

# Environmental Rehabilitation in a Rapidly Developing Urban Area



## Development and Damage

Decades ago, Xiamen pursued economic development with little regard for the environment. Capture fishers used destructive and illegal fishing methods. Fisheries stocks were overexploited. Causeways from Xiamen Island to the mainland (Gaoqi-Jimei) and across the mouths of Xinglin Bay, Maluan Bay, and Yuandang Bay built from the 1950s to the 1970s restricted natural water and silt flow. In 1955-2005, 122 km<sup>2</sup> of sea or 7.5 percent of Xiamen's current land area, were reclaimed primarily from the West Sea and Tong'an Bay. Beach sand was illegally taken from the storm-vulnerable east coast of Xiamen Island to support the booming construction industry. Marine aquaculture rapidly increased since the 1980s and intensified with new technology in the mid-1990s. It covered nearly half of the sea area by 2001. Wastes from coastal aquaculture ponds and excreta and excess feeds from fish cages polluted the sea. Nearly all domestic and industrial wastewater was discharged into the sea untreated. Various industrial and shipping accidents spilled oil and chemicals into the sea. As a consequence, coastlines and water flow were altered. Natural habitats were damaged and polluted. Mangrove forests declined to 1.793 km<sup>2</sup> in 1987 and to just 0.203 km<sup>2</sup> in 1995. Major fish kills occurred around twice per year (1984-1996), and populations of dolphins, egrets, and lancelets declined (ITXDP, 1996a; XDPO, 1998; Xue, et al., 2004; Lin, et al., 2005; PEMSEA, 2006a & b).

## A Lesson from Yuandang

The situation was especially bad in Yuandang. This bay had once sheltered huge flocks of egrets that earned Xiamen its nickname "Egret Island". By the early 1980s, the bay had been cut off from the sea by a causeway and reclamation, and untreated industrial and domestic wastewater was being discharged into the bay. The waterbody shrank to just one-fifth of its original surface area. The foul smell repulsed would-be investors and red tides often arose on the lake. The flocks of egrets disappeared. Residents began leaving the area (PEMSEA, 2006b). The National Environmental Protection Agency blacklisted the site giving the local government a deadline to clean up the lake.

In 1988, Xiamen began phase 1 of Yuandang rehabilitation at an estimated cost of US\$25 million. Infrastructure was built to intercept wastes and a sewage treatment plant was built to treat the wastes. The city government dredged silt out of the bottom, built tidal channels to increase water exchange with the West Sea, and tightened enforcement of regulations on the disposal of wastes. By the end of phase 1 in 1992, dissolved oxygen had risen from 0 to 5.2 mg/liter (**Figure 1**). However, total sewage had also increased by then and other water quality parameters still failed government standards. Thus, Xiamen began phase 2 of rehabilitation at an estimated cost of US\$19 million: building more waste interceptors, upgrading sewage treatment capacity, increasing tidal channels, actively pumping water through the tidal channels, and dredging out more silt. Water quality then met the national standards.

The public and the national government praised government achievements in Yuandang. High-rise buildings rapidly increased in number around Yuandang, housing big names of the corporate world.

Yang Donghong, a real estate developer, observed *"In 1970s, we were losing money invested in real estate because no one wanted to buy the houses around this area (Yuandang) due to its bad environment. Fortunately, the government paid attention to it, and began to repair Yuandang Lagoon and got good results. Our industry has boomed, we investors got great profits."*

The Yuandang rehabilitation had been costly but this bay was in a very prominent location of the city. Rehabilitation was mandated by national government, and so was hard to ignore. The West Sea was also in a prominent location and polluted. It was larger and was the site of conflicts between among economic sectors: aquaculture, shipping, tourism, and pollutive coastal industries. Government funds were limited and environmental management was not directly an income-generating activity. Would cleaning up the West Sea, which would be costlier than Yuandang, be worth the cost? Would cleaning up less central areas be worth the cost?



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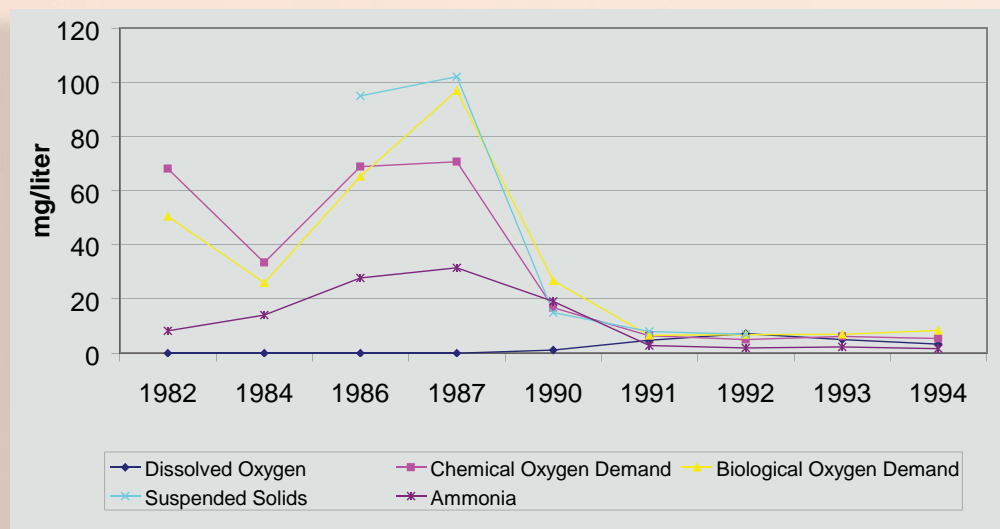


Figure 1. Water quality in Yuandang (from data in Hao, 1998).

## Integrated Coastal Management

In 1994, the GEF/UNDP/IMO's Regional Programme for the Prevention and Management of Marine Pollution in the East Asian Seas (MPP-EAS) introduced integrated coastal management (ICM) to Xiamen. MPP-EAS began supporting the integration of science into management decisionmaking, supporting the integration of both socioeconomic and environmental considerations, and facilitating cooperation among various sectors. In addition to supporting the development of an integrated coastal profile and a joint strategic plan, the programme also supported an assessment of the Yuandang project including its benefits and costs, an environmental profile, a pollution management plan for Xinglin Bay, and sea use zoning (MPP-EAS, 1999).

The coastal environmental profile (ITTXDP, 1996a) showed that even as the various bureaus were each trying to reduce pollution in their individual sectors, there was no effective operational mechanism for bureaus to coordinate their individually limited efforts. There was also no mechanism for bureaus managing conflicting activities to jointly decide to favor one sector over another to optimize overall societal benefits. ICM helped Xiamen's various government bureaus better understand the usefulness of interagency cooperation and helped them better understand the need for sectoral bureaus to support the objectives of other sectors for overall holistic development. In particular, ICM helped emphasize the importance of sustainability in Xiamen's drive for development. Together the various sectoral bureaus forged a joint Strategic Management Plan for Marine Pollution Prevention and Management in Xiamen based on the city's overall vision of "a socialist, modern, international, and scenic port city" (ITTXDP, 1996b). In support of the initiative, the municipal legislative assembly issued "Regulations for Marine Environmental Protection and Management" in 1996.

The multisectoral interaction and the joint strategy also facilitated the articulation of a zoning plan which reduced conflicts among sectors by allocating each use to various areas according to the optimal uses of each area's resources. In 1997, "Regulations for the Management of Sea Area Use in Xiamen" consciously chose large-scale removal of pollutive aquaculture in favor of shipping and tourism in the West Sea. Also, despite inconvenience to its top earning shipping and tourism industries, Xiamen issued in 1997 the "Regulation for the Protection of Chinese White Dolphins". Aquaculture operations were phased-out and compensation was paid out to help shift affected sea farmers to other locations or occupations (Ruan and Yu, 1999).

Commissioned technical studies estimated the economic damage of pollution and the value of improving the environment. This was done through environmental monitoring and interviews of the public regarding its willingness-to-pay and of investors relocating around Yuandang. The studies showed that individuals were willing to pay an average of US\$34/year to manage fisheries, endangered species, and beaches and to treat sewage (Abansi, 1999). Fifty-three percent of 173 investors cited the good environment as a reason for locating around Yuandang. Despite the estimated total rehabilitation cost of between US\$43.75 million and 135.5 million, Yuandang's central location helped it yield a benefit-cost ratio estimated at 9:1! This helped convince Xiamen's leaders that good environmental management could return social and economic benefits. As early as the first phase of the ICM program, the city government initiated Xinglin Bay rehabilitation including sewage treatment and tightening enforcement of waste disposal regulations applying the framework and approaches of the Xiamen Demonstration Project (MPP-EAS, unpublished). Later, the second phase of the GEF/UNDP/IMO Regional Programme helped expand the ICM program by supporting the development of a feasibility study for the

rehabilitation of Maluan Bay and the management of Jiulong River Basin.

## Rehabilitation of coastal areas

Nature protected areas were set up for lancelets in 1991, Chinese egrets in 1995 and Chinese white dolphins in 1997 (PEMSEA, 2006a). In addition to protecting remaining natural features, the rehabilitation program also exerted a lot of effort to open and reconstruct causeways, build sewage treatment plants, return and retain beach sand, and revive populations of plants and animals.

After investing in the rehabilitation of Xinglin Bay, Xiamen

initiated a US\$87 million project for rehabilitating and managing Maluan Bay (West Sea) then continued to invest significant amounts in a program for rehabilitating various other areas (**Table 1, Figure 2**). Among its more recent projects is the US\$2 billion Tong'an Bay Integrated Rehabilitation Project began in 2006 (Lin, 2008). Xiamen has invested a total of US\$2 billion in sewage treatment over the last 20 years (XOFB, 2009). Treatment of industrial sewage rose from 20 percent in 1994 to nearly 100 percent in the 2000s while treatment of domestic sewage rose from 28 percent in 1995 to 85 percent in 2007 (Zhang, unpublished; PEMSEA, 2006a). Green area as a ratio of total land area has risen from 27 percent in 1995 to 37 percent in 2007 (Zhang, unpublished). Modern business centers, convention areas, landscaped parks, and beaches now

**Table 1.** Summary of environmental rehabilitation activities by area (Pei, 2008).

Area (timeframe)	Issues	Actions	Results
Yuandang Bay (1988-1996)	<ul style="list-style-type: none"> <li>• Causeway construction</li> <li>• Reclamation for agriculture</li> <li>• Decreased water flow</li> <li>• Silt accumulation</li> </ul>	<ul style="list-style-type: none"> <li>• Interception of waste</li> <li>• Sewage treatment plant</li> <li>• Improving water exchange</li> <li>• Dredging sludge</li> <li>• Cleansing wastes with the help of mangroves and seaweeds</li> </ul>	<ul style="list-style-type: none"> <li>• Water quality has improved considerably.</li> <li>• Egrets have returned.</li> <li>• Area surrounding Yuandang is pleasant.</li> <li>• Real estate values have risen.</li> </ul>
Xinglin Bay (1995-2005)	<ul style="list-style-type: none"> <li>• Yintan-Xiamen railway cutoff</li> <li>• Xinglin Bay from the sea</li> <li>• Aquaculture developed inside</li> </ul>	<ul style="list-style-type: none"> <li>• Aquaculture removed</li> <li>• Dredging</li> <li>• Landscaping and park development</li> </ul>	<ul style="list-style-type: none"> <li>• Flood and drainage were controlled.</li> <li>• Xiamen Garden Expo Park was developed.</li> </ul>
West Sea, including Maluan Bay (2002-present)	<ul style="list-style-type: none"> <li>• Excessive aquaculture</li> <li>• Causeway decreased water flow</li> <li>• Degradation of wetlands</li> </ul>	<ul style="list-style-type: none"> <li>• Aquaculture removed</li> <li>• Reclamation restricted</li> <li>• Opening of causeway</li> <li>• Dredging out sediments</li> <li>• Construction of shore protection and wetlands</li> </ul>	<ul style="list-style-type: none"> <li>• Dolphins are now more common.</li> <li>• Water flow is expected to increase (30 million m<sup>3</sup>), as well as increase coastline (14 km) and sea areas (8 km<sup>2</sup>).</li> </ul>
Wuyuan Bay (2005-present)	<ul style="list-style-type: none"> <li>• Seawall construction</li> <li>• Reclamation for farmland</li> <li>• Decreased water flow and silt accumulation</li> </ul>	<ul style="list-style-type: none"> <li>• Opening of seawall</li> <li>• Dredging</li> <li>• Keeping water level in dams low</li> </ul>	<ul style="list-style-type: none"> <li>• Reclaimed land of 0.013 km<sup>2</sup> was returned to sea.</li> <li>• High-tech park and business center were developed. (developed already)</li> </ul>
Uninhabited islands (2005- present)		<ul style="list-style-type: none"> <li>• Revegetation and landscaping</li> </ul>	<ul style="list-style-type: none"> <li>• Beautiful landscapes appeared on Monkey and Lantau Islands.</li> </ul>
East Coast, including Tong'an Bay (2006-2013)	<ul style="list-style-type: none"> <li>• Gaoji causeway and Jixing seawall</li> </ul>	<ul style="list-style-type: none"> <li>• Opening and rebuilding of causeway and seawall; dredging; reclamation between Dadeng and Xiaodeng</li> </ul>	<ul style="list-style-type: none"> <li>• Reclaimed land of 4.5 km<sup>2</sup> was returned to sea.</li> <li>• Rehabilitation is ongoing.</li> </ul>
Xiangshan-Chanwei, Guanyinshan, and Eastern beach (2007-2009)	<ul style="list-style-type: none"> <li>• Mining sand from the beach</li> </ul>	<ul style="list-style-type: none"> <li>• Beach rehabilitation with artificial sand</li> <li>• Removing stones, replenishing sand, and stabilizing slope</li> </ul>	<ul style="list-style-type: none"> <li>• Beach is now protected from sand extraction and is used for public recreation and tourism.</li> </ul>





Xiangnan before



Xiangnan after



Tongan before



Tongan after



Xinglin before



Xinglin after



West Sea before



West Sea after



Houyu Island before



Houyu Island after



Yuandang before



Yuandang after



East beach before



East beach after



Wuyuan Bay before



Wuyuan Bay after

**Figure 2.** Map showing location of protected and rehabilitation areas surrounded by pictures for each site showing before and after rehabilitation.

make Xiamen attractive for both work and play.

### Rehabilitation of selected species

Xiamen also began helping selected species recover by releasing artificially bred prawns (*Penaeus penicillatus*, *Penaeus japonicus*) and fish (*Sparuslatus sp.*, *Pagrosomus major*, *Pseudosciaena crocea*) beginning in 2002, and horseshoe crabs and lancelets (*Branchiostoma belcheri*)

beginning in 2005. Fish catch of both *Pagrosomus major* and *Pseudosciaena crocea* has increased since 2003 compared to a slump before 2002 (Zhang, unpublished). "Plan on mangrove planting", "Plan on wetland protection in Xiamen", and "Program on the Construction of Shelter Forest" were developed. By 2006, nearly 0.27 km<sup>2</sup> of mangrove forests had been planted. Although still much less than what it used to be, mangrove abundance has since risen to 0.40 km<sup>2</sup> and 0.60 km<sup>2</sup> more mangroves

are to be planted. These mangroves and other suitable tree species planted on the eastern shore of Xiamen Island are expected to help reduce erosion, cleanse water, and protect against more extreme storms expected with climate change. Xiamen has established a warning system for and removed several square kilometers of alien cord grass species and has improved implementation of regulations to reduce the transport of alien species through ship ballast water. Egrets have returned and dolphins have more than doubled (XOFB, 2009).

## Getting things done

Early on, it was evident that Xiamen exhibited one of the key principles of ICM: policy-functional integration, that is, implementing policy. After development of a profile and strategy, Xiamen crafted an appropriate policy and legal framework which it then translated into laws, regulations, and plans. More importantly, Xiamen then allocated human and financial resources to carry out field action.

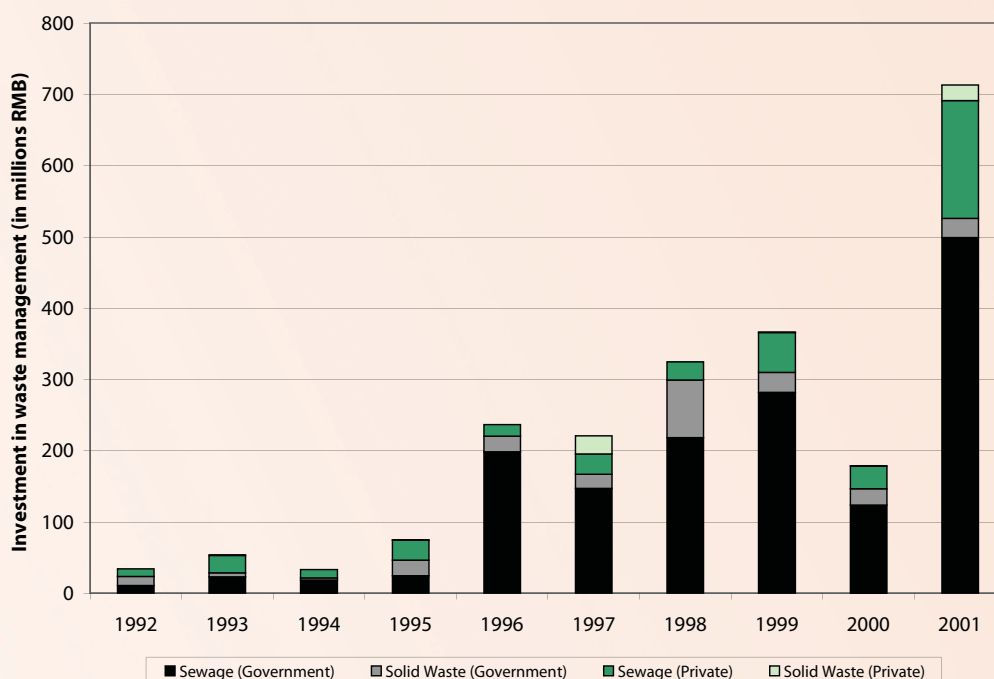
The government remains as the major financier of environmental rehabilitation, but the private sector investors have also been involved in providing environmental services (**Figure 3**). Funds were also generated by levying fees for the use of sea areas, waste disposal, and exceeding waste standards. Landscaped areas were developed into business parks and property sold or leased for large sums. Even dredging materials have been used to reclaim sea areas that were then auctioned off to generate funds. Funds generated from sea area use are allocated for marine management and help support costs of the management program.

## ICM Delivers Results

The ICM program has remained relevant to development priorities through various changes in leadership and five-year plans. It has helped various sectors in Xiamen realize that environmental quality matters to their sector and to overall social and economic development. Its relevance and attractive benefit-cost ratio have put environmental rehabilitation into laws and plans and have helped it get personnel, funding, and sustained on-the-ground action. Although these rehabilitation programs will not be able to return the many damaged areas to their pre-industrial state, they have nevertheless considerably improved environmental conditions and made Xiamen a very pleasant place to live in. The rehabilitated natural habitats and species are under less stress and are thus more robust to more intense climate variability expected in the coming years.

*Zhou Lumin, Deputy Director of the Xiamen Oceans and Fisheries Bureau, stated that "ICM is playing a great role in solving the tension between development and protection, as well as sea-use conflict, in the context of rapid economic development, urban expansion, increasing population, and growing pressure on resources and the environment."*

Xiamen's incorporation of sustainability considerations in its pursuit of development has delivered results and won it many awards: the 1997 National Model City for Environment Protection, the 2002 International Garden City Award, the 2004 UN Habitat Scroll of Honor Award, the 2005 National Sanitary City Award, and China's 2005 Top Ten Livable Cities Award. Xiamen has not only become



**Figure 3.** Government and private investments in environmental services (PEMSEA, 2006a, based on data from Xiamen statistics yearbooks, 1992-2002 and Xiamen environmental statistics, 1995-2001).

more sustainable, its beauty has also attracted immigrants, tourists, and real estate development. A sense of pride in the beauty of their city has also grown in Xiamen's people.

*Dr. Yu Xingguang, Director of the Third Institute of Oceanography said, "The environmental restoration project in Xiamen – like the rehabilitation of Xiamen East Sea and West Sea – is advanced and is a demonstrative model for China. It is rare that a city has initiated ecological restoration and paid attention to the harmony of human and nature in the development of its economy."*

Much still remains to be done to repair the extensive damage to the environment. Moreover, despite much rehabilitation work and the rapid rise in wastewater treatment, the following still persist:

- A lot of previously disposed of waste continues to exude pollutants.
- Xiamen's population and economic production continue to increase very rapidly.
- A significant proportion of nutrient pollution continues to flow in from adjacent upstream cities through the Jiulong River. Nutrient pollution has thus continued to increase (**Figure 4**).
- Maluan Bay, Jiulong River estuary and West Sea are the major polluted areas (**Figure 5**). In response, Xiamen has followed through on initial studies for Maluan Bay and Jiulong River Basin developed during ICM phase 2. The city government has removed aquaculture, opened up the causeway, and dredged out silt in Maluan Bay; however, more time is needed

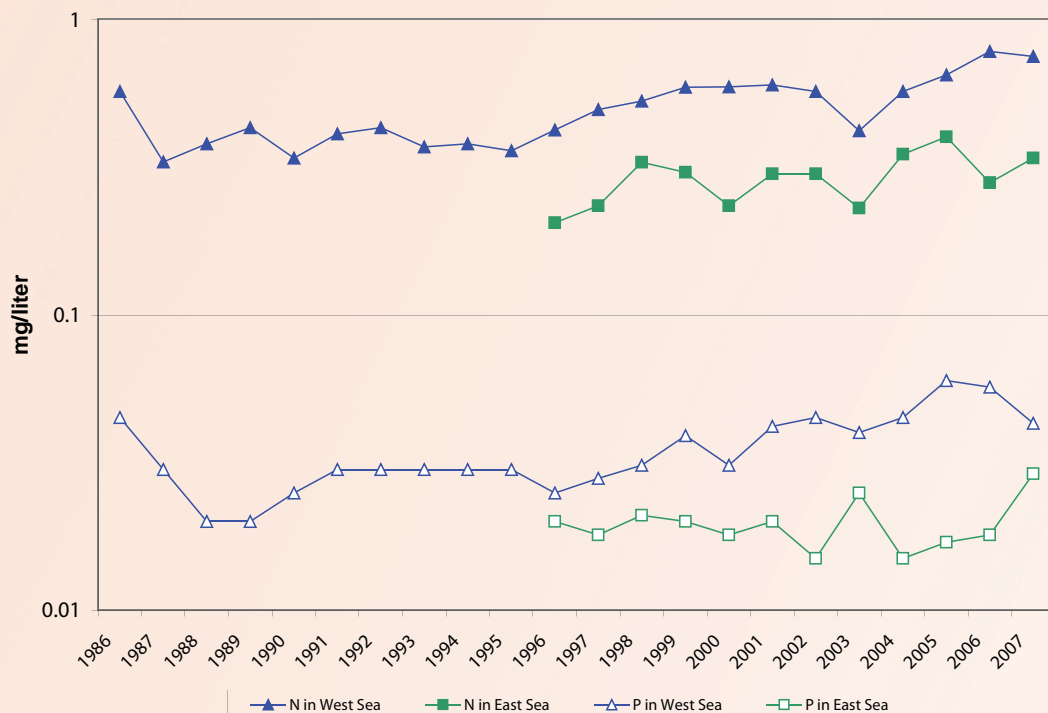
for natural processes to clean the water. It has also developed partnerships and is contributing financially to adjacent cities to reduce the influx of silt, and agricultural and other pollution into Xiamen via Jiulong River (Zhou, 2007).

Xiamen not only continues to regularly allocate effort in ICM and environmental rehabilitation to facilitate its own sustainable development. It has also become an active proponent in using and sharing these lessons beyond its borders. Xiamen has been sharing its lessons with other cities by hosting the annual Xiamen World Oceans Week and leading the PEMSEA Network of Local Governments (PEMSEA, 2009).

In the late 1980s, Xiamen aimed to be a "SEZ [Special Economic Zone] which is economically prosperous, and has advanced science and technologies, a beautiful environment, and a high degree of social civilization, and which implements certain policies of a free port" (Erjun, 1988) by 2000. In the mid-1990s, Xiamen envisioned a "socialist, modern, international, and scenic port city" by 2000. It has certainly achieved these.

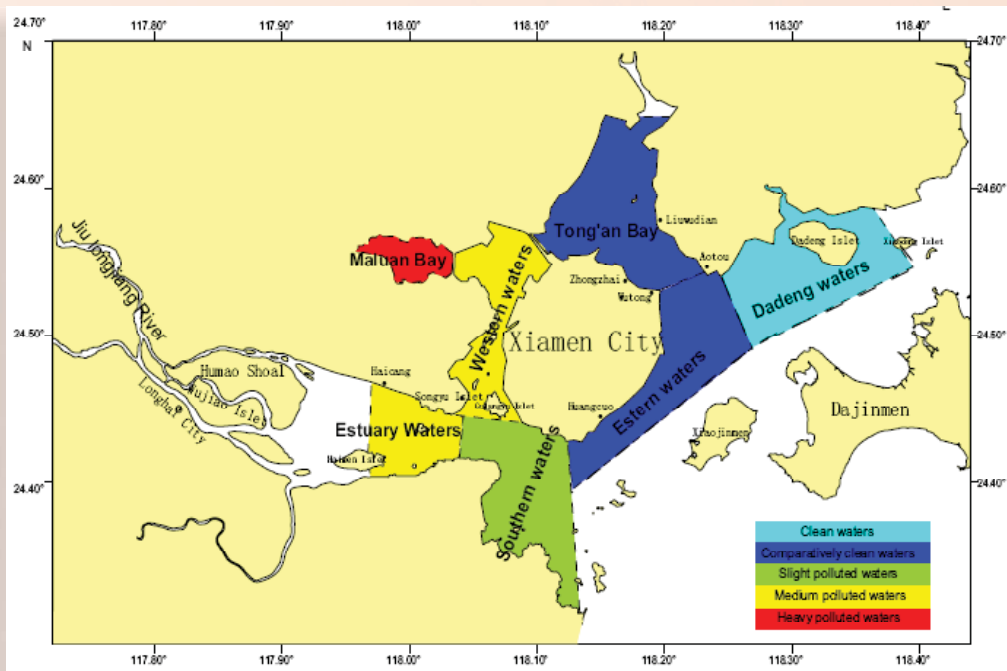
## Lessons Learned

- The socioeconomic benefits of environmental management are much higher than its costs. It can even justify billions of dollars



**Figure 4.** Nitrogen and phosphorus pollution in the East and West Seas.





**Figure 5.** Integrated assessment of seawater quality in Xiamen 2008.

of investment if used wisely. There are many means of raising revenue for and from the environment, including taking advantage of the increase of real estate value due to environmental improvements.

- To manage effectively, coastal managers have to focus on the objective and sometimes look beyond one's area and sector of jurisdiction.
- An environmental rehabilitation program must contribute to both socioeconomic development as well as sustainability priorities if it is to be relevant and sustained. It must be mainstreamed in various economic sectors to achieve those. ICM can facilitate mainstreaming.
- To help carry good policy directions through to field actions, there must be strong political will backed by a management and an effective enforcement mechanism institutionalized within the government through legislation, relevant objectives, sound scientific basis, and broad public support fostered by high public awareness.
- Larger investments are sometimes needed to repair environmental damage which has occurred as compared to the costs of simply protecting the environment early on. Moreover, human interventions can only do so much. It can still take a long time for nature to heal.



Early investments in environmental management can have unforeseen benefits such as improved robustness to climate change.

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