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China Mangrove Component

Guangxi Mangrove Research Center

Final Report of Review of China National Mangrove Economic Values

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1 Data available about ecological values of mangroves in China

Because of the difficulties of determining the ecological and community values of mangroves, no quantification assessment of mangrove values on its contribution to environment has been tried until Dr. Fan Hangqing (1995) made an attempt to identify the ecological and community values of mangroves in Guangxi (see table1). The assessment was based on 5654 ha of existing mangroves and 3945.8 ha of mangroves that are planned to restore.

Table 1 Ecological and Community values of mangroves in Guangxi

Items	Assessment coefficient	Scope of project	Annual Benefits (million Yuan)
Reduce loss caused by cyclone 60%	/	9599.8 ha	13.8084
Lower coastal levee maintenance70%	/	9599.8 ha	16.7862
Paddy fields protection	14927.9 yuan/km year	453.84 km	6.7749
Fruits of Avicennia marina	3600.0 yuan/ ha year	3359.9 ha	12.0956
Lumber	1050.0 yuan/ ha year	9599.8 ha	10.0798
Erosion prevention	465.0 yuan/ ha year	9599.8 ha	4.4639
Soil fertility Maintain	200.0 yuan/ ha year	9599.8 ha	1.9200
Oxygen release	70.0 yuan/ ha year	9599.8 ha	0.672
Sustain fauna	15000.0 yuan/ ha year	9599.8 ha	143.9970
Purify air and water	25000.0 yuan/ ha year	9599.8 ha	239.9950
Benefit inshore fishery	15000.0 yuan/ ha year	9599.8 ha	14399.70
Total	/		594.5898

Han Weidong et al. (2000) also tried to identify the ecological and community values of 13, 646 ha of all the existing mangroves in China by adopting financial analysis method. The measurement results showed that the ecological values of mangroves in China are 2365.31 million Yuan, of which biomass values are 81.63 million Yuan, coast protection 992.06 million Yuan, soil erosion prevention 1156.92 million Yuan, CO_2 fixation O_2 release 67.06 million Yuan, fauna habitat 54.70 million Yuan, Nutrient accumulation 10.12 million Yuan, pollutant degradation and diseased and insect damage prevention 2.82 million Yuan.

Assessment of mangrove ecological and community values can help to improve the understanding of mangroves and raise public awareness of the importance of mangrove ecosystem. But determination of the values is still difficult, as it depends on the view of different user groups and techniques, and the concept is constant development with social progress.

2 Comments on the data available

In China, the northernmost boundary of naturally occurred mangrove, the growth of mangrove is comparatively slower and trees are usually smaller (less than four meters). Hence, mangrove forests have been hardly used by Chinese people as lumber or similar construction wood. The destruction of mangrove in China is mainly attributed to the rampant cutting of mangrove trees for the purpose of fuel wood. To protect mangrove resources in China, a batch of relevant laws or regulations have been formulated, such as China Biodiversity Protection Action Plan (1994), Forestry Action Plan for China's Agenda 21 (1995), China Ecological Environment Construction Plan (1998), Ocean Action Plan for China's Agenda 21 (1996), China Wetland Protection Action Plan (2000), and China Mangrove Protection, Management, and Utilization Plan (2002), in which illegal cutting of mangrove is strictly forbidden and rehabilitation of mangrove is encouraged. Now in China, mangrove has been placed at the top list of protected resources by appreciating its significant indirect ecological value, as well as its limited direct value (e.g. the fruit of *Avicennia marina*).

Dr. Fan Hangqing's estimation on the value of mangrove in China involved not only routine thinking of its contribution to fishery and environment (calculated on reference to Indian standard) but also special

consideration of its contribution to disaster alleviation in combating the impact of cyclone and tidal surge. This estimation may ignore the economic difference between India and China and the change of price factors arising from rapid growth of Chinese Economy, and hence may underestimate the substantial value of mangrove. Han Weidong also made some approaches in estimation on mangrove values by incorporating productivity of mangrove communities, but his valuation is still not complete since mangrove related fishery data are scanty. So far, valuation on mangroves in China has been pursued mainly based on assumption and deduction, without the support of real data and case study.

In association with the collections of GEF potential demonstration sites, Fangchenggang mangroves of Guangxi were particularly surveyed as a case in order to consolidate the values of China mangroves and attempt to make some correction and supplement on the existing evaluation parameters.

3 Evaluation of ecological and economic value of mangroves in Fangchenggang GEF potential mangrove demonstration site

At Fangchenggang GEF potential mangrove demonstration site, there are altogether 19 villages (mean distance to mangrove is 882.5 km). Sea dikes at the site are 65.71 km long, protecting 1,799.4 ha tillable land and favoring 44,217 local residents.

Table 2 Sea dikes in Fangchenggang site and their maintenance (survey results of October, 2002)

Town	Village	Equidistance to mangrove (m)	Population	Tillable land area (mu)	Farm cattle number	Tillable land within seadike (mu)	Seadike length (km)	Construction time of seadike	Labor use in the year with typhoon occurring (person/year)	Regular labor use for maintenance (person/year)
Dongxing	Nanmu	1000	4675	5068	680	2500	3	1975	45000	25000
	Zhushan	800	3638	4130	780	2700	7	Not clear	8000	2000
Jiangping	Zhazu	1500	1750	2470	90	500	4	1969	1500	600
	Ban'ai	500	1420	1490		1100	2	1972	600	200
	Tanji	1000	1296	1570	80	0	1	1957	500	300
	Jianglong	1000	6898	6500	730	3500	15	1957	13000	6500
	Wutou	1000	1618	2229	115	2229	3.9	1968	5000	1000
	Jiaodong	1000	1129	1100	66	0	4.5	1966	600	200
	Shanxin	100	1268	1394	75	1394	3	1957	5000	1000
	Wanwei	2000	3962	3197	70	2500	5	1969	2500	800
	Guiming	1000	2956	2908	560	2908	8	1953	15000	0
Jiangshan	Xinliu	3500	1850	3500	380	1100	0.22	1971	0	0
	Xinji	300	1998	2420	150	2200	3.9	1913	3500	1800
	Tanxi	1000	1970	2097	178	500	2	1943	1000	600
	Shawan	600	123			0	0		0	0
	Tanpeng	1000	1990	2254	238	1992	0.9	1936	2000	1000
	Wan'ou	50	302	103	2	81	0.73	1963	500	300
	Bailong	200	2037	1787	42	1787	1.16	1950	5000	1000
Gangkou (Port)	Hongxing	100	410			0	0.4	1975	100	50
	Total	882.5	41290	44217	4236	26991	65.71		108800	42350

3.1 Cases and reason for setting of estimation factors

3.1.1 Disaster reduction service

Dr. Fan Hangqing indicated in his paper (1995) that to set up mangrove ecological maintenance mode of sea dike could reduce disaster loss caused by storm tide by 60%, i.e. 1448 Yuan/ha·year. As marine eco-economy has grown rapidly at coast of Guangxi (surpass 20% in growth rate) since 1995, the dis-

disaster alleviation service of mangrove in Guangxi can be estimated to be 2548.2 Yuan/ha·year in 2002.

3.1.2 Reduction of seadike construction cost

Case 1: In Hepu, from 1997 to 2002, average cost of seadike construction is 6.504 million Yuan/km, and from 2002 to 2003, average cost of seadike construction is 13.697 million Yuan/km. Thus average cost of seadike construction along the coastline of Guangxi can be estimated to be 10 million Yuan/km. Depreciation rate of seadike can be defined as 50 years.

Cost for building seadike partly result from the devastation of mangrove. It is reasonable to define the contribution of mangrove to reduction of seadike construction cost as 40% of the seadike construction cost, i.e. 4 million Yuan/km. In Fangchenggang GEF potential mangrove demonstration site, total length of seadike is 65.71 km and mangrove area is 1414.6 ha. Therefore, mangrove's contribution to the reduction of seadike construction cost should be:

$$(\mathbf{65.71}\,km \times \mathbf{4}\,million\ Yuan/km)/(\mathbf{1414.6}\,ha \times \mathbf{50}\,year) = \mathbf{3716}\,Yuan/ha \cdot year$$

3.1.3 Reduction of seadike maintenance cost

Case 2: By analyzing the case in Yingluo Harbor where the maintenance cost of a 1.4 km long earth seadike was reduced considerably owing to the existence of mangrove, we can expect a 70% reduction of labor cost for maintaining the sea dikes in the GEF site.

- **Regular year**

Labor used for maintenance of sea dikes in Fangchenggang GEF potential mangrove demonstration site is 42,350 person·day/year (table 1). Average cost of one labor per day is 25 Yuan, so total labor cost in seadike maintenance is 1.0588 million Yuan/year. Provided that mangrove were absent in the GEF site, annual labor cost in regular year would be:

$$\mathbf{1.0588}\,million\ Yuan/(\mathbf{1}-\mathbf{70}\%) = \mathbf{3.5292}\,million\ Yuan$$

Thereby cost reduction service provided by mangrove in the GEF site is:

$$\mathbf{3.5292}\,million\ Yuan/year\ /\mathbf{1414.6}\,ha = \mathbf{2494.82}\,Yuan/ha \cdot year$$

- **Year with strong typhoon occurring**

Labor used for maintenance of sea dikes in Fangchenggang GEF potential mangrove demonstration site is 108,800 person·day/year (table 2). Total labor cost in seadike maintenance is 2.72 million Yuan/year. Provided that mangrove were absent in the GEF site, annual labor cost in the year with strong typhoon occurring would be:

$$\mathbf{2.72}\,million\ Yuan/(\mathbf{1}-\mathbf{70}\%) = \mathbf{9.0667}\,million\ Yuan$$

Suppose that strong typhoon occurs every nine year, reallocation of the extra cost to each year for combating typhoon disaster is: (cost in the year with strong typhoon occurring-cost in regular year)/9 year=(9.0667 million Yuan-3.5292 million Yuan)/9 year=0.6153 million Yuan/year. Therefore, the cost reduction service provided by mangrove in the GEF site can be defined as:

$$\mathbf{0.6153}\,million\ Yuan/\mathbf{1414.6}\,ha = \mathbf{434.96}\,Yuan/ha \cdot year$$

- **Reduction of total cost of seadike maintenance**

The reduction service provided by mangrove on total cost of seadike maintenance is:

$$Regular\ cost + extra\ cost = \mathbf{2494.82}Yuan/ha \cdot year + \mathbf{434.96}Yuan/ha \cdot year = \mathbf{2929.78}Yuan/ha \cdot year$$

3.1.4 Ecological secure of fishery

3.1.5 On site fishery in mangrove area

In the 19 villages near Fangchenggang GEF potential mangrove demonstration site, daily number of the farmers who go fishing wild marine animals in mangrove areas represents 33% of total number of residents in the villages. Annually, the fishing activities can generate 48.4157 million Yuan income for

local residents (table 3). Biomass of marine animals on mangrove flats is highly correlated with mangroves, and the degree of correlation can be as high as 95%. Hence, the contribution of mangrove in the GEF site to annual income of local farmers can be defined as:

$$\mathbf{48.4157}\ million\ Yuan/year \times \mathbf{95}\% / \mathbf{1414.6}\ ha = \mathbf{32514.43}\ Yuan/ha \cdot year$$

Table 3 Fishing output and output value in Fangchenggang GEF potential mangrove demonstration site (2002)

No.	Village	Fishing targets	Families involved	Annual fishing day	Daily number of fishman	Output (kg/d)	Annual output (kg)	Price (Yuan/kg)	Output value (10000 Yuan)
1	Dongxing, Nanmu	Phascolosoma	800	135	700	1400	189000	9.0	170.10
		Geloina erosa	110	180	100	500	90000	1.4	12.60
		Clam	25	90	20	90	8100	5.6	4.54
		Mud crab	80	120	60	90	10800	40.0	43.20
		Hard clam	100	360	80	120	43200	3.8	16.42
2	Dongxing, Zhushan	Sipunculus	1100	240	500	1250	300000	11.0	330.00
		Phascolosoma	12	240	10	10	2400	10.0	2.40
		Razoe clam	100	240	50	62.5	15000	10.0	15.00
		Shellfish	80	240	40	70	16800	5.0	8.40
		Blood worm	30	240	25	6.25	1500	30.0	4.50
		Oyster	30	240	25	81.25	19500	1.0	1.95
		Hard clam	100	240	70	175	42000	4.0	16.80
3	Jiangping, Ban'ai	Sipunculus	205	165	50	75	12375	16.0	19.80
		Phascolosoma	50	45	10	10	450	11.0	0.50
		Shrimp	201	75	30	45	3375	30.0	10.13
		Clam	390	150	70	175	26250	3.0	7.88
		Crab	18	210	15	7.5	1575	26.0	4.10
		Fish	12	210	20	20	4200	6.0	2.52
4	Jiangping, Zhazu	Sipunculus	300	180	300	750	135000	18.0	243.00
		Phascolosoma	200	200	200	200	40000	16.0	64.00
		Shellfish	100	240	100	500	120000	6.0	72.00
5	Jiangping, Tanji	Sipunculus	150	240	150	375	90000	12.0	108.00
		Phascolosoma	20	100	20	20	2000	18.0	3.60
		Shellfish	30	240	65	175	42000	6.0	25.20
6	Jiangping, Jianglong	Sipunculus	650	180	1800	450	81000	12.0	97.20
		Phascolosoma	300	100	600	900	90000	18.0	162.00
		Clam	250	180	1300	2600	468000	6.0	280.80
7	Jiangping, Wutou	Sipunculus	1000	240	700	210	50400	14.0	70.56
		Blood worm	110	240	100	45	10800	50.0	54.00
		Hard clam	220	240	200	150	36000	6.0	21.60
		Oyster	28	240	20	500	120000	1.0	12.00
		Razoe clam	50	240	35	175	42000	15.0	63.00
		Phascolosoma	15	300	8	10	3000	20.0	6.00
		Ark shell	30	240	25	31.25	7500	16.0	12.00
8	Jiangping, Jiaodong	Fish	270	120	270	100	12000	6.0	7.20
		Shrimp		120	40	40	4800	20.0	9.60
		Crab		120	30	20	2400	30.0	7.20
		Clam		180	150	300	54000	3.6	19.44
9	Jiangping, Shanxin	Fish	349	210	100	350	73500	10.0	73.50
		Mud crab	349	210	100	150	31500	48.0	151.20
		Shrimp	349	360	80	200	72000	12.0	86.40
		Phascolosoma	349	80	30	200	16000	10.0	16.00
		Shellfish	349	360	30	120	43200	5.0	21.60
10	Jiangping,	Sipunculus	600	180	600	1500	270000	18.0	486.00

	Wanwei	Phascolosoma	200	100	200	200	20000	16.0	32.00
		Shellfish	100	240	100	500	120000	6.0	72.00
11	Jiangping, Guiming	Fish	180	126	250	1000	126000	10.0	126.00
		Shrimp	120	80	120	150	12000	40.0	48.00
		Sipunculus	690	240	1000	2000	480000	12.0	576.00
		Clam	230	240	300	1500	360000	4.0	144.00
		Phascolosoma	500	160	250	250	40000	10.0	40.00
12	Jiangshan, Xinliu	Sipunculus	15	52	16	40	2080	8.0	1.66
		Geloina erosa	60	60	20	100	6000	1.4	0.84
		Clam	10	75	12	30	2250	2.0	0.45
13	Jiangshan, Xinji	Sipunculus	350	52	100	400	20800	8.0	16.64
		Phascolosoma	60	162	20	60	9720	12.0	11.66
		Geloina erosa	110	55	50	200	11000	2.0	2.20
		Shellfish	100	75	35	135	10125	4.0	4.05
		Ark shell	120	140	40	80	11200	10.0	11.20
		Hard clam	130	72	30	150	10800	4.0	4.32
		Small fishes	6	175	6	7	1225	26.0	3.19
14	Jiangshan, Tanxi	Sipunculus	100	180	160	400	72000	16.0	115.20
		Blood worm	100	180	150	50	9000	50.0	45.00
		Phascolosoma	30	240	30	45	10800	12.0	12.96
		shellfish	150	180	300	750	135000	6.0	81.00
		Hard clam	30	180	50	50	9000	4.0	3.60
		Ark shell	50	180	60	60	10800	8.0	8.64
15	Jiangshan, Shawan	Sipunculus	23	180	20	20	3600	16.0	5.76
		Phascolosoma	5	240	5	5	1200	12.0	1.44
		Shellfish	20	180	20	50	9000	6.0	5.40
		Blood worm	10	180	10	5	900	50.0	4.50
16	Jiangshan, Wan'ou	Phascolosoma	30	200	30	45	9000	12.0	10.80
		Mud crab	5	160	5	2.5	400	30.0	1.20
		Shellfish	5	160	5	2.5	400	6.0	0.24
		Geloina erosa	5	160	5	2.5	400	2.0	0.08
		Hard clam	5	160	5	2.5	400	8.0	0.32
17	Jiangshan, Tanpeng	Sipunculus	300	180	350	525	94500	16.0	151.20
		Phascolosoma	30	240	50	100	24000	12.0	28.80
		Hard clam	200	180	250	625	112500	4.0	45.00
		Shellfish	100	180	150	375	67500	6.0	40.50
18	Jiangshan, Bailong	Mud crab	30	160	30	15	2400	30.0	7.20
		Phascolosoma	100	240	100	150	36000	12.0	43.20
		Shellfish	80	160	80	80	12800	6.0	7.68
		Geloina erosa	100	160	100	150	24000	2.0	4.80
		Hard clam	80	160	80	80	12800	8.0	10.24
19	Gangkou (Port) Hongxing	Phascolosoma		300	50	75	22500	12.0	27.00
		Mud crab		180	20	20	3600	40.0	14.40
		Shellfish		240	60	90	21600	8.0	17.28
		Oyster		240	35	875	210000	10.0	210.00
	Total				13687				4841.57

3.1.6 Off site fishery in shallow waters beyond mangrove forest

Off site fishery in shallow waters beyond mangrove forest is another major income generation activities of the people in the 19 villages in the GEF site (table 4). The annual output value of Off site fishery is 34.522 million Yuan. By the judgement that the biomass of commercial animals in shallow waters drops by 40% in the area without mangroves, the contribution of mangroves in Fangchenggang GEF potential mangrove demonstration site to Off site fishery in shallow waters can be defined as:

$$34.522\ million\ Yuan/year \times 40\% / 1414.6\ ha = 9761.63\ Yuan/ha \cdot year$$

Table 4 Fishing output and output value of off site fishery in shallow waters outside mangrove forests in Fangcheng-gang GEF potential mangrove demonstration site (2002)

Township	Village	Items	Annual output (kg)	Price (Yuan/kg)	Output value (Ten thousand Yuan)
Dongxing	Nanmu	Trash fish	14400	2.0	2.88
		Shrimp	12600	12.0	15.12
	Zhushan	Trash fish	45000	5.0	22.50
		Shrimp	9000	20.0	18.00
	Ban'ai	Trash fish	360	8.0	0.29
		Shrimp	180	20.0	0.36
		Crab	90	30.0	0.27
Jiangping	Zhazu	Trash fish	21600	8.0	17.28
		Shrimp	2160	30.0	6.48
		Crab	10200	24.0	24.48
		Clam	3000	6.0	1.80
	Tanji	Trash fish	18000	10.0	18.00
		Shrimp	5400	20.0	10.80
		Crab	1800	30.0	5.40
	Jianglong	Trash fish	96000	10.0	96.00
	Wutou	Trash fish	79200	8.0	63.36
		Shrimp	31500	30.0	94.50
	Jiaodong	/	0	0.0	0.00
	Shanxin	Trash fish	250000	6.0	150.00
		Shrimp	80000	20.0	160.00
		Crab	80000	14.0	112.00
		Clam	586000	6.0	351.60
	Wanwei	Trash fish	216000	8.0	172.80
		Shrimp	21600	30.0	64.80
		Crab	1620000	10.0	1620.00
		Clam	300000	6.0	180.00
	J Guiming	Shrimp	1250	20.0	2.50
Jiangshan	Xinliu	Trash fish	14000	4.0	5.60
		Jellyfish	52500	3.0	15.75
	Xinji	Trash fish	45500	7.6	34.58
		Angling	12750	12.0	15.30
		Jellyfish	37500	3.0	11.25
	Tanxi	Trash fish	10000	5.0	5.00
	Shawan	Trash fish	4000	5.0	2.00
	Wan'ou	Trash fish	30000	5.0	15.00
	Tanpeng	Trash fish	45000	5.0	22.50
	Bailong	Net fishing	38000	30.0	114.00
Gangkou (Port)	Hongxing	/	0	0.0	0.00
	Total		3794590		3452.20

3.1.7 Aquaculture in mangrove area

Farming shrimp, clam, oyster, crab, and fishes in Fangchenggang GEF potential mangrove demonstration site are regular mariculture practice of local people (table 5). Mariculture in mangrove areas are favored by mangrove, which is regarded as an ecological secure of the industry, for mangrove has some positive impacts on environment, such as purification of water, maintenance of ecosystem balance, and supporting high productivity. At coast of Guangxi and Zhanjiang of Guangdong where shrimp farming is practiced extensively, It was found that mangrove coast support a relatively high survival of farmed shrimp, 15-35% higher than that of shrimp farmed at coast where mangrove is absent. There-

fore, we believe that the contribution of mangrove to mariculture at least account for 25%. By following this judgment, contribution of mangrove in Fangchenggang GEF potential mangrove demonstration site can defined as:

$$\mathbf{140.022}\ million\ Yuan/year \times \mathbf{25}\% / \mathbf{1414.6}\ ha = \mathbf{24781.17}\ Yuan/ha \cdot year$$

Table 5 Farming output and output value in Fangchenggang GEF potential mangrove demonstration site

Village	Farming Species	Farming area (ha)	Output (kg/ha)	Price (Yuan/kg)	Output value (Ten thousand Yuan)
Dongxing, Nanmu	Geloina erosa	5.33	17500	4.0	7.0
	Penaeus sp.	2.00	7500	24.0	18.0
Dongxing, Zhushan	Penaeus sp.	23.33	70000	24.0	168.0
	Mud crab	1.33	3000	40.0	12.0
Jiangping, Ban'ai	Penaeus sp.	13.33	30000	26.0	78.0
Jiangping, Zhazu	Penaeus sp.	53.33	200000	20.0	400.0
	Crustacean	13.33	200000	5.0	100.0
Jiangping, Tanji	-	0.00	0	0.0	0.0
Jiangping, Jianglong	Mud crab	66.67	750000	40.0	3000.0
	Penaeus sp.	53.33	20000	30.0	60.0
Jiangping, Wutou	Hard clam	133.33	800000	4.0	320.0
	Penaeus sp.	53.33	320000	20.0	640.0
	Geloina erosa	1.00	2250	4.0	0.9
	Razoe clam	33.33	100000	16.0	160.0
	Bloody clam	30.00	180000	16.0	288.0
Jiangping, Jiaodong	Penaeus sp.	86.67	195000	24.0	468.0
	Mud crab	1.33	5000	36.0	18.0
Jiangping, Shanxin	Hard clam	13.33	200000	4.0	80.0
Jiangping, Wanwei	Penaeus sp.	186.67	700000	20.0	1400.0
	Crustacean	133.33	2000000	5.0	1000.0
Jiangping, Guiming	Penaeus sp.	106.67	400000	24.0	960.0
	Mud crab	33.33	5000	40.0	20.0
Jiangshan, Xinliu	Penaeus sp.	33.33	75000	20.0	150.0
Jiangshan, Xinji	Oyster	13.33	10000000	1.0	1000.0
	Hard clam	13.33	600000	4.0	240.0
	Sipunculus	0.67	3000	8.0	2.4
	Bloody clam	2.00	45000	16.0	72.0
	Mud crab	0.67	2250	40.0	9.0
	Penaeus sp.	53.33	120000	20.0	240.0
Jiangshan, Tanxi	Hard clam	73.33	6000000	4.0	2400.0
	Clam	16.67	1500000	4.0	600.0
Jiangshan, Shawan	Hard clam	6.67	50000	4.0	20.0
Jiangshan, Wan'ou	-	0.00	0	0.0	0.0
Jiangsha, Tanpeng	Oyster	8.67	545000	1.0	54.5
	Hard clam	6.67	50000	4.0	20.0
Gangkou (Port) Hongxing	White Shrimp	0.84	6300	26.0	16.4
Total		1273.84	25201800.00	578.00	14022.18

3.1.8 Contribution of mangrove to pearl farming in the GEF potential mangrove demonstration site

In Fangchenggang GFE potential mangrove demonstration site, pearl farming is a major industry. High quality pearls produced in the area has brought it a nation wide reputation.

Case study:

In history, Hepu of Guangxi was well known in China for its production of high quality pearl. It was recorded that along the coast of Hepu, pearl production was mainly practiced in seven sea areas ("pearl pool" as ancient people called it), where mangrove used to flourish. As approximately 70% of the mangroves have been cleared duo to reclamation of coastal land, good quality pearls have never been found in the seven "pearl pools" any more. This phenomenon might suggest a close linkage between pearl and mangroves.

Yingpan town of Hepu is the hometown of famous "south pearl". "South pearl" was famed for its best quality in China for over 2000 years and used to be an article of tribute. From 1968 to 1974, blooming pearl farming in Bailong, Yingpan made it one of the major pearl farming places in China. In 1974, coastal land in Bailong, where used to grow 333 ha mangrove (half of which was destroyed before 1949), was reclaimed, and all the remaining mangrove flats were converted to paddy fields. Since then, low survival of pearl shell and quality reduction of pearls have been observed in this area, resulting in a sharp drop of pearl generation rate from 1.25 kg/10000 shells to 0.175 kg/10000 shells in 1999. Pearl price has also declined badly to such a low level (5000 Yuan/kg) that this profitable industry has nearly been destroyed. Pearl farmers in Bailong, who have engaged in pearl production for many generations, now have to choose an alternative job or move to Zhenzhu Harbor in Fangchenggang City to continue their traditional pearl farming.

In 1999, there are still 1030 ha mangrove in Fangchenggang GEF potential mangrove demonstration site. Now, pearl farming is still extensively practiced in this area. It was recorded that in 1999 in Bailongwei, the best pearl farming place in Guangxi, pearl generation rate was 1.0kg/10000 shells (average), the price of pearl was 12,000 Yuang/kg, and total output was 3 tons.

The growth of pearl shell in mangrove areas may be favored by the suitable environmental conditions maintained by mangroves, such as good water quality and abundant foods (phytoplankton). In reality, mangrove benefits pearl farming industry by increasing pearl generation rate, improving pearl quality, and raising the environmental capacity of farming areas (Fig. 1).

Fig. 1 The aspects of pearl farming benefited by mangrove

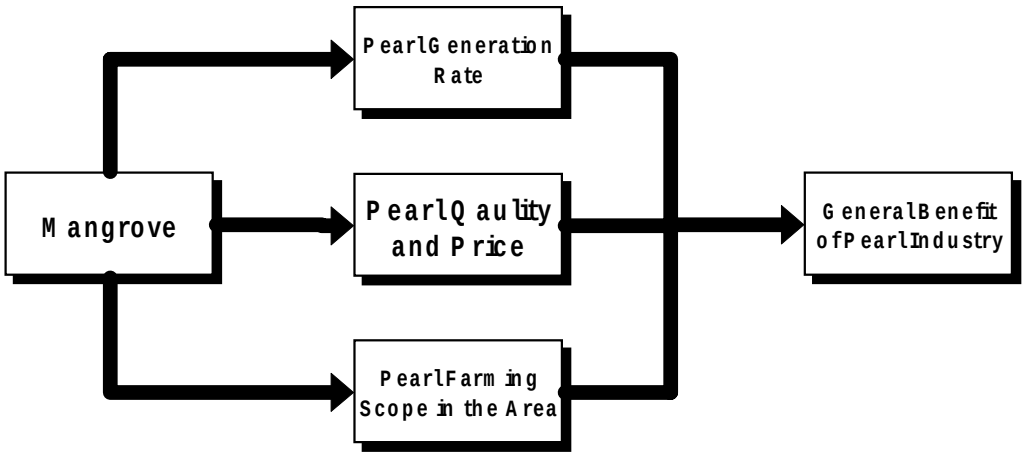

Table 6 shows that pearl farming profit in mangrove area is 13.71 times higher than that outside mangrove area. Comparison of unit profit of pearl production can be used to illustrate the difference. Outside mangrove area, the profit of farming 10000 shells is 875 Yuan, but in mangrove area, the profit is 12,000 Yuan. The difference can be viewed as the contribution of mangroves. Thus the contribution rate of mangrove in the GEF site can be defined as:

$$(\mathbf{12000}\,Yuan - \mathbf{875}\,Yuan) \times \mathbf{100} / \mathbf{12000}\,Yuan = \mathbf{92.71}\%$$

The contribution of mangroves to pearl farming in Fangchenggang GEF potential mangrove demonstration site can be quantified as:

$$\mathbf{66.00}\ million\ Yuan/year \times 92.71\% / \mathbf{1414.6}\ ha = \mathbf{43255.05}\ Yuan/ha \cdot year$$

Table 6 Comparison of the benefit of pearl farming in and outside mangrove area

	Bailong, Hepu, Guangxi	Zhenzhu Harbor	Explanation
Historical change of mangrove area			
Mangrove area in past (ha)	330	3278	100-150 years ago
Mangrove area in 1999 (ha)	4	1030	
Proportion of remaining mangrove area	1.21%	31.42%	
Output and value of Farm raised pearl (10000 shell)			
Average pearl generation rate in 1999 (kg/10000 shell)	0.175	1.0	
Average selling price in 1999 (Yuan/kg)	5000	12000	Quality dependent
Average output value in (Yuan/10000 shell)	875	12000	Output value=pearl generation rate×price
Comparison of benefit/ 10000 shell	1	13.71	
Pearl farming scope (kg)			
Pearl output in 1999 (kg)	300	5500	
Profit of pearl farming in 1999 (Ten thousand Yuan)	150	6600	Whole benefit=total output×price
Comparison of whole benefit	1	44.00	
Pearl farming history and development	For 2000 years, “South pearl” used to be article of tribute. Pearl farming started in 1968.	About 45 years.	Conclusion: Profit of pearl farming in mangrove area is 13.71 times higher than that in other sea area (10,000 shells).

3.1.9 Contribution of mangrove to fishery in Fangchenggang GEF potential mangrove demonstration site

By analyzing the four aspects concerning the influences of mangrove on fisheries, we concluded that the contribution of mangrove in Fangchenggang GEF potential mangrove demonstration site could be defined as: 10,300 Yuan/ha·year (7354.15 Yuan/mu/year).

Table 7 Contribution of mangrove GEF potential demonstration site to fishery

Content	Contribution by mangrove (Yuan/ha·year)
On site fishery in mangrove areas	32514.43
Off site fishery in shallow waters beyond mangrove forest	9761.63
Mariculture in mangrove areas	24781.17
Contribution of mangrove to pearl farming	43255.05
Total	110312.28

3.1.10 Beautify coastal landscape

Mangrove growing in urban coast is a beautiful landscape which can raise the value of coastal land. Fangchenggang City has about 6 kilometers long urban mangrove coast, where a price rise (at least 5%) of real estate can be expected. In 2000, average price of the coastal land with mangrove occurring nearby (less than 300 meters) was 2.25 million Yuan/ha. The contribution of entire urban mangrove to price rise of coastal land can be estimated to be:

$$\mathbf{180}\ ha \times \mathbf{2.25}\ million\ Yuan/ha \times \mathbf{0.05} = \mathbf{20.25}\ million\ Yuan\ .$$

The contribution of per hectare urban mangrove (348.7 ha) in particular is 58,100 Yuan/ha. For mangroves in the whole area, the contribution of mangroves (1414.6 ha) in general is 14,300 Yuan.

3.1.11 Produce edible fruits

The fruit of *Avicennia marina* is a traditional food of the people at coastal areas of South China Sea. Price of the fruit ranges from 1.4 to 3.2 Yuan/kg (average at 2.4 Yuan/kg).

In Fangchenggang GEF potential mangrove demonstration site, there are 606.7 ha pure forest of *Avicennia marina*. At average, one hectare of pure forest of *Avicennia marina* can produce 750 kg (wet weight) fruit per year. Annual output value of the fruits collected in the GEF site may be 1.092 million Yuan. So the output value of fruits produced by per hectare mangrove in the GEF site is: 1.092 Yuan/1,414.6ha＝771.99 Yuan/ha.

3.1.12 Prevent sea way from siltation

Fangchenggang Port is a key port in West China. West wing of the port is the West Bay, in which 144.8 ha mangroves flourish. Siltation is enhanced in the mangrove area, where total volume of silt is estimated to be 33,300 m^3/year. In some berths at Fangchenggang Port, an increment of siltation was observed, 1-2 cm deeper than that in ten years ago. The increment of siltation is believed arising from the destruction of mangrove in the West Bay in past ten years. At present, annual cost for dredging out the siltation is three million Yuan more than before. Through careful calculation, we can give an estimation that the cost saving for dredging is 20,700 Yuan/ha for mangroves in West Bay in particular, and is 2120.74 Yuan/ha for mangroves in the whole site in general.

3.1.13 Other ecological effects

Han Weidong et al. (2000) attempted to make a macro analysis to estimate the value of mangroves in China at a national level. He pointed out that the value of mangroves in producing timer and litter is 5,982 Yuan/ha, in fixing CO_2 and releasing O_2 is 4,914.3 Yuan/ha, and in protecting tidal flats and coastal land is 84,780.89 Yuan/ha, etc..

3.2 The total value of mangroves in Fangchenggang GEF potential mangrove demonstration site

In Table 8, contribution of mangroves in the GEF site in various fields is listed clearly, and the existing value of mangrove is quantified to be 0.2128 million Yuan/ha·year, and 125 times than cost(1697Yuan/ha.a) . In this table, the contribution of mangrove to ecotourism and social development is not included. Evaluation of the value of mangrove is not only mangrove resources dependent, but also closely linked with socio-economic development stage of the place where mangrove occurs. Therefore, the economic value of mangrove is a variable related with multiple factors.

Table 8 The value of mangrove ecosystem in Fangchenggang GEF potential mangrove demonstration site

Bennifit/Cost	Contents	Value (CNY/ha·a)	Total value (CNY/ha)	Remark
Existing benefits	Natural disaster reduction	2548.2	3,604,684	Field survey
	Sea dike construction reduction	3716	5,256,654	Field survey
	Sea dike maintenance reduction	2929.78	4,144,467	Field survey
	On site fishery in mangrove area	32514.43	45,994,913	Field survey
	Off site fishery in shallow waters	9761.63	13,808,802	Field survey
	Mariculture in mangrove area	24781.17	35,055,443	Field survey

	Contribution to pearl farming	23593.67	33,375,606	Field survey
	Beautify coastal landscape	14300	20,228,780	Field survey
	Production of edible fruits	771.99	1,092,057	Field survey
	Prevent sea way from siltation	2120.74	2,999,999	Field survey
	Produce timber and litter	5982	8,462,137	Han WD 2000
	Fix CO_2 and release O_2	4914.3	6,951,769	Han WD 2001
	Protect tidal flats and coastal land	84780.89	119,931,047	Han WD 2002
	Contaminant sink	150.22	212,501	Han WD 2003
	sub-total	212865.02	301,118,857	
Potential benefits	Ecoturism	2120.74	3,000,000	Mangrove park
	sub-total	2120.74	3,000,000	
Investment and cost	Conservation management	353.46	500,000	Natural Re-serve
	Replanting	1060.37	1,500,000	National Debt
	Research	212.07	300,000	
	Education	70.69	100,000	Publicity
	sub-total	1696.59	2,400,000	

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