officer	Leaders of enterprise	Farmer	Fisher	Gov. officer	Leaders of enterprise	Farmer	Fisher
Average	**3.54**	**3.42**	**3.28**	**2.87**	**c**	**cb**	**b**	**a**
10 tourism	2.80	2.64	2.29	1.73	b	b	ab	a
6 transportation	2.87	3.50	2.59	2.27	ab	b	a	a
20 beautiful environment	3.80	3.71	3.41	2.50	b	b	ab	a
3 industrial water supply	4.00	4.14	2.35	2.66	b	b	a	a
-11 picking up river garbage	3.47	4.07	3.47	2.89	ab	b	ab	a
1 irrigation	4.40	4.71	3.70	1.85	bc	c	b	a
12 air humidity	3.60	3.42	3.53	2.50	b	ab	b	a
13 stable air temperature	3.53	3.71	3.35	2.61	ab	b	ab	a
18 biodiversity	4.13	3.57	3.17	2.61	c	bc	ab	a
-1 flooding	5.00	5.00	4.47	3.16	b	b	b	a
15 flooding control	4.60	4.21	4.21	3.24	b	ab	b	a
2 daily water supply	4.93	5.00	4.05	3.13	b	b	ab	a
-8 tree planting	4.06	3.78	4.12	2.42	b	b	b	a
14 clean environment	4.40	4.07	2.95	4.41	b	b	a	b
-4 pollutant diffusion	3.80	2.35	3.41	3.74	b	a	b	bc
4 aquatic products	3.80	3.21	3.53	4.32	b	a	ab	b
-2 drought	1.53	1.00	2.65	2.41	ab	a	c	bc

* Factors with the same character did not significantly different within 5% significant level; they can be assigned to the same group. The numbers in front of the service items are the same as in table 17. Negative number indicates ecosystem cost.

For the lowest ranking 'group' of services, the value given from government officers and leaders of enterprises is significantly higher than from fishers and farmers, possibly as these groups may have more opportunity to enjoy these services due to their better financial situation. The leaders of enterprise gave significantly lower values than the other stakeholders on pollutant diffusion by the river (Table 21, item 4), possibly as many companies are releasing pollutants in to the river and they are not directly affected by the polluted river. Whereas, fishers gave a significant lower value to tree planting than other groups. This may be due to the fact that only a very few activities of fishers link directly to the forest up in the hill and mountain, like firewood collecting if flooding did not carry enough wood downstream for them.

Fishers gave lower value to many ecosystem services and costs, but they did score the clean environment (Table 21, no. 14), water pollution (Table 21, no. -4), aquatic production (Table 21 no. 4), and drought disaster (Table 21, no. -2) very highly. Although leaders of enterprises gave high scores for

many ecosystem services and costs, they scored pollutant diffusion, aquatic products and drought relatively low. This may be a reason for the conflict of interest among different stakeholders, which could be solved by improving education and awareness of ecosystem services and how different groups rely upon them. Leaders of enterprises need a greater understanding of the importance of the river to the livelihoods of fishers and the serious impacts of water pollution. Government policy should help fishers to overcome the loss caused by pollution and other economic activities. For example, an ecological compensation fund could be set up and collected from industrial companies that damage ecosystem services. More financial support should be channelled to help the conservation and sustainable use of aquatic species, to improve the housing and employment opportunities for fishermen, and to recover ecosystem structure such as reforestation, soil erosion control and pollution treatment.

5.4. Ecosystem service maps

The following maps (Figure 48- Figure 56) present spatial information on the ecosystem services provided at a watershed scale and show the areas generating the services and the areas receiving (or benefiting) from the services.

Water supply depends upon the forested areas in the upper catchment to capture and store the water and then supply it through the rivers and ground water throughout the year. The areas benefiting from this water supply are the agricultural areas for irrigation (Figure 44), urban areas for domestic water supply (Figure 45) and the industrial areas where it is used in industrial process (Figure 46). Any damage to the forested areas within this catchment would negatively impact the water supply by degrading quality (increased sediment) and reducing quantity in dry periods (by increasing runoff and reducing the amount of water stored in the ground water) and also increase flooding risk (by increasing flash floods).

Aquatic products (fishes, plants, molluscs, shrimps etc.) are generated primarily from the rivers and reservoirs within the catchment as this is their primary habitat (Figure 47). However this service also relies upon the upper catchment to provide the water in the correct quantity and quality to sustain their life cycles. In addition the rivers and catchments downstream are also generating this ecosystem service (historically in this case) as many migratory species require suitable conditions and free passage downstream to the ocean. Unfortunately due to damming and pollution many migratory species that once provided ‘aquatic products’ (e.g. *Anguilla marmorata* the marbled eel) are no longer found in the upper catchment. The aquatic products are harvested from the rivers and reservoirs but the benefits spread further than just the fishing villages as they are consumed by people across the region, especially in those cities and towns with high population density. Degradation to the water quality or continued loss of habitat for the species that provide this service will not only impact the livelihoods of those that harvest the species but also those who consume the products.

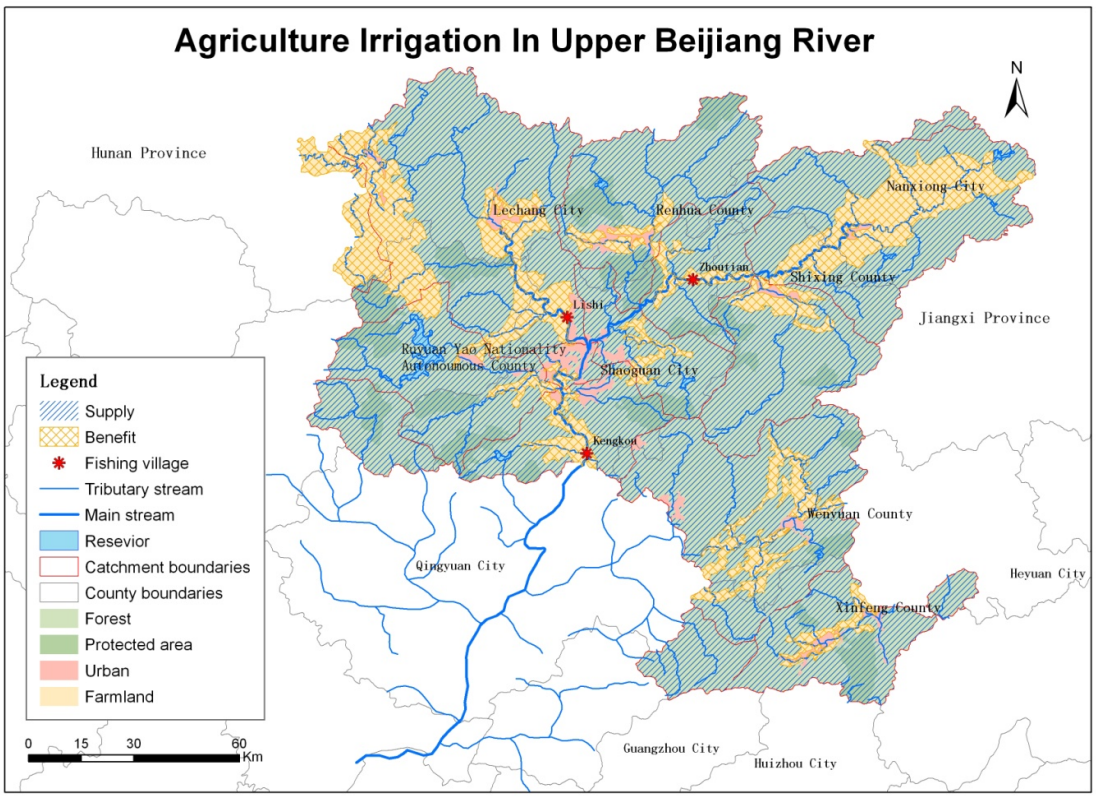

Figure 44. Water provision for irrigation of agricultural areas

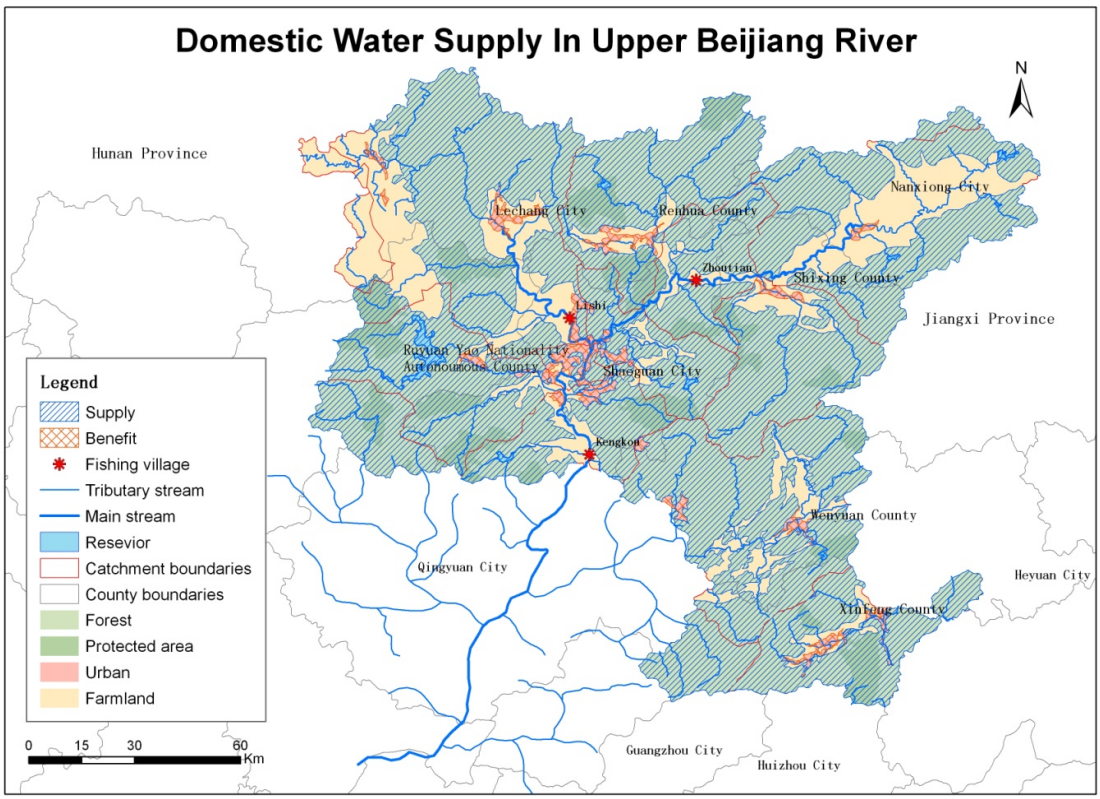

Figure 45. Water provision for domestic water supply

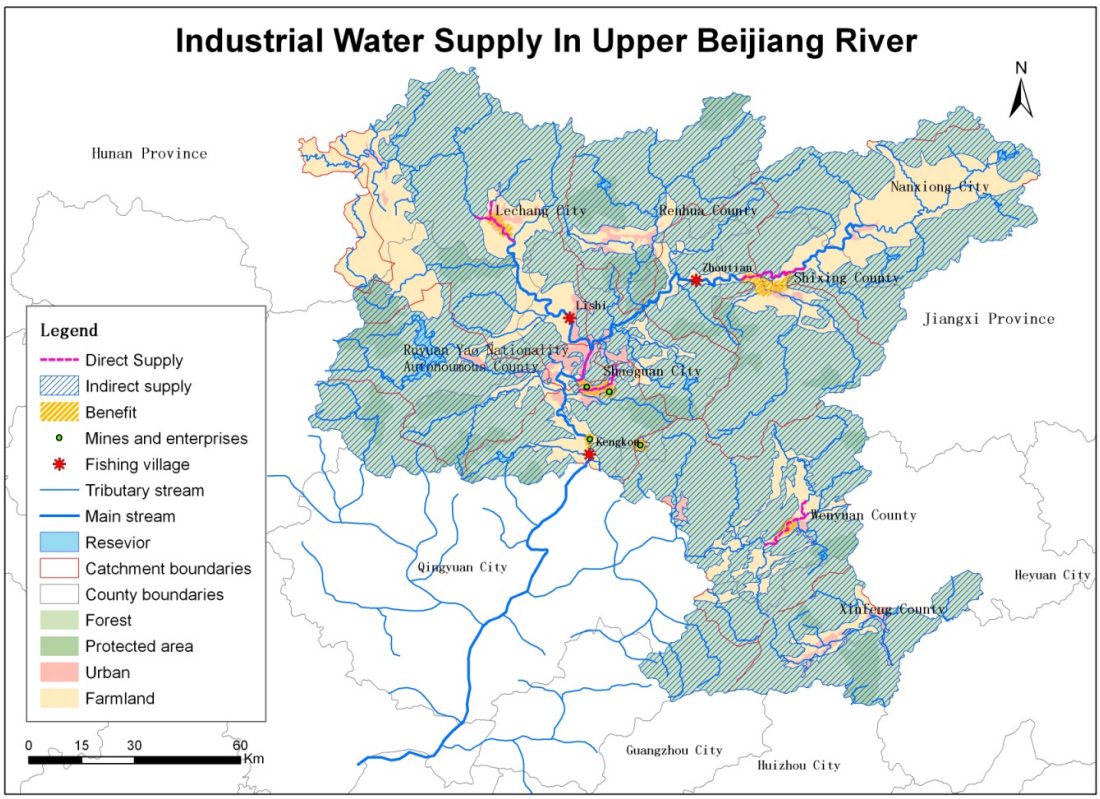

Figure 46. Water provision for industrial water supply

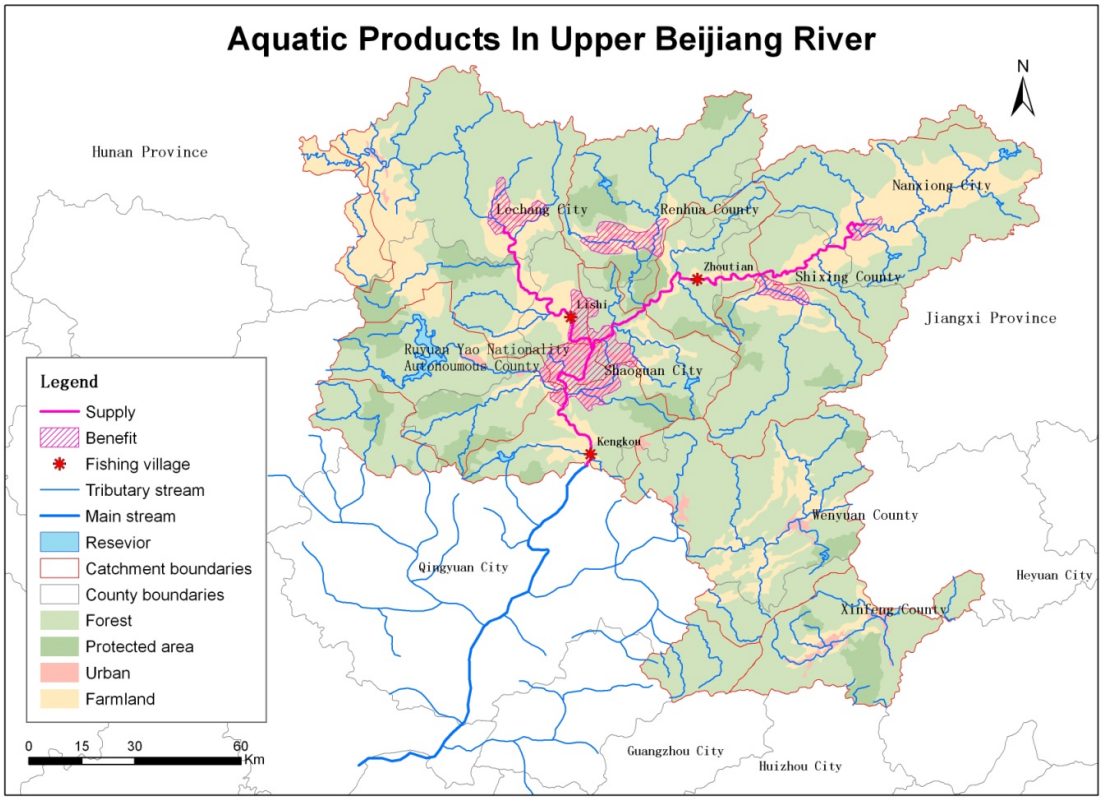

Figure 47. Provision of aquatic products

River transportation is no longer as important today as it once as dam construction within the river has limited the available transportation routes. However the river still provides a cheap and accessible way to transport goods up and down the river, and the areas that benefit from this are the major urban areas that are connected by the river (Figure 48).

Sand lying in the river bed is a major resource for the construction industry across the catchment (Figure 49). The sand is 'generated' by the erosion of material from the bed and banks of rivers and transported down the river until the flow is not strong enough to carry the particles, where it deposits the particles (sand) to the river bed. However, this process takes place over many hundreds of years to produce the sand beds that are being mined and it is not a service that can be renewed quickly. Therefore this is not a 'renewable' ecosystem service in the conventional time frame, and harvesting of the sand now reduces the value of the service in the future. The sand that is mined is transported to major cities and towns where it is used as construction material.

There are over 500 power stations along streams and major rivers in the watershed which are generating power to industrial and urban area areas in the region (areas benefiting from this service) (Figure 50). This service depends upon the supply of water, which is provided by the whole upper catchment.

Tourism not only benefits the tourists themselves but also the local people and businesses that generate an income in providing services for the tourists. Within the catchment there are many beautiful forest parks, natural reserves and historical sites in the region (areas generating the services of tourism) which are attracting more and more visitors from the region and outside the region (Figure 51).

Key recreation activities within the catchment are angling, boating and swimming that take place in the major sections of the Beijiang River and benefit the many people living and working in the cities and towns (Figure 52). This service is generated by many different areas, from the wider catchment that generates water provision (quantity and quality) to allow swimming and boating and the provision of biodiversity to provide fish for angling.

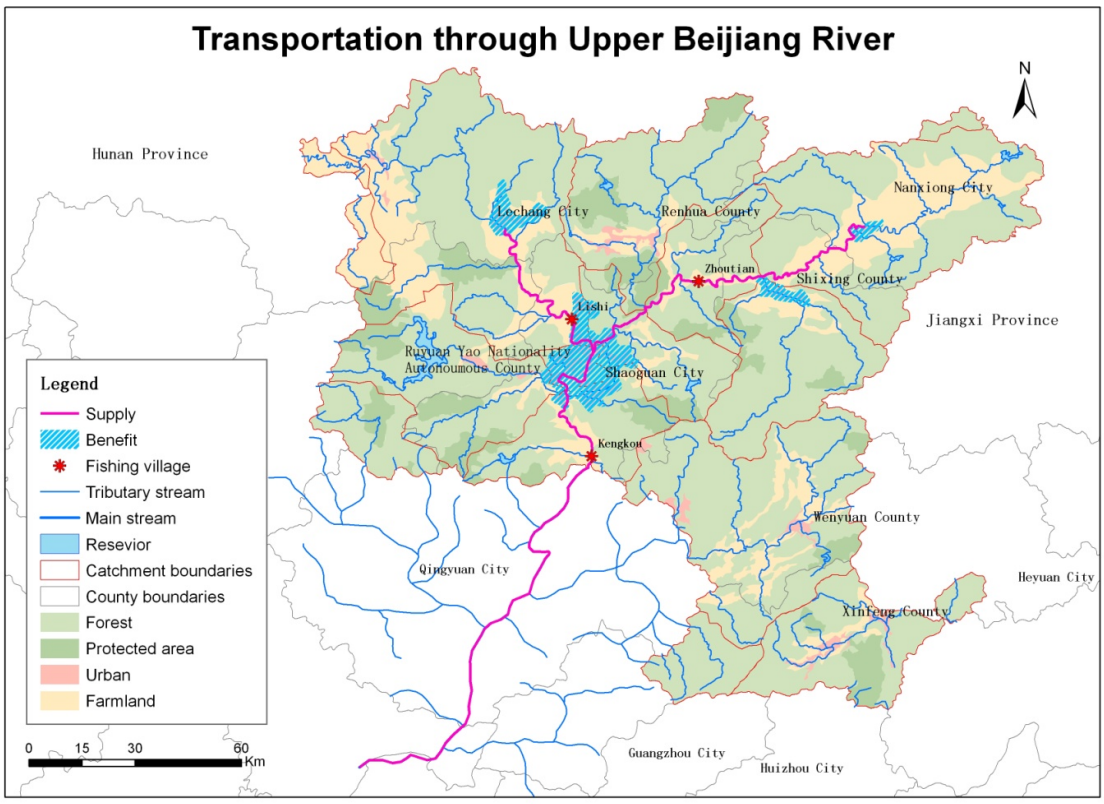

Figure 48. River transportation

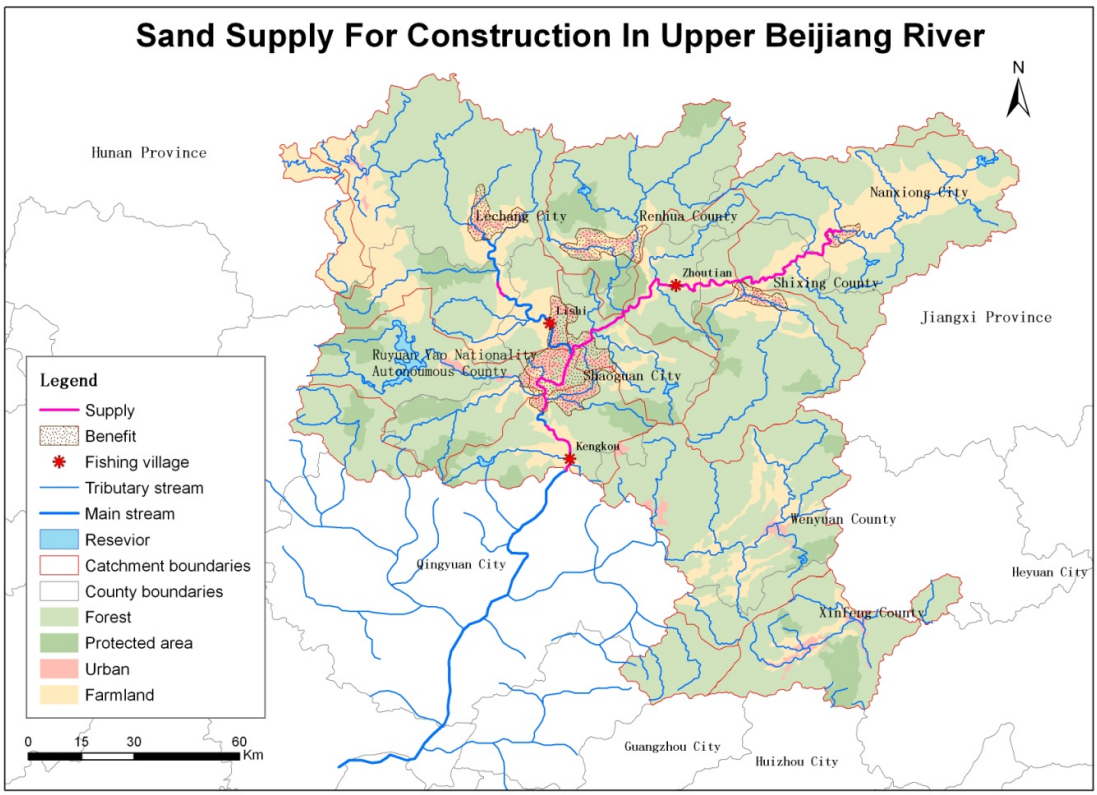

Figure 49. Sand supply

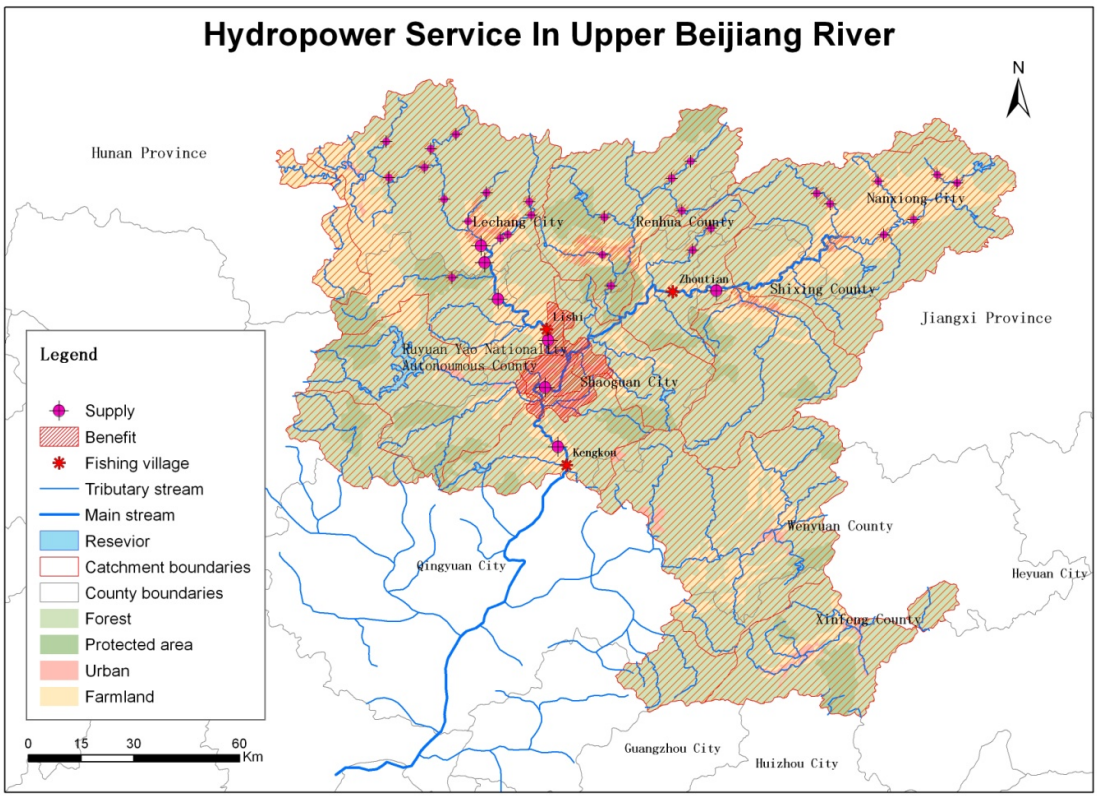

Figure 50. Hydropower supply

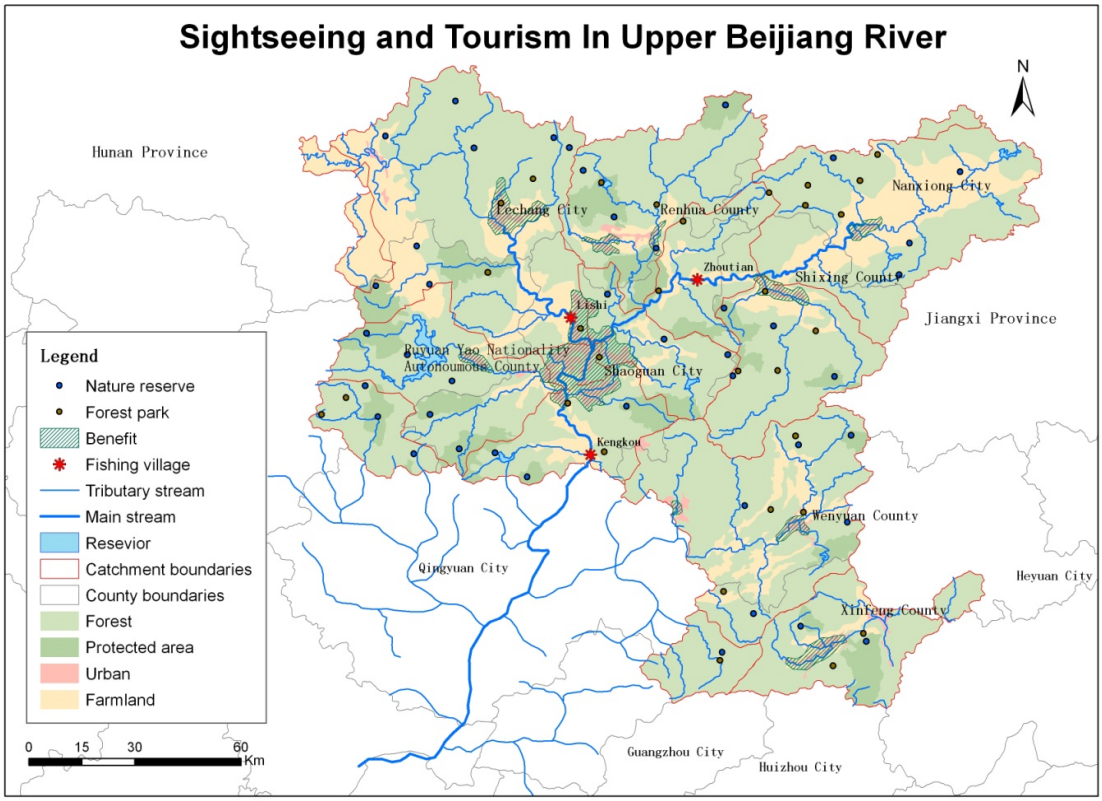

Figure 51. Sightseeing and tourism

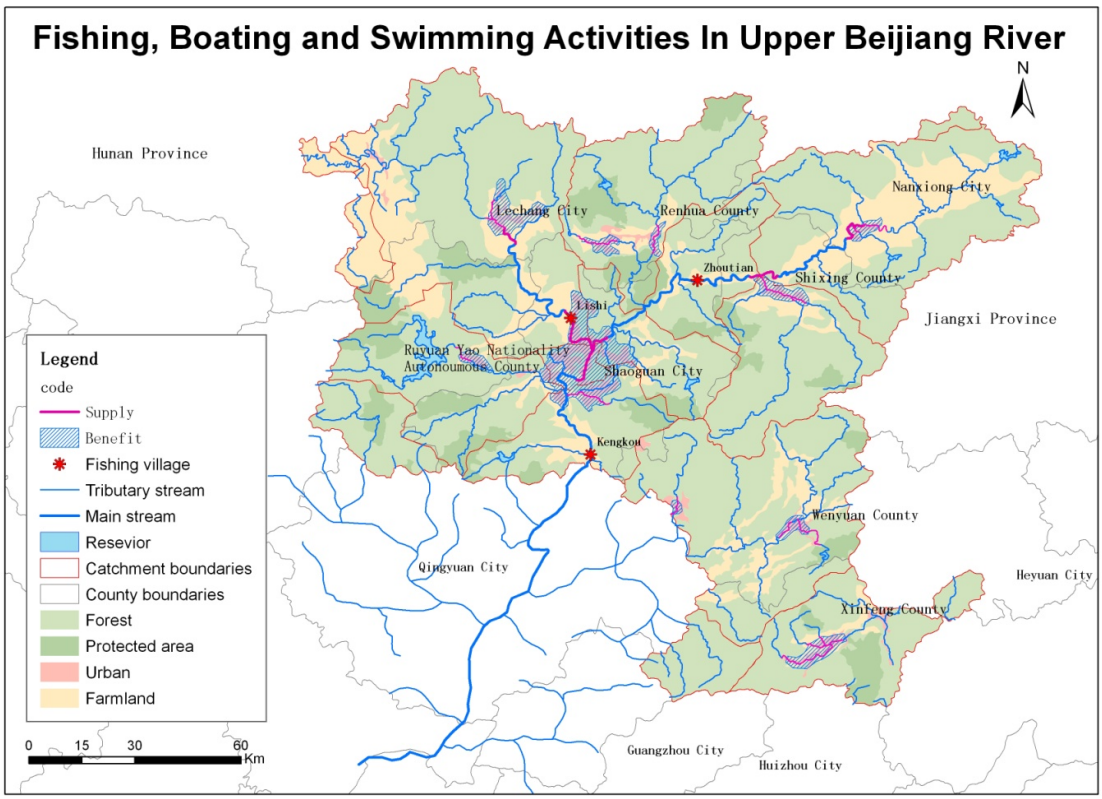

Figure 52. Leisure activities including fishing, boating and swimming

5.5. Economic valuation of ecosystem services

According to Xie Gaodi's improvement on Costanza's ecosystem valuation study (Xie *et al.,* 2003); there is an equation which is more suitable for the calculation of China's ecosystem service value:

$$ESV = \sum_{i=1}^{n} VC_i \times A_i$$

Where:

ESV = the total ecosystem service value (Yuan) in the research area.

VC_i = the unit value of ecosystem service provided by the i^{th} type of land use pattern (yuan/hm^2).

A_i = the total area of the i^{th} type of land use pattern.

n = the number of land use patterns.

For example, woodland can provide 3,097 Yuan service each hm2 (square hectometre = 1 hectare or 0.01km^2) for gas regulation (see Table 23), therefore 1.3879 million hm^2 woodland (see Table 22) provides 4,298.4 million Yuan of gas regulation service (see Tables 22 and 23).

Here:

$VC_i = VC_{(woodland\ gas\ regulation)}$ = 3097 Yuan,

Ai=$A_{(woodland)}$ = 1.3879 million hm^2,

Therefore: VC_i X A_i = 3096.8 (Yuan/hm^2) X 1.3879 (million hm^2) = 4298.4 (million Yuan)

The value of ecosystem services provided by Beijiang River watershed in Shaoguan City is calculated according to Shaoguan land use data in 2007 (Table 22). The value of $\boldsymbol{VC_i}$ is adopted from Xie Gaodi's research on Chinese land ecosystem services (Xie *et al.* 2003). The calculated results are in Table 23, and show that ecosystem services in Shaoguan provided are valued at 29,801.45 million Yuan.

Woodland is by far the greatest contributor being valued at 27,385.23 million Yuan, followed by cropland (1517.75 million Yuan) and water bodies (1471.26 million Yuan). Woodland provides more economic value than every other land type for every service apart from food production, where cropland has the highest value. Water bodies may have a lower value than woodland or cropland, but they cover a significantly smaller land area. If the total value for each land type is divided by the area that they cover to give a million Yuan per hm^2 value, water bodies are the most valuable with cropland valued at 0.0062 million Yuan per hm2, woodland 0.0197, grassland 0.0065, water bodies 0.0411 and unused land 0.0001.

Table 22. Land use cover in Shaoguan City in 2007 (unit: hm^2)

Type of land use	cropland	Woodland	Grassland	Water surface	Land for construction	Unused land
Area	242986.67	1387926.67	2460.00	35813.33	70440.00	89413.33

Table 23. Ecosystem service values in Shaoguan City for 2007 (unit: million Yuan)

Ecosystem service	Cropland	Woodland	Grassland	Water body	Unused land	Total
Gas regulation	107.50	4298.41	1.74	0.00	0.00	4407.65
Climate regulation	1913.52	3315.90	19.59	145.76	0.00	3523.78
Water conservation	129.00	3929.91	1.74	645.83	2.37	4708.86
Soil formation	313.91	4789.60	4.24	0.32	1.58	5109.65
Water treatment	352.62	1608.88	2.85	576.11	0.79	2541.26
Biodiversity conservation	152.64	4003.61	2.37	78.91	2.75	4240.29
Food production	215.02	122.83	0.65	3.17	0.79	342.46
Raw materials	21.50	3193.06	0.11	0.32	0.00	3214.99
Recreation	2.14	1571.97	0.09	137.53	0.79	1712.51
Total value	**1517.75**	**27385.23**	**16.09**	**1471.26**	**9.15**	**29801.45**
Total value per hm^2	**0.0062**	**0.0197**	**0.0065**	**0.0411**	**0.0001**	**0.0162**

5.6. Economic cost of maintaining ecosystem services in the Beijiang River

The economic cost of maintaining the ecosystem services of the Beijiang River has been calculated by using different methods including expert consultation, social-economic data sources and participation techniques as suggested by the IUCN toolkit. All statistical data in this section are provided by the Shaoguan Bureau of Environment Protection according to different internal reports.

5.6.1. Management costs

Management costs are the cost of equipment, capital, wages, buildings and running costs etc. required to manage the system.

5.6.1.1. Costs of water pollution control

Major water pollution sources along the Beijiang River include agricultural, household sewage and industrial discharge. The costs of water pollution control include the costs for water quality and quantity monitoring; soil erosion control; the construction and maintenance of wastewater treatment plants and pipe network for collecting sewage water; construction of biogas tanks, cropland ditch networks, wastewater filtration wetlands, and rural domestic sewage and animal husbandry wastewater treatment facilities. The cost includes infrastructure construction, maintenance and human resources used for pollution control. The total direct cost of water pollution control is 670 million Yuan during the period 2006-2010 (Table 24).

5.6.1.2. Cost of river channel maintenance

During the period 2006-2010 the cost for river dike protection was 2,000 million Yuan RMB, and the construction of flood control reservoirs was 3,680 million Yuan RMB (Table 24). For the same period river bed dredging cost about 400 million Yuan RMB (sand mining can also be regarded as a dredging process, which is very active in the Beijiang River and the income gained from selling the sand is 800 million Yuan RMB during the period 2006-2010). The costs of collecting and transporting river garbage and water hyacinth are about 200,000 RMB every year (but it can bring 100,000 Yuan RMB back per year by selling wood collected from the river). Costs of treating industrial solid waste, hazardous waste, and clinical waste came to 247.2 million Yuan RMB during the period 2006-2010.

Table 24. Project costs for the protection and improvement of water quality in Shaoguan City 2006-2010.
(Provided by Environmental Protection Agency of Shaoguan City)

NO.	Name of Projects	Investment (million)
1	The second wastewater treatment plants of Shaoguan city (50000t/d)	101.8
2	Wastewater treatment plants of Wengyuan County (15000t/d)	53.44
3	Wastewater treatment plants of Ruyuan County (15000t/d)	53.44
4	Wastewater treatment plants of Renhua County (10000t/d)	36.4
5	Wastewater treatment plants of Lechang City (10000t/d)	36.4
6	Wastewater treatment plants of Nanxiong City (15000t/d)	46.46
7	Wastewater treatment plants of Qujiang District (the second phase, 20000t/d)	61.95
8	Wastewater treatment plants of Lechang City (the second phase, 20000t/d)	61.95
9	Wastewater treatment plants of 16 centre towns	103.5
10	Pollutant intercepting network construction	330
11	Hualazhai refuse landfill of Shaoguan City (755 t/d)	222
12	Refuse landfill of Shaoguan urban district (800 t/d)	200
13	Refuse landfill of Ruyuan County (60 t/d)	19
14	Refuse landfill of Shixing County (60 t/d)	19
15	Refuse landfill of Renhua County (50 t/d)	16
16	Refuse landfill of Wengyuan County (70 t/d)	21.5
17	Refuse landfill of Xiongfeng County (90 t/d)	27
18	Refuse landfill of Lechang County (210 t/d)	50
19	Refuse landfill of Nanxiong City (120 t/d)	30
20	Industrial solid waste disposal centre of Shaoguan City (500 t/d)	60
21	North Guangdong hazardous waste disposal centre of (the first phase, 30 t/d)	180

NO.	Name of Projects	Investment (million)
22	Clinical waste disposal centre of Shaoguan City (10t/d)	7.2
23	River dredging of Wujiang River	200
24	River dredging of Zhenjiang Rive	200
25	Soil erosion management of Zhenjiang River drainage basin	16.593
26	Water pollution of Dabaoshan mine	100
27	Construction of public welfare forest	1700
28	Conservation of water and soil	4.35
29	Construction of nature reserve	200
30	Construction of "green channel"	384
31	Projects for technological ability construction of environmental management	19.63
Total investment		**4,561.613**

5.6.1.3. Cost for biodiversity protection

In order to protect aquatic species and fish resources, nine conservation areas have been established. Cost of fish species protection and proliferation is about 3 million Yuan RMB every year.

5.6.1.4. Cost for fisheries management

The Fisheries Administration Team of Shaoguan City is in charge of fisheries management which includes the supervision of fishing activity and the setting up, management and monitoring of natural reserves. The cost of fisheries administration is about 3 million Yuan RMB per year.

5.6.1.5. Cost of reforestation and water conservation

One example of a reforestation project is the reforestation of the hilly areas of Shaoguan highway system, costing 384 million Yuan RMB during 2006-2010. It included a reforestation project for an area of 2,133 ha along both sides of the highway. In 2009, reforestation project in both sides of Beijing-Zhuhai Expressway was also completed. There were 918.5 km2 of soil erosion areas in Shaoguan City in 2006-2009, and 209.6 km2 have been treated by biological (re-vegetation) and engineering (sand dam, contour terrace, and drainage channel) methods. The investment for this work was about 171 million Yuan for the period 2001-2005. During the period 2006-2010, the level of investment increased up to 2,100 million Yuan (Table 25).

Table 25. Project costs for increasing technological ability for environmental management in Shaoguan during the period 2006-2010.
(provided by Environmental Protection Agency of Shaoguan City)

NO.	Name of Projects	Investment (million)
1	Emergency monitoring system for environmental safety	2.8
2	Monitoring information network for city and county	2
3	Automatic monitoring station in drinking water source	2.2
4	Environmental monitoring centre station of Shaoguan City	1.7
5	Personal training for information management	2.1
6	Personal training for implementation and education of environmental law and related legislation system	1
7	Personal training and hardware purchasing for monitoring	7.83
	Total investment	**19.63**

5.6.2. Opportunity costs

An opportunity cost is alternative uses that are forgone, the loss of potential profits and alternative investment caused by maintaining an ecosystem service, i.e. preventing it being used to provide another service. The cost can be estimated by the alternative use which is sacrificed.

5.6.2.1. Industrial development and water quality

For maintaining the water quality of the Beijiang River, the development of certain heavily polluting industries is not allowed. The local government has turned down many proposals for the establishment of chemical or other heavy industry. The economic loss will be large but is hard to estimate.

5.6.2.2. Industrial development and biological conservation

Some industrial projects in the Beijiang River watershed have had to change design or location due to conservation purposes. For example, the Wu River Bridge project for the GuangLe freeway had to change location to cross the river, so to avoid a nature reserve in the Beijiang River. It also had to pay a compensation fee of 90 million Yuan to fund artificial reproduction of fish projects and 75 million Yuan for ecological monitoring.

5.6.3. Cost for other reasons

5.6.3.1. Water borne diseases

River water can transmit water borne diseases, such as schistosomiasis. The cost of projects that to try control water bourn diseases in Shaoguan City is estimated to be about 200 thousand Yuan each year.

5.6.3.2. Flooding

Although much work has been undertaken to control flooding in the Beijiang River, flooding still occasionally happens. For example, in 2006 a typhoon caused a large flood that caused 2.6 billion Yuan in damage. In order to prepare for flooding, the expenditure for material purchase and personal training is 3.65 million Yuan each year in Shaoguan City.

6. Policy relating to biodiversity and ecosystem services

Local government has made great efforts to solve the problems facing the freshwater systems and their ecosystem services and biodiversity.

6.1. Development strategy of Shaoguan

The development strategy for Shaoguan City has been defined by the provincial government as an important ecological buffering zone, tourist development region and an important transportation channel. The coordination between the development of the regions economy and protection of ecology are emphasized. For example, high quality food production methods with lower levels of chemical fertilizer and pesticides are encouraged. Industry with modern technology, low energy consumption and low pollution are also emphasized. Nature conservation and ecological tourism can be coordinated. Shaoguan is a popular tourist destination as it is one of the oldest places of civilization in southern China, with the Maba people living in the area 130,000 years ago. There are many tourist attractions such as Nanhua Temple, with more than 1,000 years of history, which was founded by Huineng, the Sixth Patriarch of Zen Buddhism, and Danxia Mountain and Nanling national forest parks and Guangdong Grand Canyon are tourist hot spots.

6.2. Protected areas in Shaoguan

6.2.1. Forests

Forested areas have been continuously increasing since 2005 (Figure 53), and now covers 78% of the total land area of Shaoguan (Figure 54) (Guangdong Bureau of Statistics 2002-2009).

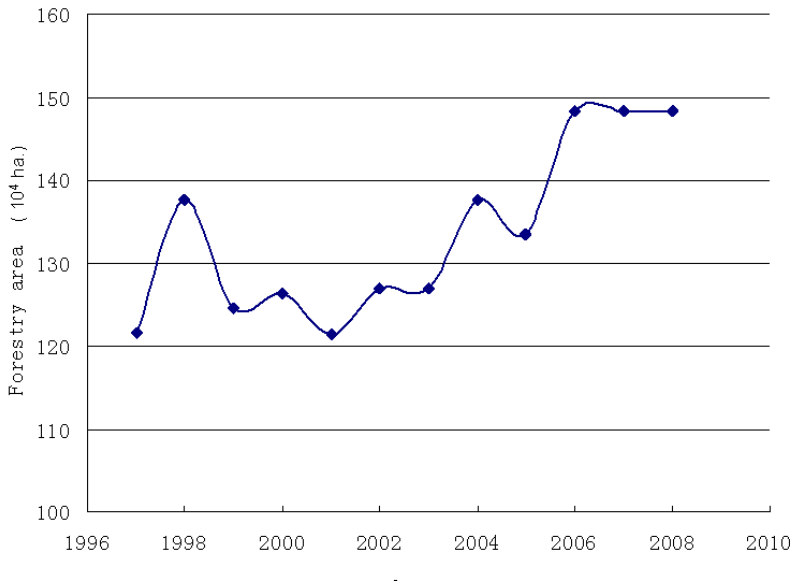

Figure 53. Forested area in Shaoguan (Guangdong Bureau of Statistics 2002-2009)

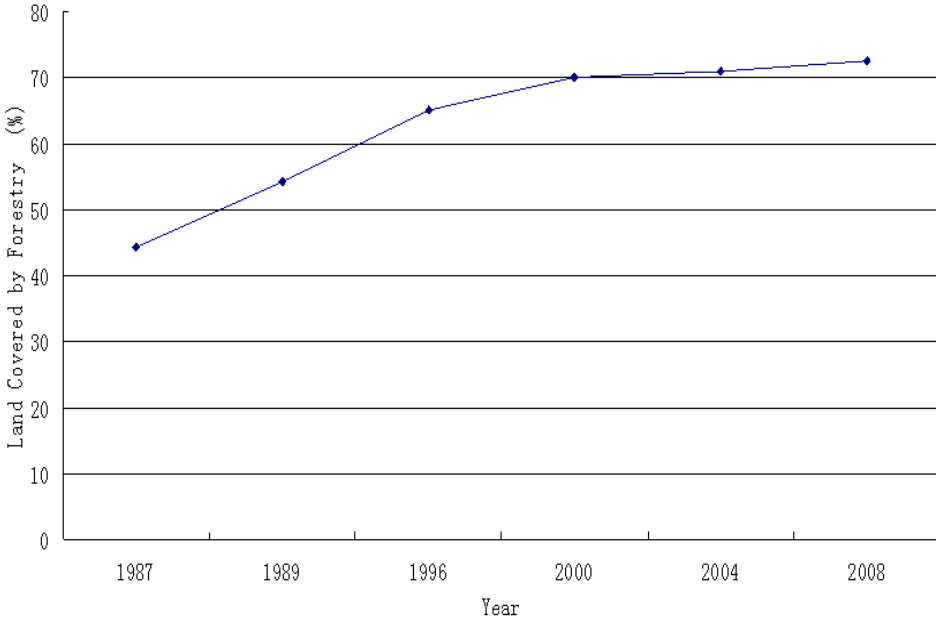

Figure 54. Land covered by forest in Shaoguan (Sources: http://number.cnki.net/)

Since 1999, all forests are classified as either commercial forest or ecological forest based on their major functions. In 2008 in Shaoguan, 31.54% of forest land was designated as ecological forest. 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 obtain compensation from the Government. The compensation fees have increased from 37.5 Yuan/hm2 in 1999 to 180 Yuan/hm2 in 2009. There are 22 nature reserves in Shaoguan City, which cover a total area of 25.3 $\times$ 106 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 $\times$ 104 hm2. Among these, 3 are national, 2 are provincial, and 6 are county level. The forest disturbances caused by fire and wood cutting has decreased dramatically since 1985, however, the impacts caused by the building of hydropower stations (deforestation) still exist.

6.2.2. Aquatic resource conservation zones

In order to protect native aquatic species and fish resources, the “Fisheries Law of the People's Republic of China” (1986) and “Protection Law of Wildlife” (1988) were passed. Under these pieces of legislation nine conservation areas with an area more than 3,780 ha have been set up in order to protect biodiversity in Shaoguan. The protected species include Asian giant soft-shell turtle (*Pelochelys cantorii* or *Amyda sincnsis* an Endangered species), marbled eel (*Anguilla marmorata)*, and wattle-necked soft-shell turtle (*Palea steindachneri* an Endangered species) (Table 26). At the same time, destructive fishing methods such as explosives, poison or electricity have been prohibited and the fishermen require a fishing licence to catch fish, which they receive from Shaoguan Fisheries Administration Team. There are 180 families with Fishing License at present. Fish fry releasing (all of native species) has been strengthened in the past decade (see section 6.5.2.).

Table 26. Aquatic conservation areas in Shaoguan
(Institute of Aquaculture of Shaoguan City, 1991)

Name of conservation area	Objective	Area protected
Shaoguan Beijiang endemic and rare fish Provincial conversation area	High quality and rare fish resources	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 (*Semilabeo notabilis*)	*Semilabeo notabilis* 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

6.3. Waste water and pollution control in Shaoguan

Shaoguan, as a less developed part of Guangdong Province, has been designated as an important ecological buffering zone and faces the sharp conflict between environmental protection and economic development. This conflict is clearly evident within freshwater systems. In China, through the Environmental Quality Standard for Surface Water bodies (GB3838-2002) (including rivers, lakes and reservoirs) are divided into 5 classes (or functions) based on its purpose of use and protection target (see below) and the water quality needs to pass standards for each category (class I/II is regarded 'good', III/IV 'moderate' and V/V+, 'poor').

Type I - refers to the water quality for National Preserved Areas,
Type II - refers to water quality for drinking water and important fish species,
Type III - refers to water quality for dinking water, swimming and fishing,
Type IV - refers to water suitable for industrial water resources, and
Type V - refers to agricultural water resources.

To protect water resources and improve the water quality of the Beijiang River, water quality goals for 2010 were set up through the Zhujiang River Valley Pollution Remediation Project. These goals included: that 80% of the surface water in the Beijiang River should reach the national water quality standards according to its purpose of use; 80% of the total volume of water that is 'handed over' to the next city must be able to reach the required standard; 95% of the water discharged from industry will be treated and should reach the required standard; and 60% of domestic wastewater should be treated and should the required standard (Government of Shaoguan City 2003).

According to monitoring data under the Environmental Quality Standard for Surface Water bodies, water quality in 2008 was 'good' in the upper reaches of Beijiang River (Shaoguan section) and the total 'pass rate' of water quality in major rivers and lakes is 93.50%. One hundred percent of water quality samples in the four Class II zones in Shaoguan City passed the standard, 97.2% of water samples in the six Class III zones reached the required standard, 83.3% of water samples in the three Class IV

zones reached the required standard. The major pollutants of the Class III and IV zones was *E. coli* Water quality of the Wujiang River, Nanshui River, Jingjiang River, Mojiang River, Wengjiang River, Beijiang River (Shaoguan section), and Xinfengjiang River were good, with a 100% pass rate (Bureau of Environment Protection of Shaoguan, 2009).

6.3.1. Closure of polluting industries

The local government (Shaoguan City) has closed polluting small steel factories that have 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 within the past five years. They have also reduced the amount of pulp and paper sludge, grain industries, dyeing factories and electroplating industries.

6.3.2. Waste water treatment measures

In recent years in Shaoguan enforcement of waste water treatment measures for major industries has been strengthened and there has been more investment in the infrastructure for environmental protection. The percentage of industrial waste water discharge that has reached the required standard is fluctuating around 80% (Figure 55). In 2008, 8,915,000 tons of industrial solid wastes were produced in Shaoguan city, but 80% of this was recycled (Figure 56).

Seven domestic wastewater treatment plants (WWTP) have been established since 2007 with the total treatment capacity reaching 140,000 tons per day, and 23.3 km of waste pipes have been laid (Bureau of Environment Protection of Shaoguan, 2009). The total domestic wastewater treatment capability of Shaoguan now has reached 260,000 tons per day. With an investment of 0.12 billion RMB the first phase (600 t per day) of the Hualazhai sanitary landfill for domestic waste has been built and put into use (Bureau of Environment Protection of Shaoguan, 2009).

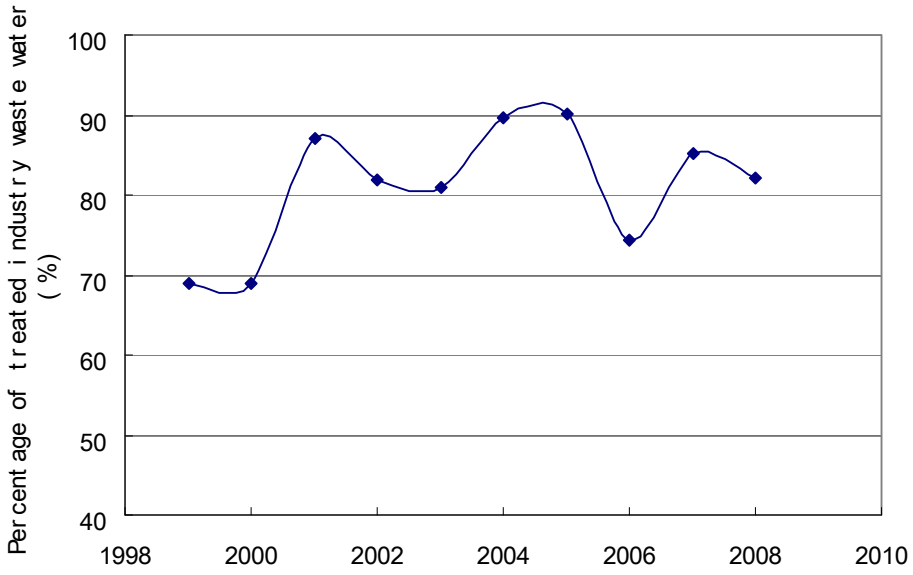

Figure 55. Percentage of industrial waste water discharged which reached the standard in Shaoguan

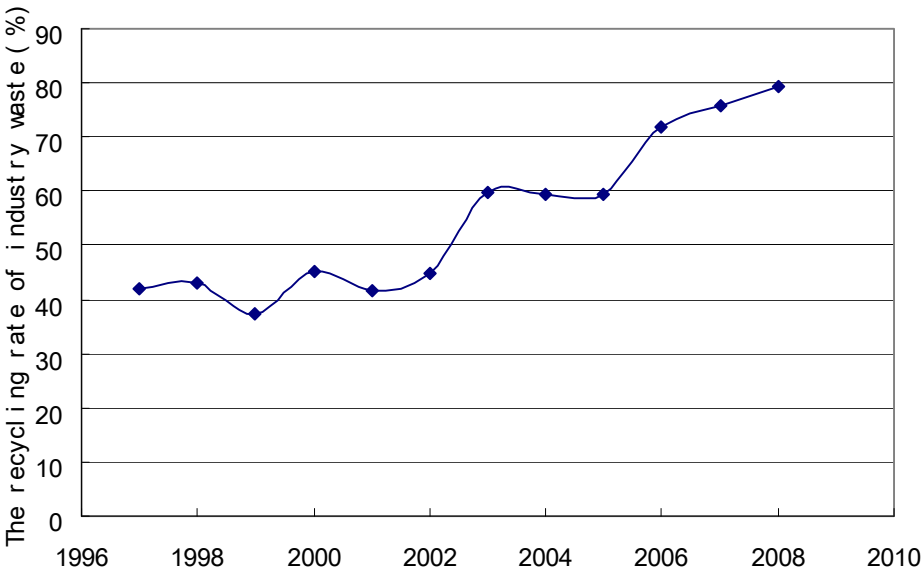

Figure 56. The recycling rate of industrial solid waste in Shaoguan

6.4. Environmental protection in rural areas

Major rural pollution sources of the Beijiang River include animal husbandry, overuse of pesticides and fertilizers, and household sewage discharge. Strategies for water quality improvement in agricultural areas include: 1) Reinforcing the environmental management of livestock farms by building biogas tanks and collecting and recycling animal excrement. 2) Developing eco-agriculture and extend biogas application - there have been 175,000 biogas pools established up to 2010 reducing COD (Chemical Oxygen Demand) by 6,566 t per year 3) Reinforcing the management of agricultural chemicals by the extension of optimum fertilizer application methods and more accurate forecasting for the outbreak of crop pests. The level of pesticide and fertilizer application will be reduced and bio-fertilizer, organic fertilizer, bio-pesticides, green feed and green feed additives will be encouraged (Government of Shaoguan City, 2003).

6.5. Conservation of aquatic resources

6.5.1. Research and monitoring of aquatic resources

Since the mid 1990s the Shaoguan Fishery Monitoring Team (local government) has monitored the daily fishing activity along the Beijiang River and recorded the amount and size of fish caught and their price at the market. The total aquatic production has continuously increased since 1970, however the percentage of this from river fish has decreased (Figure 57). Species of conservation concern such as the Asian giant soft-shell turtle, marbled eel, hilsa herring, wattle-necked soft-shell turtle and *Luciobrama macrocephalus* are now very rare in the Beijiang River. Nine conversation areas with area more than 3,780 ha have been set up in order to protect the biodiversity in Shaoguan.

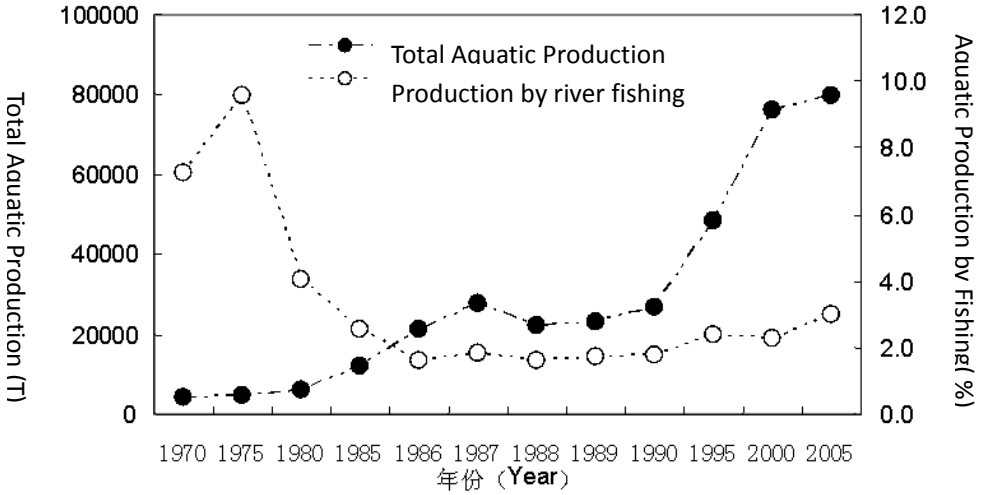

Figure 57. Aquatic production of fish in Shaoguan

6.5.2. Fish breeding and release of fry

Since 2006, the principle of "government guide and public participation" for releasing fish fry back to Beijiang River has been implemented. Native species of captive bred fish, shrimp, crab and shellfish are released into the river at different sites along the Beijiang. On average, five million fish are released every year to the river with 60% being purchased by the public. Ten to 20 thousand people have so far taken part by visiting the fish releasing sites and paying to release fish in to the river (Figure 58 and 59).

Figure 58. The opening of the Shaoguan Association of Animal Releasing Culture in 2009
(Source: http://www.gdyzhj.gov.cn)

Figure 59. Local people releasing fish fry in to the Beijiang River (Source: http://www.gdyzhj.gov.cn)

6.5.3. Net-cage fishing in conservation and protected areas

In order to protect water quality, aquatic resources and rare species, the local government has banned net-cages from protected areas and reservoirs and issued compensation for the fisherman's loss of livelihood (Figure 60).

Figure 60. Fish farmers removing net-cages from Nanshui reservoir which is a source of drinking water (Source: http://www.gdyzhj.gov.cn)

6.5.4. Management of sand mining

Efforts to monitor the bidding and operational activity of sand mining companies has been strengthened by coordinating activities of different law enforcement agencies such as Bureau of Environment Protection, Bureau of Water Management, and Bureau of Land Resources. In 2008 the Department of Water Conservancy of Guangdong issued a bulletin to prohibit sand mining in some major watercourses of the Pearl River. This new regulation is important for improving the management of sand mining in Beijiang River (Yang *et al.* 2009).

6.5.5. Development plans for ecology and resources protection

Various development plans have been published including the Ecological Agriculture in Shaoguan (2008-2015), Fishing in Shaoguan (2008-2015-2020) and Water Management Monitoring Agency (2008-2010). Also, legal infringement cases in large-and-medium reservoirs have been investigated and people have been charged. In 2000 and 2004, the People's Congress of Shaoguan put forward proposals for setting up economic compensation systems for the negative impacts on aquatic resources and livelihoods caused by the construction of dams and hydropower stations.

7. Conclusions and recommendations

Within the three sampling sites in the Beijiang River, 26 fish species, 8 mollusc species, 11 aquatic plant species, and 25 odonate species have been identified. One species, the fish *Pseudohemiculter dispar* has been identified as globally threatened, and two species the fish *Metzia formosae* and the mollusc (gastropod) *Cipangopaludina ampulliformis* are nationally threatened. The traditionally high value economic species such as *Pseudohemiculter dispar* and *Misgurnus anguillicaudatus* are decreasing, and many others are suspected to be declining also based on the general decline in fishery catch. Some species such as the marbled eel (*Anguilla marmorata*) once an important fishery species at the sites has now almost disappeared due to dams blocking the species migration route. All the molluscs and plants the majority of the fishes that were identified through the site species surveys were of livelihood importance to the communities at the sites. Their uses varied widely from providing income (selling as food) to providing fodder for livestock, medicinal use and to produce biogas. Many species have also been identified at the sites that can act as indicators for environmental quality (in particular molluscs and plants) and status of fisheries.

The Beijiang river provides many ecosystem services to the communities at the fishing villages (such as food, water etc) but also to the people of Shaoguan (including power, sand for construction, water for industry). Through the ecosystem service prioritisation exercise undertaken with the different stakeholders, the provisioning services of aquatic products, water provision and electricity, along with the regulating service of flood control and pollution removal were the highest valued services by all the stakeholders. There were differences among the stakeholder groups, but it was felt that the fishermen and farmers did not understand the concept of ecosystem services as well as government officers and company leaders. Also both government officers and company leaders need to understand the importance of aquatic products and other services to the fishermen and farmers, and the damage caused to ecosystem services by polluted waste water. More education and awareness building is needed for all stakeholder groups.

The total economic value of the ecosystem services provided by the Beijiang river and its watershed is estimated at 29.8 billion Yuan in 2007 (~3.4 billion (as in thousand million) Euros in 2007). This is the equivalent of 61.4% of the GDP of Shaoguan City in the same year. The major provisional services provided include wood, aquatic products, clean water, sand, hydropower, agricultural food and transportation channel. Regulating services, such as flood regulation are also very important. Cultural services are becoming more valuable as there is a development in tourism, recreation, education and research. Ecosystem service costs spent on management are calculated to be 1.41 billion Yuan each year which is less than 5% of the ecosystem services value. Among all ecosystem service costs, the management costs are by far the biggest, as there has been costly investment in to the construction and maintenance of dikes, deepening river beds, protection of biodiversity, fishery management, reforestation projects, and soil and water conservation projects.

The major threats to the sites aquatic resources and ecosystem services are water pollution (mostly from urban and industrial sources in Shaoguan City), sand mining and hydropower dams. In order to protect these ecosystem services, the government of Shaoguan have taken many actions including the

closing of many polluting industries and have refused to allow the development of environmentally harmful businesses. These opportunity costs may need to be compensated for in the future.

In order to achieve the sustainable use of aquatic resources, many stakeholders in Shaoguan have taken action, in particular:

- Regional strategic development plans have been made;
- Nature preservation zones for forest and aquatic organisms have been set up;
- Water pollution control has been strengthened;
- Regulation of sand mining in the river has been strengthened,
- Fishing activities are under continuous monitoring by a government agency;
- Breeding and releasing of fish fry in to Beijiang River have put into action for many years.
- A 'no fishing season' in the Pearl River began to be implemented from April 1, to June 1, each year from 2011. Although it will be good for the recovery of some aquatic species, it will be a challenge for the monitoring force.

All these measures need to continue, but they need to be strengthened if they are to be successful in the future. For example we recommend that the below actions need to be considered:

- Shaoguan is considered an important ecological buffering zone, however, ecological compensation mechanisms need to be considered to improve the relatively poor economic situation of the area.
- Preservation zones for aquatic organisms have been set up, but sand dredging and fishing activities have not been prevented and therefore better management and enforcement is needed.
- More preservation zones need to be considered in the near future, in particular to aid in the conservation of globally, nationally locally threatened species and species that are declining and are of direct livelihood value.
- Although regulation and monitoring of water pollution have been improved, not all waste water from industry and residential regions is treated. Sections of the river are still polluted due to the waste water from iron ore mining activities. Fertilizer and pesticide used in agriculture sectors need to be reduced and more environmentally friendly methods for agricultural production needs to be developed. Waste water treatment capacity still needs to be expanded.
- Destructive fishing methods such as electricity and poison are still used illegally by some people to kill fish in river. More education and monitoring activities need to be developed.
- There are only 10 locations for releasing fish fry. Releasing points should be expanded. Only common low price species are raised and released at present. More locally rare species and economically high value fish fry should be raised and released. This will depend upon the financial resources available, but these could be strengthened by gathering money from resources tax from various industries.
- The sections of river bed destroyed by dredging should be restored by the replanting of aquatic plant species, particularly those that are important for fish, shrimp, turtles, crabs and snails.
- Compensation for the fisher's loss of income and food from the new "no fishing season" needs to be developed.

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Annex I. Locations of species survey sites

Fishes and molluscs

Site		Longitude	Latitude	Habitats
Zhoutian	1	113.852800	24.973600	fast flowing channel
	2	113.854500	24.974600	fast flowing channel
	3	113.855900	24.975700	fast flowing channel
	4	113.861100	24.978300	fast flowing channel
	5	113.862300	24.979500	deep slow channel
	6	113.864000	24.980600	deep slow channel
	7	113.867500	24.979600	deep slow channel
	8	113.869000	24.978200	shallow slow channel
	9	113.870600	24.976400	shallow slow channel
	10	113.871100	24.974500	shallow slow channel
	11	113.872000	24.971900	shallow slow channel
	12	113.874100	24.971400	shallow slow channel
	13	113.877000	24.974800	shallow slow channel
	14	113.873200	24.973700	shallow slow channel
	15	113.877000	24.974100	fast flowing channel
	16	113.876000	24.974300	fast flowing channel
	17	113.878700	24.976000	fast shallow channel
	18	113.879400	24.976300	fast shallow channel
	19	113.879900	24.976800	fast shallow channel
	20	113.881400	24.977900	fast flowing channel
	21	113.884000	24.979100	fast flowing channel
Lishi	1	113.544300	24.870490	near village
	2	113.544740	24.872610	near village
	3	113.545080	24.870900	about 2m deep water
	4	113.543300	24.868170	about 2m deep water
	5	113.541600	24.862120	about 2m deep water
	6	113.541040	24.860120	about 2m deep water
	7	113.539980	24.855460	about 2m deep water
	8	113.542510	24.867780	around sand mining
	9	113.541470	24.871420	deep water
	10	113.539650	24.875420	deep water
	11	113.537520	24.880100	deep water
	12	113.534100	24.886100	deep water
	13	113.531650	24.888050	15m deep water
	14	113.527900	24.892400	near waste water outlet
	15	113.523850	24.895620	deep water
	16	113.523150	24.897000	deep water

Site		Longitude	Latitude	Habitats
	17	113.522200	24.899640	forest area
	18	113.517500	24.901540	about 2m deep water
	19	113.514060	24.903300	about 2m deep water
	20	113.510300	24.899790	around small island
	21	113.508800	24.896540	about 2m deep water
	22	113.508960	24.899120	about 2m deep water
	23	113.506700	24.887940	about 2m deep water
	24	113.505090	24.886950	about 2m deep water
	25	113.502450	24.887160	about 2m deep water
	26	113.496380	24.890000	about 2m deep water
	27	113.488310	24.892230	about 2m deep water
	28	113.484500	24.894600	about 2 to 5m deep water
	29	113.503750	24.885270	about 2 to 5m deep water
	30	113.510580	24.890630	about 2 to 5m deep water
	31	113.513250	24.893700	about 2 to 5m deep water
	32	113.513650	24.899330	about 2 to 5m deep water
	33	113.519450	24.899480	near dam, deep water
	34	113.526670	24.891510	near dam, deep water
Kengkou	1	113.566700	24.588200	close to Mengli dam, Shallow water, fast flow
	2	113.566900	24.586200	close to bamboo dike
	3	113.569300	24.586600	close to bamboo dike
	4	113.580600	24.583300	close to Shaoguan Power Plant
	5	113.582300	24.583000	close to the dock of power plant for coal loading
	6	113.585300	24.574000	major fishing section with slow water flow
	7	113.589700	24.558100	major fishing section
	8	113.588600	24.549600	close to the sandy island with bamboo
	9	113.588400	24.546500	close to the collapse dike
	10	113.588600	24.535700	close to the fishing village
	11	113.590000	24.533200	close to the discharge channel for iron ore washing water
	12	113.590300	24.531400	close to the sand pile
	13	113.590000	24.524700	deep water section, close to dike with very few plants
	14	113.589200	24.521600	deep water section

Aquatic plants

Site	Longitude	Latitude	Habitat

Site			Longitude	Latitude	Habitat
Rujiang	Site 1-1	1	113.268465	24.777209	Shallow Water about 0.5m
	Site 1-2	2	113.273431	24.775246	Shallow Water about 0.5m
	Site 1-3	3	113.268777	24.777669	Shallow Water about 0.5m
	Site 1-4	4	113.273506	24.776069	Shallow Water about 0.5m
	Site 2-1	5	113.259591	24.787760	Shallow Water about 0.5m
	Site 2-1	6	113.259167	24.781782	Shallow Water about 0.5m
	Site 2-2	7	113.259890	24.787795	Shallow Water about 0.5m
	Site 2-3	8	113.259765	24.781861	Shallow Water about 0.5m
Shiliting	Site 1-1	1	113.533849	24.825033	water about 1 m
	Site 1-2	2	113.535397	24.826220	
	Site 1-3	3	113.533991	24.824842	
	Site 1-4	4	113.535458	24.826044	
	Site 2-1	5	113.532253	24.825433	water about 1 m
	Site 2-2	6	113.534047	24.823427	
	Site 2-3	7	113.533467	24.824453	
	Site 2-4	8	113.532943	24.825483	
	Site 3-1	9	113.534821	24.825412	water about 1 m
	Site 3-2	10	113.535012	24.837218	
	Site 3-3	11	113.535151	24.835384	
	Site 3-4	12	113.535296	24.837414	
Lishi	1		113.516875	24.900571	Shallow water, about0.5 m
	2		113.517882	24.901803	Deep water, about0.8 m
	3		113.520586	24.899256	Deep water, about0.8 m
	4		113.521366	24.899971	Deep water, about0.8 m
Zhoutian	1		113.856369	24.981652	about 1 m
	2		113.856497	24.981393	about 0.8 m
	3		113.857287	24.982114	about 1 m
	4		113.857419	24.981720	about 0.7 m
Kekou	1		113.586422	24.537251	water about 1 m
	2		113.588091	24.537184	water about 0.8 m
	3		113.581520	24.549053	water about 1 m
	4		113.587354	24.549665	water about 0.8 m

Odonata

Site		Longitude	Latitude	Habitat
Lishi	1	113.544700	24.876600	River bank
	2	113.510300	24.901200	Permanent pool

	3	113.523600	24.899300	River bank near sand mining
Zhoutian	1	113.835600	24.926700	Temporary pool in sand mining near river
	2	113.884600	24.982000	The confluence downstream of a hydropower dam and a small stream
Kengkou	1	113.580800	24.509900	River bank near a village
	2	113.593300	24.520000	Permanent pool at a tributary of the Beijiang River

Annex II. Summary of the IUCN Red List criteria

Summary of the five criteria (A–E) used to evaluate if a taxon belongs in a threatened category (Critically Endangered, Endangered or Vulnerable).

Use any of the criteria A–E	Critically Endangered	Endangered	Vulnerable
A. Population reduction	Declines measured over the longer of 10 years or 3 generations		
A1	≥ 90%	≥ 70%	≥ 50%
A2, A3 & A4	≥ 80%	≥ 50%	≥ 30%
A1. Population reduction observed, estimated, inferred, or suspected in the past where the causes of the reduction are clearly reversible **AND** understood **AND** have ceased, based on and specifying any of the following: (a) direct observation (b) an index of abundance appropriate to the taxon (c) a decline in area of occupancy (AOO), extent of occurrence (EOO) and/or habitat quality (d) actual or potential levels of exploitation (e) effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.			
A2. Population reduction observed, estimated, inferred, or suspected in the past where the causes of reduction may not have ceased **OR** may not be understood **OR** may not be reversible, based on (a) to (e) under A1.			
A3. Population reduction projected or suspected to be met in the future (up to a maximum of 100 years) based on (b) to (e) under A1.			
A4. An observed, estimated, inferred, projected or suspected population reduction (up to a maximum of 100 years) where the time period must include both the past and the future, and where the causes of reduction may not have ceased **OR** may not be understood **OR** may not be reversible, based on (a) to (e) under A1.			
B. Geographic range in the form of either B1 (extent of occurrence) AND/OR B2 (area of occupancy)			
B1. Extent of occurrence (EOO)	< 100 km²	< 5,000 km²	< 20,000 km²
B2. Area of occupancy (AOO)	< 10 km²	< 500 km²	< 2,000 km²
AND at least 2 of the following:			
(a) Severely fragmented, **OR** Number of locations	= 1	≤ 5	≤ 10
(b) Continuing decline in any of: **(i)** extent of occurrence; **(ii)** area of occupancy; **(iii)** area, extent and/or quality of habitat; **(iv)** number of locations or subpopulations; **(v)** number of mature individuals.			
(c) Extreme fluctuations in any of: **(i)** extent of occurrence; **(ii)** area of occupancy; **(iii)** number of locations or subpopulations; **(iv)** number of mature individuals.			
C. Small population size and decline			
Number of mature individuals	< 250	< 2,500	< 10,000
AND either C1 or C2:			
C1. An estimated continuing decline of at least: (up to a max. of 100 years in future)	25% in 3 years or 1 generation	20% in 5 years or 2 generations	10% in 10 years or 3 generations
C2. A continuing decline **AND** (a) and/or (b):			
(a i) Number of mature individuals in each subpopulation:	< 50	< 250	< 1,000
or			
(a ii) % individuals in one subpopulation =	90–100%	95–100%	100%
(b) Extreme fluctuations in the number of mature individuals.			
D. Very small or restricted population			
Either:			
Number of mature individuals	< 50	< 250	**D1.** < 1,000
			AND/OR
	Restricted area of occupancy		**D2.** typically: AOO < 20 km² or number of locations ≤ 5
E. Quantitative Analysis			
Indicating the probability of extinction in the wild to be:	≥ 50% in 10 years or 3 generations (100 years max.)	≥ 20% in 20 years or 5 generations (100 years max.)	≥ 10% in 100 years

Annex III. Species lists from the Pearl River

The IUCN Red List categories are EX – Extinct; EW Extinct in the Wild; CR – Critically Endangered; EN – Endangered; VU – Vulnerable; NT – Near Threatened; LC – Least Concern; DD – Data Deficient; NA – Not assessed. The categories CR, EN and VU are classed as the 'threatened' categories. '*' indicates a draft Red List assessment, that still needs to be peer reviewed.

Fishes

Order	Family	Binomial	IUCN Red List Category
Acipenseriformes	Acipenseridae	*Acipenser sinensis*	CR
Anguilliformes	Anguillidae	*Anguilla marmorata*	LC*
Beloniformes	Adrianichthyidae	*Oryzias sinensis*	LC
Cypriniformes	Balitoridae	*Balitora longibarbata*	LC
Cypriniformes	Balitoridae	*Beaufortia cyclica*	LC
Cypriniformes	Balitoridae	*Beaufortia pingi*	LC
Cypriniformes	Balitoridae	*Beaufortia polylepis*	LC
Cypriniformes	Balitoridae	*Erromyzon sinensis*	DD
Cypriniformes	Balitoridae	*Formosania tinkhami*	LC
Cypriniformes	Balitoridae	*Hemimyzon macroptera*	LC
Cypriniformes	Balitoridae	*Liniparhomaloptera disparis*	DD
Cypriniformes	Balitoridae	*Micronemacheilus pulcher*	LC
Cypriniformes	Balitoridae	*Oreonectes platycephalus*	DD
Cypriniformes	Balitoridae	*Paranemachilus genilepis*	DD
Cypriniformes	Balitoridae	*Protomyzon pachychilus*	LC
Cypriniformes	Balitoridae	*Pseudogastromyzon changtingensis changtingensis*	DD*
Cypriniformes	Balitoridae	*Pseudogastromyzon fangi*	LC
Cypriniformes	Balitoridae	*Pseudogastromyzon myersi*	LC
Cypriniformes	Balitoridae	*Schistura fasciolata*	DD
Cypriniformes	Balitoridae	*Schistura hingi*	LC
Cypriniformes	Balitoridae	*Schistura incerta*	DD*
Cypriniformes	Balitoridae	*Sinogastromyzon sichangensis*	LC
Cypriniformes	Balitoridae	*Sinogastromyzon szechuanensis*	LC
Cypriniformes	Balitoridae	*Sinogastromyzon wui*	LC
Cypriniformes	Balitoridae	*Sinohomaloptera kwangsiensis*	LC*
Cypriniformes	Balitoridae	*Vanmanenia pingchowensis*	LC
Cypriniformes	Balitoridae	*Yunnanilus pleurotaenia*	VU
Cypriniformes	Cobitidae	*Acantopsis arenae*	DD
Cypriniformes	Cobitidae	*Cobitis sinensis*	LC*
Cypriniformes	Cobitidae	*Leptobotia guilinensis*	LC
Cypriniformes	Cobitidae	*Leptobotia pellegrini*	LC
Cypriniformes	Cobitidae	*Misgurnus anguillicaudatus*	LC*

Order	Family	Binomial	IUCN Red List Category
Cypriniformes	Cobitidae	*Parabotia banarescui*	DD
Cypriniformes	Cobitidae	*Parabotia fasciata*	LC
Cypriniformes	Cobitidae	*Parabotia lijiangensis*	DD
Cypriniformes	Cobitidae	*Parabotia maculosa*	LC
Cypriniformes	Cobitidae	*Paralepidocephalus yui*	EN
Cypriniformes	Cobitidae	*Sinibotia pulchra*	DD*
Cypriniformes	Cobitidae	*Sinibotia robusta*	DD
Cypriniformes	Cobitidae	*Sinibotia superciliaris*	DD
Cypriniformes	Cobitidae	*Sinibotia zebra*	DD
Cypriniformes	Cyprinidae	*Acheilognathus barbatulus*	LC
Cypriniformes	Cyprinidae	*Acheilognathus chankaensis*	LC*
Cypriniformes	Cyprinidae	*Acheilognathus macropterus*	DD
Cypriniformes	Cyprinidae	*Acheilognathus meridianus*	DD
Cypriniformes	Cyprinidae	*Acheilognathus taenianalis*	LC
Cypriniformes	Cyprinidae	*Acheilognathus tonkinensis*	DD
Cypriniformes	Cyprinidae	*Acrossocheilus beijiangensis*	LC
Cypriniformes	Cyprinidae	*Acrossocheilus clivosius*	DD
Cypriniformes	Cyprinidae	*Acrossocheilus hemispinus*	LC
Cypriniformes	Cyprinidae	*Acrossocheilus iridescens*	DD
Cypriniformes	Cyprinidae	*Acrossocheilus parallens*	LC
Cypriniformes	Cyprinidae	*Acrossocheilus rendahli*	NT
Cypriniformes	Cyprinidae	*Acrossocheilus wenchowensis*	DD*
Cypriniformes	Cyprinidae	*Acrossocheilus yunnanensis*	LC
Cypriniformes	Cyprinidae	*Anabarilius andersoni*	CR
Cypriniformes	Cyprinidae	*Anabarilius liui yiliangensis*	EN*
Cypriniformes	Cyprinidae	*Anabarilius macrolepis*	EX
Cypriniformes	Cyprinidae	*Anabarilius maculatus*	DD
Cypriniformes	Cyprinidae	*Anabarilius qiluensis*	CR
Cypriniformes	Cyprinidae	*Anabarilius transmontanus*	DD
Cypriniformes	Cyprinidae	*Anabarilius yangzonensis*	CR
Cypriniformes	Cyprinidae	*Aphyocypris chinensis*	LC
Cypriniformes	Cyprinidae	*Atrilinea roulei*	LC
Cypriniformes	Cyprinidae	*Bangana decorus*	CR
Cypriniformes	Cyprinidae	*Bangana wui*	DD
Cypriniformes	Cyprinidae	*Bangana yunnanensis*	DD
Cypriniformes	Cyprinidae	*Carassioides acuminatus*	LC
Cypriniformes	Cyprinidae	*Carassius auratus*	LC
Cypriniformes	Cyprinidae	*Chanodichthys dabryi*	LC
Cypriniformes	Cyprinidae	*Chanodichthys erythropterus*	LC*
Cypriniformes	Cyprinidae	*Cirrhinus molitorella*	NT
Cypriniformes	Cyprinidae	*Cirrhinus mrigala*	LC

Order	Family	Binomial	IUCN Red List Category
Cypriniformes	Cyprinidae	*Ctenopharyngodon idella*	LC
Cypriniformes	Cyprinidae	*Culter recurviceps*	LC
Cypriniformes	Cyprinidae	*Cyprinus chilia*	EN
Cypriniformes	Cyprinidae	*Cyprinus fuxianensis*	CR
Cypriniformes	Cyprinidae	*Cyprinus ilishaestomus*	CR
Cypriniformes	Cyprinidae	*Cyprinus longzhouensis*	DD
Cypriniformes	Cyprinidae	*Cyprinus multitaeniata*	NT
Cypriniformes	Cyprinidae	*Cyprinus rubrofuscus*	LC
Cypriniformes	Cyprinidae	*Cyprinus yilongensis*	EX
Cypriniformes	Cyprinidae	*Cyprinus yunnanensis*	CR
Cypriniformes	Cyprinidae	*Discogobio tetrabarbatus*	LC
Cypriniformes	Cyprinidae	*Discogobio yunnanensis*	LC
Cypriniformes	Cyprinidae	*Distoechodon tumirostris*	LC
Cypriniformes	Cyprinidae	*Elopichthys bambusa*	DD
Cypriniformes	Cyprinidae	*Garra imberba*	DD
Cypriniformes	Cyprinidae	*Garra orientalis*	LC
Cypriniformes	Cyprinidae	*Garra yiliangensis*	DD
Cypriniformes	Cyprinidae	*Gnathopogon taeniellus*	DD
Cypriniformes	Cyprinidae	*Gobiobotia kolleri*	DD
Cypriniformes	Cyprinidae	*Gobiobotia longibarba*	DD*
Cypriniformes	Cyprinidae	*Gobiobotia meridionalis*	DD
Cypriniformes	Cyprinidae	*Gobiobotia tungi*	DD
Cypriniformes	Cyprinidae	*Hemibarbus longirostris*	LC
Cypriniformes	Cyprinidae	*Hemibarbus macracanthus*	DD*
Cypriniformes	Cyprinidae	*Hemibarbus medius*	DD
Cypriniformes	Cyprinidae	*Hemibarbus umbrifer*	LC
Cypriniformes	Cyprinidae	*Hemiculter leucisculus*	LC
Cypriniformes	Cyprinidae	*Hemiculter tchangi*	DD
Cypriniformes	Cyprinidae	*Hemiculterella sauvagei*	LC
Cypriniformes	Cyprinidae	*Huigobio chenhsienensis*	LC
Cypriniformes	Cyprinidae	*Hypophthalmichthys molitrix*	NT
Cypriniformes	Cyprinidae	*Hypophthalmichthys nobilis*	DD
Cypriniformes	Cyprinidae	*Labeo rohita*	LC
Cypriniformes	Cyprinidae	*Luciobrama macrocephalus*	DD
Cypriniformes	Cyprinidae	*Luciocyprinus langsoni*	None
Cypriniformes	Cyprinidae	*Megalobrama amblycephala*	LC
Cypriniformes	Cyprinidae	*Megalobrama terminalis*	LC
Cypriniformes	Cyprinidae	*Metzia formosae*	LC
Cypriniformes	Cyprinidae	*Metzia lineata*	LC
Cypriniformes	Cyprinidae	*Microphysogobio chinssuensis*	LC
Cypriniformes	Cyprinidae	*Microphysogobio fukiensis*	LC

Order	Family	Binomial	IUCN Red List Category
Cypriniformes	Cyprinidae	*Microphysogobio kachekensis*	LC
Cypriniformes	Cyprinidae	*Microphysogobio kiatingensis*	LC
Cypriniformes	Cyprinidae	*Microphysogobio labeoides*	DD*
Cypriniformes	Cyprinidae	*Microphysogobio tafangensis*	LC
Cypriniformes	Cyprinidae	*Microphysogobio tungtingensis*	NT
Cypriniformes	Cyprinidae	*Mylopharyngodon piceus*	DD
Cypriniformes	Cyprinidae	*Ochetobius elongatus*	DD*
Cypriniformes	Cyprinidae	*Onychostoma barbatulum*	DD
Cypriniformes	Cyprinidae	*Onychostoma barbatum*	DD
Cypriniformes	Cyprinidae	*Onychostoma gerlachi*	NT
Cypriniformes	Cyprinidae	*Onychostoma lini*	DD*
Cypriniformes	Cyprinidae	*Onychostoma ovale*	DD
Cypriniformes	Cyprinidae	*Onychostoma rarum*	DD
Cypriniformes	Cyprinidae	*Onychostoma simum*	DD
Cypriniformes	Cyprinidae	*Opsariichthys bidens*	DD*
Cypriniformes	Cyprinidae	*Osteochilus salsburyi*	LC
Cypriniformes	Cyprinidae	*Parasinilabeo assimilis*	VU
Cypriniformes	Cyprinidae	*Parator zonatus*	DD*
Cypriniformes	Cyprinidae	*Parazacco spilurus*	DD
Cypriniformes	Cyprinidae	*Percocypris pingi*	NT
Cypriniformes	Cyprinidae	*Platysmacheilus exiguus*	LC
Cypriniformes	Cyprinidae	*Poropuntius chonglingchungi*	CR
Cypriniformes	Cyprinidae	*Procypris mera*	DD
Cypriniformes	Cyprinidae	*Pseudogobio guilinensis*	DD
Cypriniformes	Cyprinidae	*Pseudogobio vaillanti*	LC
Cypriniformes	Cyprinidae	*Pseudogyrinocheilus prochilus*	LC
Cypriniformes	Cyprinidae	*Pseudohemiculter dispar*	VU
Cypriniformes	Cyprinidae	*Pseudohemiculter hainanensis*	LC
Cypriniformes	Cyprinidae	*Pseudolaubuca engraulis*	LC
Cypriniformes	Cyprinidae	*Pseudolaubuca sinensis*	LC
Cypriniformes	Cyprinidae	*Pseudorasbora elongata*	LC
Cypriniformes	Cyprinidae	*Pseudorasbora parva*	LC
Cypriniformes	Cyprinidae	*Ptychidio jordani*	CR
Cypriniformes	Cyprinidae	*Ptychidio macrops*	DD
Cypriniformes	Cyprinidae	*Puntius semifasciolatus*	DD*
Cypriniformes	Cyprinidae	*Rasbora steineri*	LC
Cypriniformes	Cyprinidae	*Rectoris luxiensis*	DD
Cypriniformes	Cyprinidae	*Rectoris posehensis*	DD*
Cypriniformes	Cyprinidae	*Rhodeus fangi*	LC
Cypriniformes	Cyprinidae	*Rhodeus lighti*	LC
Cypriniformes	Cyprinidae	*Rhodeus ocellatus*	DD

Order	Family	Binomial	IUCN Red List Category
Cypriniformes	Cyprinidae	*Rhodeus sinensis*	LC
Cypriniformes	Cyprinidae	*Sarcocheilichthys kiangsiensis*	DD*
Cypriniformes	Cyprinidae	*Sarcocheilichthys nigripinnis*	LC*
Cypriniformes	Cyprinidae	*Sarcocheilichthys parvus*	LC
Cypriniformes	Cyprinidae	*Sarcocheilichthys sinensis*	LC
Cypriniformes	Cyprinidae	*Saurogobio dabryi*	LC*
Cypriniformes	Cyprinidae	*Schizothorax griseus*	LC
Cypriniformes	Cyprinidae	*Schizothorax lissolabiatus*	LC
Cypriniformes	Cyprinidae	*Schizothorax wangchiachii*	NT
Cypriniformes	Cyprinidae	*Schizothorax yunnanensis*	DD
Cypriniformes	Cyprinidae	*Semilabeo notabilis*	DD
Cypriniformes	Cyprinidae	*Semilabeo obscurus*	LC
Cypriniformes	Cyprinidae	*Sinibrama macrops*	LC
Cypriniformes	Cyprinidae	*Sinibrama melrosei*	DD*
Cypriniformes	Cyprinidae	*Sinocyclocheilus tingi*	EN
Cypriniformes	Cyprinidae	*Sinocyclocheilus yangzongensis*	CR
Cypriniformes	Cyprinidae	*Spinibarbus denticulatus*	LC
Cypriniformes	Cyprinidae	*Spinibarbus hollandi*	DD*
Cypriniformes	Cyprinidae	*Squalidus argentatus*	DD
Cypriniformes	Cyprinidae	*Squalidus wolterstorffi*	LC
Cypriniformes	Cyprinidae	*Squaliobarbus curriculus*	DD
Cypriniformes	Cyprinidae	*Tanichthys albonubes*	DD
Cypriniformes	Cyprinidae	*Tor brevifilis*	DD*
Cypriniformes	Cyprinidae	*Tor yunnanensis*	EN
Cypriniformes	Cyprinidae	*Toxabramis hoffmanni*	DD
Cypriniformes	Cyprinidae	*Toxabramis houdemeri*	LC
Cypriniformes	Cyprinidae	*Xenocypris davidi*	LC*
Cypriniformes	Cyprinidae	*Xenocypris macrolepis*	LC*
Cypriniformes	Cyprinidae	*Yaoshanicus arcus*	LC
Cypriniformes	Cyprinidae	*Zacco platypus*	DD*
Osmeriformes	Salangidae	*Neosalanx tangkahkeii*	LC
Osmeriformes	Salangidae	*Salanx chinensis*	DD
Osmeriformes	Salangidae	*Salanx cuvieri*	DD
Perciformes	Anabantidae	*Anabas testudineus*	DD
Perciformes	Channidae	*Channa asiatica*	LC*
Perciformes	Channidae	*Channa gachua*	LC
Perciformes	Channidae	*Channa maculata*	LC
Perciformes	Eleotridae	*Eleotris fusca*	LC
Perciformes	Eleotridae	*Eleotris oxycephala*	LC
Perciformes	Eleotridae	*Hypseleotris compressocephalus*	LC
Perciformes	Eleotridae	*Micropercops cinctus*	LC*

Order	Family	Binomial	IUCN Red List Category
Perciformes	Gobiidae	*Glossogobius giuris*	LC
Perciformes	Gobiidae	*Glossogobius olivaceus*	LC
Perciformes	Gobiidae	*Rhinogobius brunneus*	DD
Perciformes	Gobiidae	*Rhinogobius giurinus*	LC
Perciformes	Gobiidae	*Rhinogobius leavelli*	LC
Perciformes	Labridae	*Pseudolabrus crassilabris*	DD*
Perciformes	Odontobutidae	*Sineleotris chalmersi*	LC
Perciformes	Osphronemidae	*Macropodus opercularis*	LC
Perciformes	Percichthyidae	*Coreoperca whiteheadi*	LC
Perciformes	Percichthyidae	*Siniperca fortis*	DD
Perciformes	Percichthyidae	*Siniperca kneri*	DD
Perciformes	Percichthyidae	*Siniperca obscura*	LC
Perciformes	Percichthyidae	*Siniperca roulei*	DD
Perciformes	Percichthyidae	*Siniperca scherzeri*	DD
Perciformes	Percichthyidae	*Siniperca undulata*	NT
Siluriformes	Amblycipitidae	*Xiurenbagrus xiurenensis*	DD
Siluriformes	Bagridae	*Hemibagrus guttatus*	DD*
Siluriformes	Bagridae	*Hemibagrus macropterus*	LC
Siluriformes	Bagridae	*Pelteobagrus argentivittatus*	LC
Siluriformes	Bagridae	*Pelteobagrus intermedius*	LC*
Siluriformes	Bagridae	*Pseudobagrus albomarginatus*	DD*
Siluriformes	Bagridae	*Pseudobagrus gracilis*	DD*
Siluriformes	Bagridae	*Pseudobagrus ondon*	LC
Siluriformes	Bagridae	*Pseudobagrus vachellii*	DD*
Siluriformes	Bagridae	*Pseudobagrus virgatus*	DD*
Siluriformes	Bagridae	*Tachysurus adiposalis*	LC
Siluriformes	Bagridae	*Tachysurus fulvidraco*	LC
Siluriformes	Clariidae	*Clarias fuscus*	LC*
Siluriformes	Clariidae	*Clarias macrocephalus*	NT
Siluriformes	Cranoglanididae	*Cranoglanis bouderius*	VU
Siluriformes	Siluridae	*Pterocryptis anomala*	LC
Siluriformes	Siluridae	*Pterocryptis cochinchinensis*	LC
Siluriformes	Siluridae	*Silurus asotus*	LC
Siluriformes	Siluridae	*Silurus meridionalis*	LC
Siluriformes	Sisoridae	*Glyptothorax fokiensis*	LC
Siluriformes	Sisoridae	*Glyptothorax pallozonus*	DD
Siluriformes	Sisoridae	*Parachiloglanis hodgarti*	LC
Siluriformes	Sisoridae	*Pareuchiloglanis longicauda*	LC
Synbranchiformes	Mastacembelidae	*Mastacembelus armatus*	LC
Synbranchiformes	Mastacembelidae	*Sinobdella sinensis*	LC
Synbranchiformes	Synbranchidae	*Monopterus albus*	LC

Order	Family	Binomial	IUCN Red List Category
Tetraodontiformes	Tetraodontidae	*Takifugu orbimaculatus*	LC

Molluscs

Class	Order	Family	Binomial	IUCN Red List Category
Bivalvia	Mytiloida	Mytilidae	*Limnoperna lacustris*	LC*
Bivalvia	Unionoida	Unionidae	*Acuticosta chinensis*	LC
Bivalvia	Unionoida	Unionidae	*Acuticosta ovata*	LC
Bivalvia	Unionoida	Unionidae	*Cristaria plicata*	DD
Bivalvia	Unionoida	Unionidae	*Cuneopsis celtiformis*	LC
Bivalvia	Unionoida	Unionidae	*Cuneopsis heudei*	LC
Bivalvia	Unionoida	Unionidae	*Cuneopsis pisciculus*	LC
Bivalvia	Unionoida	Unionidae	*Hyriopsis cumingii*	LC
Bivalvia	Unionoida	Unionidae	*Lamprotula bazini*	DD
Bivalvia	Unionoida	Unionidae	*Lamprotula caveata*	LC
Bivalvia	Unionoida	Unionidae	*Lamprotula fibrosa*	LC
Bivalvia	Unionoida	Unionidae	*Lamprotula leai*	LC
Bivalvia	Unionoida	Unionidae	*Lamprotula tientsinensis*	DD
Bivalvia	Unionoida	Unionidae	*Lamprotula zonata*	DD
Bivalvia	Unionoida	Unionidae	*Lanceolaria gladiola*	LC
Bivalvia	Unionoida	Unionidae	*Lanceolaria grayana*	LC
Bivalvia	Unionoida	Unionidae	*Lanceolaria triformis*	DD
Bivalvia	Unionoida	Unionidae	*Lepidodesma languilati*	DD
Bivalvia	Unionoida	Unionidae	*Schistodesmus lampreyanus*	LC
Bivalvia	Unionoida	Unionidae	*Schistodesmus spinosus*	LC
Bivalvia	Unionoida	Unionidae	*Unio douglasiae*	LC
Bivalvia	Veneroida	Corbiculidae	*Corbicula fluminea*	LC
Bivalvia	Veneroida	Corbiculidae	*Corbicula nitens*	DD*
Gastropoda	Allogastropoda	Bullinidae	*Indoplanorbis exustus*	LC
Gastropoda	Architaenioglossa	Ampullariidae	*Pila polita*	LC
Gastropoda	Architaenioglossa	Viviparidae	*Angulyagra polyzonata*	LC
Gastropoda	Architaenioglossa	Viviparidae	*Bellamya aeruginosa*	LC*
Gastropoda	Architaenioglossa	Viviparidae	*Bellamya limnophila*	DD
Gastropoda	Architaenioglossa	Viviparidae	*Bellamya quadrata*	LC
Gastropoda	Architaenioglossa	Viviparidae	*Cipangopaludina ampulliformis*	LC
Gastropoda	Architaenioglossa	Viviparidae	*Cipangopaludina cathayensis*	LC
Gastropoda	Architaenioglossa	Viviparidae	*Cipangopaludina chinensis*	LC
Gastropoda	Architaenioglossa	Viviparidae	*Margarya mansuyi*	EN
Gastropoda	Hygrophila	Lymnaeidae	*Galba pervia*	LC

Class	Order	Family	Binomial	IUCN Red List Category
Gastropoda	Hygrophila	Lymnaeidae	*Lymnaea stagnalis*	LC
Gastropoda	Hygrophila	Lymnaeidae	*Radix auricularia*	LC
Gastropoda	Hygrophila	Lymnaeidae	*Radix plicatula*	LC*
Gastropoda	Hygrophila	Lymnaeidae	*Radix swinhoei*	LC
Gastropoda	Hygrophila	Planorbidae	*Gyraulus convexiusculus*	LC
Gastropoda	Hygrophila	Planorbidae	*Hippeutis umbilicalis*	LC
Gastropoda	Hygrophila	Planorbidae	*Polypylis hemisphaerula*	LC
Gastropoda	Littorinimorpha	Assimineidae	*Assiminea latericea*	LC
Gastropoda	Littorinimorpha	Assimineidae	*Assiminea lutea*	LC*
Gastropoda	Littorinimorpha	Bithyniidae	*Bithynia fuchsiana*	LC
Gastropoda	Littorinimorpha	Bithyniidae	*Bithynia misella*	LC
Gastropoda	Littorinimorpha	Bithyniidae	*Parafossarulus eximius*	LC*
Gastropoda	Littorinimorpha	Bithyniidae	*Parafossarulus sinensis*	LC*
Gastropoda	Littorinimorpha	Bithyniidae	*Parafossarulus striatulus*	LC*
Gastropoda	Littorinimorpha	Hydrobiidae	*Alocinma longicornis*	LC*
Gastropoda	Littorinimorpha	Pomatiopsidae	*Oncomelania hupensis*	LC
Gastropoda	Littorinimorpha	Pomatiopsidae	*Tricula cristella*	DD*
Gastropoda	Littorinimorpha	Pomatiopsidae	*Tricula gregoriana*	DD*
Gastropoda	Littorinimorpha	Pomatiopsidae	*Tricula humida*	DD*
Gastropoda	Littorinimorpha	Stenothyridae	*Stenothyra glabra*	LC
Gastropoda	Sorbeoconcha	Thiaridae	*Melanoides tuberculatus*	LC
Gastropoda	Sorbeoconcha	Thiaridae	*Semisulcospira cancellata*	LC*
Gastropoda	Sorbeoconcha	Thiaridae	*Semisulcospira libertina*	LC*
Gastropoda	Sorbeoconcha	Thiaridae	*Tarebia granifera*	LC
Gastropoda	Sorbeoconcha	Thiaridae	*Thiara riqueti*	LC
Gastropoda	Hygrophila	Planorbidae	*Gyraulus chinensis*	LC
Bivalvia	Unionoida	Unionidae	*Cuneopsis capitata*	LC
Gastropoda	Architaenioglossa	Viviparidae	*Bellamya purificata*	LC

Odonata

Family	Binomial	IUCN Red List Category
Aeshnidae	*Anaciaeschna jaspidea*	LC
Aeshnidae	*Anaciaeschna martini*	LC
Aeshnidae	*Anax guttatus*	LC
Aeshnidae	*Anax immaculifrons*	LC
Aeshnidae	*Anax nigrofasciatus*	LC
Aeshnidae	*Anax parthenope julius*	LC
Aeshnidae	*Boyeria karubei*	LC
Aeshnidae	*Cephalaeschna dinghuensis*	CR

Family	Binomial	IUCN Red List Category
Aeshnidae	*Gynacantha bayadera*	LC
Aeshnidae	*Gynacantha japonica*	LC
Aeshnidae	*Gynacantha saltatrix*	LC
Aeshnidae	*Gynacantha subinterrupta*	LC
Aeshnidae	*Periaeschna flinti*	LC
Aeshnidae	*Periaeschna gerrhon*	DD
Aeshnidae	*Periaeschna magdalena*	LC
Aeshnidae	*Periaeschna zhangzhouensis*	LC
Aeshnidae	*Planaeschna gressitti*	DD
Aeshnidae	*Planaeschna nanlingensis*	DD
Aeshnidae	*Planaeschna suichangensis*	LC
Aeshnidae	*Polycanthagyna erythromelas*	LC
Aeshnidae	*Polycanthagyna melanictera*	LC
Aeshnidae	*Polycanthagyna ornithocephala*	LC
Aeshnidae	*Tetracanthagyna waterhousei*	LC
Calopterygidae	*Archineura incarnata*	LC
Calopterygidae	*Atrocalopteryx atrocyana*	NT
Calopterygidae	*Caliphaea nitens*	LC
Calopterygidae	*Calopteryx atrata*	LC
Calopterygidae	*Matrona basilaris*	LC
Calopterygidae	*Mnais andersoni*	LC
Calopterygidae	*Mnais mneme*	LC
Calopterygidae	*Neurobasis chinensis*	LC
Calopterygidae	*Vestalaria miao*	LC
Chlorocyphidae	*Indocypha katharina*	DD
Chlorocyphidae	*Libellago lineata*	LC
Chlorocyphidae	*Rhinocypha drusilla*	LC
Chlorocyphidae	*Rhinocypha fenestrella*	LC
Chlorocyphidae	*Rhinocypha perforata*	LC
Chlorogomphidae	*Chlorogomphus papilio*	LC
Chlorogomphidae	*Chloropetalia soarer*	DD
Coenagrionidae	*Aciagrion huaanensis*	DD
Coenagrionidae	*Aciagrion migratum*	LC
Coenagrionidae	*Aciagrion tillyardi*	LC
Coenagrionidae	*Agriocnemis lacteola*	LC
Coenagrionidae	*Agriocnemis pygmaea*	LC
Coenagrionidae	*Argiocnemis rubescens*	LC
Coenagrionidae	*Ceriagrion auranticum*	LC
Coenagrionidae	*Ceriagrion azureum*	LC
Coenagrionidae	*Ceriagrion fallax*	LC
Coenagrionidae	*Ceriagrion melanurum*	LC
Coenagrionidae	*Ceriagrion olivaceum*	LC

Family	Binomial	IUCN Red List Category
Coenagrionidae	*Ischnura asiatica*	LC*
Coenagrionidae	*Ischnura aurora*	LC
Coenagrionidae	*Ischnura senegalensis*	LC
Coenagrionidae	*Mortonagrion hirosei*	NT
Coenagrionidae	*Onychargia atrocyana*	LC
Coenagrionidae	*Paracercion calamorum*	LC
Coenagrionidae	*Paracercion hieroglyphicum*	LC
Coenagrionidae	*Paracercion melanotum*	LC
Coenagrionidae	*Pseudagrion microcephalum*	LC
Coenagrionidae	*Pseudagrion pruinosum*	LC
Coenagrionidae	*Pseudagrion rubriceps*	LC
Coenagrionidae	*Pseudagrion spencei*	LC
Cordulegastridae	*Anotogaster flaveola*	DD
Cordulegastridae	*Anotogaster gregoryi*	LC
Cordulegastridae	*Anotogaster kuchenbeiseri*	LC*
Cordulegastridae	*Anotogaster sieboldii*	LC*
Cordulegastridae	*Sinorogomphus nasutus*	LC
Corduliidae	*Idionyx carinata*	LC
Corduliidae	*Idionyx claudia*	LC
Corduliidae	*Idionyx victor*	LC*
Corduliidae	*Macromidia ellenae*	None
Corduliidae	*Macromidia kelloggi*	LC
Corduliidae	*Macromidia rapida*	LC
Euphaeidae	*Anisopleura furcata*	LC
Euphaeidae	*Anisopleura qingyuanensis*	LC
Euphaeidae	*Bayadera bidentata*	LC
Euphaeidae	*Bayadera continentalis*	LC
Euphaeidae	*Bayadera melanopteryx*	LC
Euphaeidae	*Euphaea decorata*	LC
Euphaeidae	*Euphaea opaca*	DD
Euphaeidae	*Euphaea superba*	LC
Gomphidae	*Amphigomphus hansoni*	LC
Gomphidae	*Anisogomphus anderi*	LC
Gomphidae	*Anisogomphus koxingai*	LC
Gomphidae	*Burmagomphus vermicularis*	LC
Gomphidae	*Davidius fruhstorferi*	LC
Gomphidae	*Fukienogomphus choifongae*	LC
Gomphidae	*Fukienogomphus prometheus*	DD
Gomphidae	*Fukienogomphus promineus*	LC
Gomphidae	*Gomphidia kelloggi*	EN
Gomphidae	*Gomphidia kruegeri*	LC
Gomphidae	*Heliogomphus retroflexus*	LC

Family	Binomial	IUCN Red List Category
Gomphidae	*Heliogomphus scorpio*	LC
Gomphidae	*Ictinogomphus pertinax*	LC
Gomphidae	*Labrogomphus torvus*	LC
Gomphidae	*Lamelligomphus camelus*	LC
Gomphidae	*Lamelligomphus hainanensis*	LC
Gomphidae	*Leptogomphus divaricatus*	LC
Gomphidae	*Leptogomphus elegans*	LC
Gomphidae	*Leptogomphus intermedius*	DD
Gomphidae	*Leptogomphus perforatus*	LC
Gomphidae	*Megalogomphus sommeri*	LC
Gomphidae	*Melligomphus ardens*	LC
Gomphidae	*Nihonogomphus semanticus*	DD
Gomphidae	*Nihonogomphus simillimus*	DD
Gomphidae	*Ophiogomphus sinicus*	DD
Gomphidae	*Paragomphus capricornis*	LC
Gomphidae	*Phaenandrogomphus tonkinicus*	LC
Gomphidae	*Sieboldius alexanderi*	DD
Gomphidae	*Sieboldius deflexus*	LC
Gomphidae	*Sinictinogomphus clavatus*	LC
Gomphidae	*Sinogomphus telamon*	DD
Gomphidae	*Stylogomphus chunliuae*	LC
Gomphidae	*Stylogomphus tantulus*	DD
Gomphidae	*Stylurus clathratus*	LC
Gomphidae	*Stylurus nanningensis*	LC
Lestidae	*Indolestes peregrinus*	LC
Lestidae	*Lestes concinnus*	LC
Lestidae	*Lestes nodalis*	LC
Lestidae	*Lestes praemorsus*	LC
Libellulidae	*Acisoma panorpoides*	LC
Libellulidae	*Brachydiplax chalybea*	LC
Libellulidae	*Brachythemis contaminata*	LC
Libellulidae	*Cratilla lineata*	LC
Libellulidae	*Crocothemis servilia*	LC
Libellulidae	*Diplacodes nebulosa*	LC
Libellulidae	*Diplacodes trivialis*	LC
Libellulidae	*Hydrobasileus croceus*	LC
Libellulidae	*Libellula melli*	LC
Libellulidae	*Lyriothemis elegantissima*	LC
Libellulidae	*Lyriothemis pachygastra*	LC
Libellulidae	*Lyriothemis tricolor*	LC
Libellulidae	*Nannophya pygmaea*	LC
Libellulidae	*Neurothemis fulvia*	LC

Family	Binomial	IUCN Red List Category
Libellulidae	*Neurothemis tullia*	LC
Libellulidae	*Onychothemis testacea*	LC
Libellulidae	*Orthetrum chrysis*	LC
Libellulidae	*Orthetrum glaucum*	LC
Libellulidae	*Orthetrum luzonicum*	LC
Libellulidae	*Orthetrum melania*	LC
Libellulidae	*Orthetrum pruinosum*	LC
Libellulidae	*Orthetrum sabina*	LC
Libellulidae	*Orthetrum triangulare*	LC
Libellulidae	*Palpopleura sexmaculata*	LC
Libellulidae	*Pantala flavescens*	LC
Libellulidae	*Potamarcha congener*	LC
Libellulidae	*Pseudothemis zonata*	LC
Libellulidae	*Rhodothemis rufa*	LC
Libellulidae	*Rhyothemis fuliginosa*	LC
Libellulidae	*Rhyothemis variegata*	LC
Libellulidae	*Sympetrum baccha*	LC
Libellulidae	*Sympetrum darwinianum*	LC
Libellulidae	*Sympetrum infuscatum*	LC
Libellulidae	*Sympetrum parvulum*	LC
Libellulidae	*Sympetrum risi*	None
Libellulidae	*Sympetrum speciosum*	LC
Libellulidae	*Tetrathemis platyptera*	LC
Libellulidae	*Tholymis tillarga*	LC
Libellulidae	*Tramea transmarina*	LC
Libellulidae	*Tramea virginia*	LC
Libellulidae	*Trithemis aurora*	LC
Libellulidae	*Trithemis festiva*	LC
Libellulidae	*Trithemis pallidinervis*	LC
Libellulidae	*Urothemis signata*	LC
Libellulidae	*Zygonyx asahinai*	LC
Libellulidae	*Zygonyx iris*	LC
Libellulidae	*Zygonyx takasago*	LC
Libellulidae	*Zyxomma petiolatum*	LC
Macromiidae	*Epophthalmia elegans*	LC
Macromiidae	*Macromia berlandi*	LC
Macromiidae	*Macromia calliope*	LC
Macromiidae	*Macromia clio*	LC
Macromiidae	*Macromia daimoji*	LC*
Macromiidae	*Macromia flavocolorata*	LC
Macromiidae	*Macromia katae*	VU
Macromiidae	*Macromia urania*	LC

Family	Binomial	IUCN Red List Category
Megapodagrionidae	*Agriomorpha fusca*	LC
Megapodagrionidae	*Mesopodagrion tibetanum*	LC
Megapodagrionidae	*Philosina alba*	VU
Megapodagrionidae	*Philosina buchi*	DD
Platycnemididae	*Calicnemia chaoi*	DD
Platycnemididae	*Calicnemia sinensis*	LC*
Platycnemididae	*Coeliccia cyanomelas*	LC
Platycnemididae	*Coeliccia flavicauda*	LC
Platycnemididae	*Copera ciliata*	LC
Platycnemididae	*Copera marginipes*	LC
Platycnemididae	*Indocnemis orang*	LC
Platystictidae	*Drepanosticta brownelli*	NT
Platystictidae	*Drepanosticta hongkongensis*	LC
Platystictidae	*Protosticta beaumonti*	LC
Platystictidae	*Protosticta taipokauensis*	LC
Platystictidae	*Sinosticta debra*	LC
Platystictidae	*Sinosticta ogatai*	LC
Protoneuridae	*Prodasineura autumnalis*	LC
Protoneuridae	*Prodasineura croconota*	LC
Protoneuridae	*Prodasineura verticalis*	LC
Pseudolestidae	*Lestomima flavostigma*	DD
Pseudolestidae	*Rhipidolestes chaoi*	DD
Pseudolestidae	*Rhipidolestes cyanoflavus*	LC
Pseudolestidae	*Rhipidolestes janetae*	LC
Pseudolestidae	*Rhipidolestes truncatidens*	LC
Synlestidae	*Megalestes discus*	DD
Synlestidae	*Megalestes distans*	LC
Synlestidae	*Megalestes heros*	LC
Synlestidae	*Sinolestes editus*	LC
Aeshnidae	*Anax parthenope*	LC
Libellulidae	*Sympetrum eroticum*	LC

Plants

Phylum	Class	Order	Family	Binomial	Red List Category
Polypodiophyta	Polypodiopsida	Marsileales	Marsileaceae	*Marsilea crenata*	LC
Polypodiophyta	Polypodiopsida	Salviniales	Azollaceae	*Azolla pinnata*	LC
Tracheophyta	Liliopsida	Alismatales	Alismataceae	*Alisma canaliculatum*	LC*
Tracheophyta	Liliopsida	Alismatales	Alismataceae	*Alisma plantago-aquatica*	LC
Tracheophyta	Liliopsida	Alismatales	Alismataceae	*Caldesia grandis*	LC
Tracheophyta	Liliopsida	Alismatales	Alismataceae	*Sagittaria guayanensis*	LC

Phylum	Class	Order	Family	Binomial	Red List Category
Tracheophyta	Liliopsida	Alismatales	Alismataceae	*Sagittaria lichuanensis*	EN
Tracheophyta	Liliopsida	Alismatales	Alismataceae	*Sagittaria potamogetifolia*	LC
Tracheophyta	Liliopsida	Alismatales	Alismataceae	*Sagittaria pygmaea*	LC
Tracheophyta	Liliopsida	Alismatales	Alismataceae	*Sagittaria sagittifolia*	LC
Tracheophyta	Liliopsida	Alismatales	Alismataceae	*Sagittaria tengtsungensis*	DD
Tracheophyta	Liliopsida	Alismatales	Alismataceae	*Sagittaria trifolia*	LC
Tracheophyta	Liliopsida	Arales	Acoraceae	*Acorus calamus*	LC
Tracheophyta	Liliopsida	Arales	Lemnaceae	*Lemna minor*	LC
Tracheophyta	Liliopsida	Arales	Lemnaceae	*Lemna perpusilla*	LC
Tracheophyta	Liliopsida	Arales	Lemnaceae	*Lemna trisulca*	LC
Tracheophyta	Liliopsida	Commelinales	Commelinaceae	*Commelina communis*	LC*
Tracheophyta	Liliopsida	Commelinales	Commelinaceae	*Murdannia triquetra*	LC*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Blysmus compressus var. brevifolius*	DD*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Bolboschoenus yagara*	LC*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Carex alopecuroides*	LC*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Carex dimorpholepis*	LC*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Carex muliensis*	DD*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Carex schmidtii*	DD*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Carex thibetica*	LC*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Cyperus serotinus*	LC*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Eleocharis acicularis*	LC*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Eleocharis acutangula*	LC*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Eleocharis pellucida*	DD*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Eleocharis tetraquetra*	LC*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Eleocharis valleculosa*	LC*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Fimbristylis aestivalis*	LC*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Fimbristylis cymosa*	LC*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Fimbristylis longispica*	DD*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Fimbristylis squarrosa*	LC*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Kobresia tibetica*	DD*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Kyllinga brevifolia*	LC*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Lepidosperma chinense*	LC*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Pycreus delavayi*	DD*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Pycreus flavidus*	LC*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Pycreus lijiangensis*	DD*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Pycreus sulcinux*	LC*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Pycreus unioloides*	LC*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Rhynchospora rugosa*	LC*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Schoenoplectiella juncoides*	LC*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Schoenoplectus mucronatus ssp. Mucronatus*	LC*

Phylum	Class	Order	Family	Binomial	Red List Category
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Schoenoplectus tabernaemontani*	LC*
Tracheophyta	Liliopsida	Cyperales	Cyperaceae	*Scirpus lushanensis*	DD*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Alopecurus aequalis*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Alopecurus japonicus*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Arthraxon hispidus*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Beckmannia syzigachne*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Calamagrostis pseudophragmites*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Catabrosa aquatica*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Chikusichloa mutica*	DD*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Coelachne simpliciuscula*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Coix lacryma-jobi*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Deschampsia cespitosa*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Echinochloa cruspavonis*	DD*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Echinochloa oryzoides*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Eriachne pallescens*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Eriochloa villosa*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Garnotia patula*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Glyceria maxima*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Hemarthria sibirica*	DD*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Hymenachne amplexicaulis*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Isachne globosa*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Ischaemum aristatum*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Ischaemum rugosum*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Leersia japonica*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Leersia sayanuka*	DD*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Leptochloa chinensis*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Milium effusum*	DD*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Miscanthus floridulus*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Miscanthus sacchariflorus*	DD*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Oplismenus undulatifolius*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Panicum bisulcatum*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Paspalum thunbergii*	DD*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Phragmites australis*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Polypogon fugax*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Polypogon monspeliensis*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Pseudoraphis brunoniana*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Sacciolepis indica*	LC*
Tracheophyta	Liliopsida	Cyperales	Gramineae	*Sphaerocaryum malaccense*	LC*
Tracheophyta	Liliopsida	Hydrocharitales	Hydrocharitaceae	*Blyxa aubertii*	LC
Tracheophyta	Liliopsida	Hydrocharitales	Hydrocharitaceae	*Blyxa japonica*	LC

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Tracheophyta	Liliopsida	Hydrocharitales	Hydrocharitaceae	*Blyxa octandra*	LC
Tracheophyta	Liliopsida	Hydrocharitales	Hydrocharitaceae	*Hydrilla verticillata*	LC
Tracheophyta	Liliopsida	Hydrocharitales	Hydrocharitaceae	*Najas chinensis*	DD*
Tracheophyta	Liliopsida	Hydrocharitales	Hydrocharitaceae	*Najas gracillima*	DD*
Tracheophyta	Liliopsida	Hydrocharitales	Hydrocharitaceae	*Najas indica*	LC
Tracheophyta	Liliopsida	Hydrocharitales	Hydrocharitaceae	*Najas marina*	LC
Tracheophyta	Liliopsida	Hydrocharitales	Hydrocharitaceae	*Najas minor*	LC
Tracheophyta	Liliopsida	Hydrocharitales	Hydrocharitaceae	*Nechamandra alternifolia*	LC
Tracheophyta	Liliopsida	Hydrocharitales	Hydrocharitaceae	*Ottelia acuminata*	EN*
Tracheophyta	Liliopsida	Hydrocharitales	Hydrocharitaceae	*Ottelia alismoides*	LC
Tracheophyta	Liliopsida	Hydrocharitales	Hydrocharitaceae	*Ottelia balansae*	DD
Tracheophyta	Liliopsida	Hydrocharitales	Hydrocharitaceae	*Vallisneria natans*	LC
Tracheophyta	Liliopsida	Juncales	Juncaceae	*Juncus alatus*	LC*
Tracheophyta	Liliopsida	Juncales	Juncaceae	*Juncus allioides*	DD*
Tracheophyta	Liliopsida	Juncales	Juncaceae	*Juncus effusus*	LC
Tracheophyta	Liliopsida	Juncales	Juncaceae	*Juncus setchuensis*	DD*
Tracheophyta	Liliopsida	Juncales	Juncaceae	*Juncus sikkimensis*	LC*
Tracheophyta	Liliopsida	Juncales	Juncaceae	*Juncus thomsonii*	DD*
Tracheophyta	Liliopsida	Liliales	Amaryllidaceae	*Crinum asiaticum var. sinicum*	DD*
Tracheophyta	Liliopsida	Liliales	Pontederiaceae	*Monochoria korsakowii*	LC
Tracheophyta	Liliopsida	Najadales	Potamogetonaceae	*Potamogeton compressus*	LC*
Tracheophyta	Liliopsida	Najadales	Potamogetonaceae	*Potamogeton crispus*	LC
Tracheophyta	Liliopsida	Najadales	Potamogetonaceae	*Potamogeton cristatus*	DD*
Tracheophyta	Liliopsida	Najadales	Potamogetonaceae	*Potamogeton distinctus*	LC
Tracheophyta	Liliopsida	Najadales	Potamogetonaceae	*Potamogeton gramineus*	DD*
Tracheophyta	Liliopsida	Najadales	Potamogetonaceae	*Potamogeton maackianus*	LC
Tracheophyta	Liliopsida	Najadales	Potamogetonaceae	*Potamogeton natans*	LC
Tracheophyta	Liliopsida	Najadales	Potamogetonaceae	*Potamogeton octandrus*	LC
Tracheophyta	Liliopsida	Najadales	Potamogetonaceae	*Potamogeton oxyphyllus*	DD*
Tracheophyta	Liliopsida	Najadales	Potamogetonaceae	*Potamogeton pusillus*	LC
Tracheophyta	Liliopsida	Najadales	Potamogetonaceae	*Potamogeton tepperi*	LC*
Tracheophyta	Liliopsida	Najadales	Potamogetonaceae	*Potamogeton wrightii*	LC
Tracheophyta	Liliopsida	Typhales	Typhaceae	*Typha angustifolia*	LC
Tracheophyta	Liliopsida	Typhales	Typhaceae	*Typha elephantina*	LC
Tracheophyta	Liliopsida	Typhales	Typhaceae	*Typha latifolia*	LC*
Tracheophyta	Liliopsida	Typhales	Typhaceae	*Typha orientalis*	LC
Tracheophyta	Magnoliopsida	Apiales	Umbelliferae	*Angelica polymorpha*	DD*
Tracheophyta	Magnoliopsida	Apiales	Umbelliferae	*Centella asiatica*	LC*
Tracheophyta	Magnoliopsida	Apiales	Umbelliferae	*Cicuta virosa*	DD*
Tracheophyta	Magnoliopsida	Apiales	Umbelliferae	*Cnidium monnieri*	LC*
Tracheophyta	Magnoliopsida	Apiales	Umbelliferae	*Oenanthe benghalensis*	LC*
Tracheophyta	Magnoliopsida	Apiales	Umbelliferae	*Oenanthe hookeri*	DD*

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Tracheophyta	Magnoliopsida	Apiales	Umbelliferae	*Oenanthe javanica*	LC
Tracheophyta	Magnoliopsida	Apiales	Umbelliferae	*Oenanthe linearis*	LC*
Tracheophyta	Magnoliopsida	Apiales	Umbelliferae	*Oenanthe rosthornii*	DD*
Tracheophyta	Magnoliopsida	Asterales	Compositae	*Bidens tripartita*	LC*
Tracheophyta	Magnoliopsida	Asterales	Compositae	*Hemisteptia lyrata*	LC
Tracheophyta	Magnoliopsida	Asterales	Compositae	*Wedelia chinensis*	LC
Tracheophyta	Magnoliopsida	Campanulales	Campanulaceae	*Lobelia chinensis*	LC*
Tracheophyta	Magnoliopsida	Capparales	Cruciferae	*Cardamine flexuosa var. debilis*	DD*
Tracheophyta	Magnoliopsida	Capparales	Cruciferae	*Cardamine hirsuta*	LC*
Tracheophyta	Magnoliopsida	Capparales	Cruciferae	*Cardamine macrophylla*	LC*
Tracheophyta	Magnoliopsida	Capparales	Cruciferae	*Cardamine scutata*	DD*
Tracheophyta	Magnoliopsida	Capparales	Cruciferae	*Rorippa cantoniensis*	LC*
Tracheophyta	Magnoliopsida	Capparales	Cruciferae	*Rorippa globosa*	LC*
Tracheophyta	Magnoliopsida	Capparales	Cruciferae	*Rorippa palustris*	LC*
Tracheophyta	Magnoliopsida	Caryophyllales	Amaranthaceae	*Alternanthera sessilis*	LC
Tracheophyta	Magnoliopsida	Euphorbiales	Euphorbiaceae	*Glochidion hirsutum*	LC*
Tracheophyta	Magnoliopsida	Fabales	Leguminosae	*Pongamia pinnata*	LC*
Tracheophyta	Magnoliopsida	Fabales	Leguminosae	*Sesbania cannabina*	LC*
Tracheophyta	Magnoliopsida	Fabales	Leguminosae	*Sesbania javanica*	LC
Tracheophyta	Magnoliopsida	Haloragales	Haloragaceae	*Myriophyllum spicatum*	LC*
Tracheophyta	Magnoliopsida	Lamiales	Labiatae	*Dysophylla cruciata*	DD*
Tracheophyta	Magnoliopsida	Lamiales	Labiatae	*Dysophylla pentagona*	DD*
Tracheophyta	Magnoliopsida	Lamiales	Labiatae	*Dysophylla sampsonii*	LC*
Tracheophyta	Magnoliopsida	Lamiales	Labiatae	*Dysophylla stellata*	LC*
Tracheophyta	Magnoliopsida	Lamiales	Labiatae	*Dysophylla yatabeana*	DD*
Tracheophyta	Magnoliopsida	Lamiales	Labiatae	*Lycopus lucidus*	LC*
Tracheophyta	Magnoliopsida	Lamiales	Labiatae	*Salvia plebeia*	LC*
Tracheophyta	Magnoliopsida	Lamiales	Labiatae	*Scutellaria barbata*	LC*
Tracheophyta	Magnoliopsida	Myrtales	Lythraceae	*Ammannia auriculata*	LC
Tracheophyta	Magnoliopsida	Myrtales	Lythraceae	*Ammannia multiflora*	LC
Tracheophyta	Magnoliopsida	Myrtales	Lythraceae	*Lythrum salicaria*	LC*
Tracheophyta	Magnoliopsida	Myrtales	Lythraceae	*Rotala cordata*	DD*
Tracheophyta	Magnoliopsida	Myrtales	Lythraceae	*Rotala indica*	LC
Tracheophyta	Magnoliopsida	Myrtales	Lythraceae	*Rotala rosea*	LC
Tracheophyta	Magnoliopsida	Myrtales	Lythraceae	*Rotala rotundifolia*	LC
Tracheophyta	Magnoliopsida	Myrtales	Lythraceae	*Rotala wallichii*	DD*
Tracheophyta	Magnoliopsida	Myrtales	Onagraceae	*Epilobium amurense*	LC*
Tracheophyta	Magnoliopsida	Myrtales	Onagraceae	*Epilobium hirsutum*	LC*
Tracheophyta	Magnoliopsida	Myrtales	Onagraceae	*Epilobium palustre*	LC*
Tracheophyta	Magnoliopsida	Myrtales	Onagraceae	*Epilobium parviflorum*	LC*
Tracheophyta	Magnoliopsida	Myrtales	Onagraceae	*Epilobium pyrricholophum*	LC*
Tracheophyta	Magnoliopsida	Myrtales	Onagraceae	*Ludwigia prostrata*	LC*

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Tracheophyta	Magnoliopsida	Myrtales	Trapaceae	*Trapa incisa*	LC*
Tracheophyta	Magnoliopsida	Nepenthales	Droseraceae	*Drosera oblanceolata*	DD*
Tracheophyta	Magnoliopsida	Nepenthales	Droseraceae	*Drosera peltata*	LC
Tracheophyta	Magnoliopsida	Nepenthales	Droseraceae	*Drosera rotundifolia*	LC*
Tracheophyta	Magnoliopsida	Nepenthales	Droseraceae	*Drosera spathulata*	DD*
Tracheophyta	Magnoliopsida	Nymphaeales	Ceratophyllaceae	*Ceratophyllum demersum*	LC
Tracheophyta	Magnoliopsida	Nymphaeales	Ceratophyllaceae	*Ceratophyllum muricatum ssp. kossinskyi*	LC*
Tracheophyta	Magnoliopsida	Nymphaeales	Ceratophyllaceae	*Ceratophyllum platyacanthum ssp. oryzetorum*	DD*
Tracheophyta	Magnoliopsida	Nymphaeales	Nymphaeaceae	*Euryale ferox*	LC
Tracheophyta	Magnoliopsida	Nymphaeales	Nymphaeaceae	*Nuphar pumila*	LC*
Tracheophyta	Magnoliopsida	Plantaginales	Plantaginaceae	*Plantago asiatica*	LC*
Tracheophyta	Magnoliopsida	Plantaginales	Plantaginaceae	*Plantago depressa*	LC*
Tracheophyta	Magnoliopsida	Podostemales	Podostemaceae	*Cladopus austrosinensis*	DD
Tracheophyta	Magnoliopsida	Podostemales	Podostemaceae	*Cladopus nymanii*	LC
Tracheophyta	Magnoliopsida	Polygonales	Polygonaceae	*Persicaria maculosa*	LC*
Tracheophyta	Magnoliopsida	Polygonales	Polygonaceae	*Persicaria nepalensis*	LC*
Tracheophyta	Magnoliopsida	Polygonales	Polygonaceae	*Persicaria vivipara*	LC*
Tracheophyta	Magnoliopsida	Polygonales	Polygonaceae	*Polygonum chinense*	LC*
Tracheophyta	Magnoliopsida	Polygonales	Polygonaceae	*Polygonum maackianum*	LC*
Tracheophyta	Magnoliopsida	Polygonales	Polygonaceae	*Polygonum sibiricum*	LC*
Tracheophyta	Magnoliopsida	Polygonales	Polygonaceae	*Polygonum thunbergii*	LC*
Tracheophyta	Magnoliopsida	Polygonales	Polygonaceae	*Polygonum viscosum*	LC*
Tracheophyta	Magnoliopsida	Polygonales	Polygonaceae	*Rumex amurensis*	DD*
Tracheophyta	Magnoliopsida	Polygonales	Polygonaceae	*Rumex dentatus*	LC*
Tracheophyta	Magnoliopsida	Polygonales	Polygonaceae	*Rumex japonicus*	LC*
Tracheophyta	Magnoliopsida	Polygonales	Polygonaceae	*Rumex nepalensis*	DD*
Tracheophyta	Magnoliopsida	Polygonales	Polygonaceae	*Rumex trisetifer*	DD*
Tracheophyta	Magnoliopsida	Primulales	Primulaceae	*Lysimachia candida*	LC*
Tracheophyta	Magnoliopsida	Primulales	Primulaceae	*Lysimachia christinae*	LC*
Tracheophyta	Magnoliopsida	Primulales	Primulaceae	*Lysimachia stenosepala*	DD*
Tracheophyta	Magnoliopsida	Ranunculales	Ranunculaceae	*Batrachium bungei*	DD*
Tracheophyta	Magnoliopsida	Ranunculales	Ranunculaceae	*Batrachium eradicatum*	DD*
Tracheophyta	Magnoliopsida	Ranunculales	Ranunculaceae	*Caltha palustris*	DD*
Tracheophyta	Magnoliopsida	Ranunculales	Ranunculaceae	*Ranunculus cantoniensis*	LC*
Tracheophyta	Magnoliopsida	Ranunculales	Ranunculaceae	*Ranunculus chinensis*	LC*
Tracheophyta	Magnoliopsida	Ranunculales	Ranunculaceae	*Ranunculus japonicus*	LC*
Tracheophyta	Magnoliopsida	Ranunculales	Ranunculaceae	*Ranunculus nephelogenes*	DD*
Tracheophyta	Magnoliopsida	Ranunculales	Ranunculaceae	*Ranunculus popovii var. stracheyanus*	DD*
Tracheophyta	Magnoliopsida	Ranunculales	Ranunculaceae	*Ranunculus sieboldii*	LC*

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Tracheophyta	Magnoliopsida	Scrophulariales	Acanthaceae	*Hygrophila salicifolia*	LC
Tracheophyta	Magnoliopsida	Scrophulariales	Lentibulariaceae	*Utricularia aurea*	LC
Tracheophyta	Magnoliopsida	Scrophulariales	Lentibulariaceae	*Utricularia australis*	LC
Tracheophyta	Magnoliopsida	Scrophulariales	Lentibulariaceae	*Utricularia bifida*	LC
Tracheophyta	Magnoliopsida	Scrophulariales	Lentibulariaceae	*Utricularia brachiata*	DD*
Tracheophyta	Magnoliopsida	Scrophulariales	Lentibulariaceae	*Utricularia caerulea*	LC*
Tracheophyta	Magnoliopsida	Scrophulariales	Lentibulariaceae	*Utricularia exoleta*	LC*
Tracheophyta	Magnoliopsida	Scrophulariales	Lentibulariaceae	*Utricularia graminifolia*	LC
Tracheophyta	Magnoliopsida	Scrophulariales	Lentibulariaceae	*Utricularia limosa*	DD*
Tracheophyta	Magnoliopsida	Scrophulariales	Lentibulariaceae	*Utricularia scandens*	LC*
Tracheophyta	Magnoliopsida	Scrophulariales	Lentibulariaceae	*Utricularia striatula*	LC*
Tracheophyta	Magnoliopsida	Scrophulariales	Lentibulariaceae	*Utricularia uliginosa*	LC*
Tracheophyta	Magnoliopsida	Scrophulariales	Scrophulariaceae	*Centranthera cochinchinensis var. cochinchinensis*	LC*
Tracheophyta	Magnoliopsida	Scrophulariales	Scrophulariaceae	*Limnophila sessiliflora*	LC
Tracheophyta	Magnoliopsida	Scrophulariales	Scrophulariaceae	*Lindernia antipoda*	LC
Tracheophyta	Magnoliopsida	Scrophulariales	Scrophulariaceae	*Lindernia crustacea*	LC
Tracheophyta	Magnoliopsida	Scrophulariales	Scrophulariaceae	*Lindernia micrantha*	LC
Tracheophyta	Magnoliopsida	Scrophulariales	Scrophulariaceae	*Lindernia procumbens*	LC
Tracheophyta	Magnoliopsida	Scrophulariales	Scrophulariaceae	*Mazus miquelii*	DD*
Tracheophyta	Magnoliopsida	Scrophulariales	Scrophulariaceae	*Mazus pumilus*	LC*
Tracheophyta	Magnoliopsida	Scrophulariales	Scrophulariaceae	*Pedicularis longiflora var. tubiformis*	DD*
Tracheophyta	Magnoliopsida	Scrophulariales	Scrophulariaceae	*Scrophularia ningpoensis*	LC*
Tracheophyta	Magnoliopsida	Scrophulariales	Scrophulariaceae	*Veronica beccabunga ssp. muscosa*	DD*
Tracheophyta	Magnoliopsida	Scrophulariales	Scrophulariaceae	*Veronica undulata*	DD*