



Framework and practice of integrated coastal zone management in Shandong Province, China

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ABSTRACT

Integrated coastal zone management (ICZM), a modern coast management approach, provides a holistic solution to all kinds of coastal problems including geographical and political boundaries. The importance of integration in coastal management has also been recognized by coastal manager in China. In this paper, we present the ICZM framework and practices in Shandong as an example of China's ICZM on provincial level. Shandong is a coastal province in eastern China, which suffers from various coastal problems with the rapid socio-economic development in the past three decades. The framework of ICZM in Shandong, especially the legislation and administrative agencies, is described. Within this framework, the practice of ICZM, either planning or implementation, has been undertaken. It is shown that the ICZM is effective and partly solves the coastal problems. Finally, some challenges and drawbacks of current coastal zone management are also discussed.

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1. Introduction

Coastal zone are of great importance since the majority of the world's population lives not far away from the coastline (Shi et al., 2004; Communication from the Commission to the Council and European Parliament, 2000). Fubara Dagagoet al. (1984) stated that coastal zone is "the next frontier for resources exploitation for the survival of mankind". With the rapid economic development, nowadays, it is perceived that coastal zones worldwide have faced serious environmental and socio-economic problems especially in the developing countries (Chua, 1993). These problems pose a long-term threat to a sustainable development in coastal zones and strategic responses are needed. Integrated coastal zone management (ICZM) is such a concept that was proposed to manage the coastal zone using an integrated approach, regarding all aspects of the coastal zone, including geographical and political boundaries, to ensure sustainability (Clark, 1997; IOC). Compared with traditional coastal zone management, ICZM does not emphasize the needs of a single sector but takes a holistic view (Clark, 1997; Lau, 2005; Paka and Farajzadeh, 2007; Anker et al., 2004). Therefore, ICZM has drawn the general society's attention, and the framework of ICZM has also been proposed and recommended in practice (IOC; UNESCO, 2002). However, due to the diverse nature of the world's

coastline and coastal environments, it is unrealistic to count on one universal ICZM framework that is suitable for all cases. Particularly, since the regime and legislative system are different in different countries, the coastal zone management will always be unique to countries, regions and ultimately on a local scale.

As a large coastal country in Asia-Pacific region, China, having a continental coastline of 18,000 km length, also suffers from various coastal problems, such as coastal and marine pollution, habitat degradation, seawater intrusion, coastal erosion (Shi et al., 2004; Lau, 2005; Xue et al., 2004). In response to such problems, the Chinese government has made substantial progress during the last few years to implement an integrated management in order to achieve sustainable development in coastal zones. Although China's ICZM is still in its infancy, there are successful cases at local levels (Shi et al., 2004; Xue et al., 2004). Lau (2005) showed that the implementation of ICZM in China was mainly hampered by the unclear jurisdiction and irresponsibility of institutions. As matter of fact, China has no lack of laws or regulations related to coastal management. These laws are usually made on national level, and the central government can only play the role of policy-maker in coastal management (Xue et al., 2004). However, as the empirical operator, local government has no enough authority to implement an integrated coastal management. Therefore, an integrative coastal zone management on provincial level is the best choice in China. In this paper, we introduce the ICZM framework and practice in Shandong (a coastal province in China) that have partly solved the coastal problems. In addition, the drawback of current ICZM framework is also discussed.

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2. An overview of coastal zone in Shandong

2.1. General information

Shandong is located on the eastern coast of China and in the lower reaches of the Yellow River and extends out to sea in the form of the Shandong Peninsula. It covers an area of about 153.3 thousands square kilometers (Fig. 1). Shandong has a temperate climate. Summers are moist, winters dry and cold. Average temperatures are $-5-1^{\circ}\text{C}$ in January and $24-28^{\circ}\text{C}$ in July. Precipitation is 550–950 mm annually (ChinaTravelnet). The coastline of Shandong is about 3300 km in length.

As there are diverse definitions for the ‘coastal zone’ in different literatures, it is not easy to estimate an accurate value of economic and population quantities of the coastal zone in Shandong. In this paper, for convenience, the administrative boundary of the land area is adopted as the landward border of the coastal zone. There are totally 17 prefectures in Shandong and only 7 of them are contiguous to the sea (Qilunet). Hereafter, the coastal zone of Shandong is referred to as these 7 prefectures, which are Binzhou, Dongying, Weifang, Yantai, Weihai, Qingdao and Rizhao respectively. Shandong is one of the most densely inhabited areas in China and the whole province has a population of 94.45 million, and approximately 32% of them reside in the coastal zone (Xie et al., 2006). Due to the location advantage and marine traffic facility, the coastal zones in Shandong are the most rapidly developed areas.

2.2. Coastal problems

In the past three decades, the socio-economic development and urbanization in Shandong is very rapid. At the same time, many environmental problems in coastal zone have arisen. The causes of these coastal problems are either natural hazards or improper

human activities. Coastal problems have already threatened the sustainable development in Shandong. In this paper, we only list five representative coastal problems.

2.2.1. Coastal pollution

Coastal pollution, especially contamination of soil and water column, is the primary coastal problems in Shandong (Xie et al., 2006). Soil pollution is mainly caused by excessive usage of pesticides and other human-made chemicals in Shandong's coast. Marine water column pollution in Shandong is due to land-sourced pollution. The most severely polluted sea areas are semi-closed bays with exterior rivers such as Laizhou Bay and Jiaozhou Bay (Fig. 1). The transportation of land-sourced pollutant to marine water column is through rivers, urban sewage drains, and submarine groundwater discharge. It is estimated that about 2.57 billion tons wastewater was discharged into the sea in Shandong each year. The result of wastewater discharge is that 1680 km² sea area is moderately or severely polluted (Ocean and Fishery Department of Shandong Province, 2010a). The direct impact of coastal pollution is ecosystem degradation. Additionally, human health is also indirectly threatened by coastal pollution.

2.2.2. Excessive land reclamation

In Shandong, the imbalance between land supply and demand in coastal zone is remarkable. Rapid economic growth and population expansion are the major drives for land reclamation. Large-scale land reclamation can date back to the end of 1970s (Ocean and Fishery Department of Shandong Province, 2009a). The reclamation ground was firstly used as salt pans before the economic reform policy was implemented. In 1980s, a variety of small bays and lagoons were enclosed to raise shrimp or economic fish. Now, these small bays and lagoons are disappearing due to sedimentation. Since 1990, harbor/port, urban settlement, and industrial district occupy most reclaimed land. The most representative example of



Fig. 1. The coastal zone of Shandong Province and its location in China.

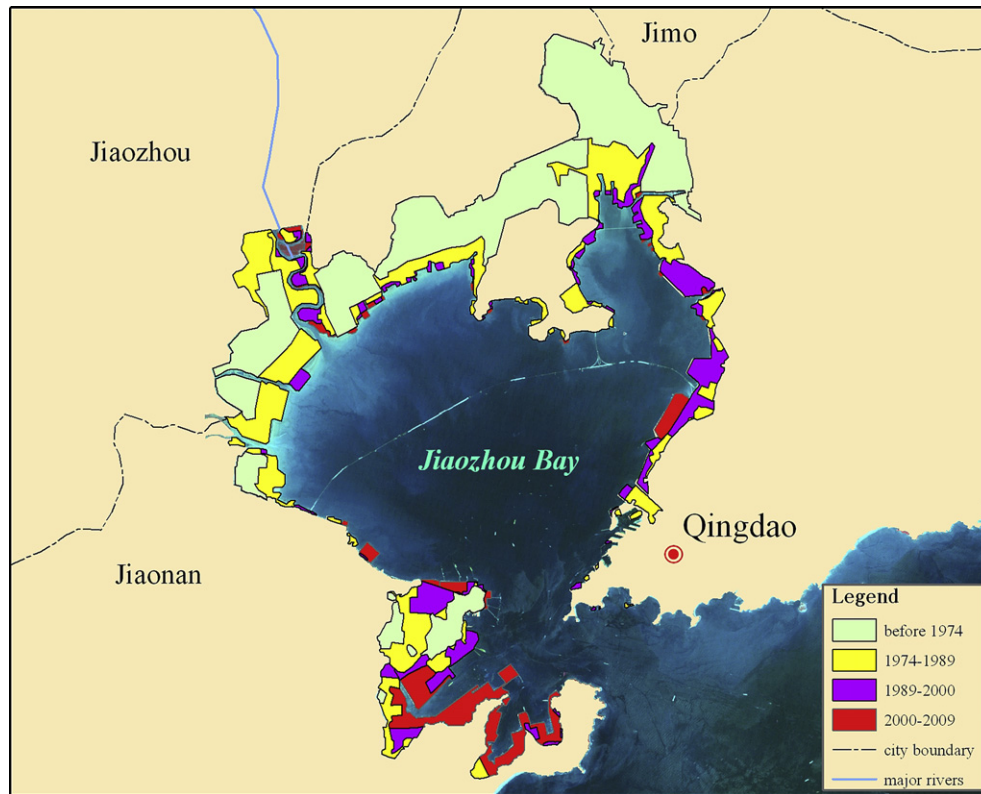


Fig. 2. Land reclamation and coastline change in Jiaozhou Bay (the second largest bays in Shandong) during the past five decades.

land reclamation is in Jiaozhou Bay, which is surrounded by Qingdao city. It is reported that the area of Jiaozhou Bay has shrunk by 35 percent – from 535 km² in 1928 to the current 367 km² (Ocean and Fishery Department of Shandong Province, 2009a). Fig. 2 shows coastline change of Jiaozhou Bay in the past five decades reflecting the history of land reclamation. Excessive land reclamation not only impacts the aesthetics coastal landscape but also results in a series of environmental problems such as habitat destruction and seawater exchange and self-purification.

2.2.3. Over fishing

People in Shandong have long relied on marine fish and fishery products as a major protein source. According to four summer bottom trawl surveys conducted between 1959 and 1998 in Bohai sea, the relative biomass (mean catch) in 1998 declined to only 4.0% of that in 1959 due to overfishing (Jin, 2004). Meanwhile, indices of species richness, diversity and evenness declined to a really low level until 1998 in Bohai sea. The Yellow sea was once one of the most intensively exploited in the world. However, nowadays, larger sized and commercially important species such as yellow croaker and hairtail is replaced by smaller-bodied and low value forage fish, such as anchovy (Tang, 1989). Overfishing is one of serious coastal problems in Shandong.

2.2.4. Seawater intrusion

In Shandong, seawater intrusion is also a serious coastal problem. It is estimated that the total area affected by seawater intrusion is 701.8 km² (Ocean and Fishery Department of Shandong Province, 2009a). Laizhou Bay is the most serious and largest seawater intrusion zone in China, and the seawater intrusion area has reached 305.9 km² (Ocean and Fishery Department of Shandong Province, 2009a). Seawater intrusion is currently one of the main causes of groundwater contamination in coastal zone.

Consequently, a series of ecological, environmental and socio-economic problems arise, such as soil salinification, coastal wetland degradation, freshwater resource shortage and high incidence rate of endemic disease (Ocean and Fishery Department of Shandong Province, 2009a). Even worse, there are more and more social conflicts incurred by the dispute for water resource and arable land between local communities in recent years. This problem has severely affected the social stability and sustainable development in Shandong Province.

2.2.5. Coastal erosion

The direct influence of coast erosion is the coastline retreat and land loss. Shandong faces a severe problem of coastal erosion (Fig. 3). There are three typical coastal profiles in Shandong: muddy



Fig. 3. Sandy coast erosion in eastern Laizhou Bay.

coast, cliff coast and sandy coast (Ocean and Fishery Department of Shandong Province, 2009a). The muddy coast is mainly located in the Yellow River delta and Laizhou Bay. The muddy coast is composed of silt–clay mixture transported by the Yellow River and other exterior rivers, therefore, it is vulnerable to wave and tidal currents. In recent years, the supply of sediments to a shoreline decreased significantly due to the regulation of rivers, i.e. the construction of dams on the Yellow River for power production and irrigation purposes, resulting in coastal erosion in this area. Moreover, extra-tropical storm surge is also the main cause of muddy coast erosion in the Yellow River delta and Laizhou Bay. The coast of Shandong Peninsula is characterized by sandy beaches and rocky cliffs. In this area, human activities such as offshore sand mining and coastal structures are the main causes of sandy coast erosion. The sandy coast in southern Shandong also faces the fate of recession, but the causes are not clear yet.

3. Framework of ICZM in Shandong Province

ICZM is a dynamic, multidisciplinary and iterative process to promote sustainable management of the coastal zones (IOC). “Integrated” in ICZM refers to the integration of all relevant policy areas, sectors, and levels of administration, and integration of the terrestrial and marine components of the target territory, in both time and space (IOC). China has implemented a new “integrated” coastal zone management policy since the early 1990s to manage coastal resources and control environmental pollution for sustainable development (Lau, 2005). Over the past 20 years, a great progress has been achieved in the framework and practice of ICZM in China. Due to the political structure of China, provincial level is considered to be the optimal level to implement ICZM. As a demonstration, ICZM in Shandong is considered to be one of the successful ICZMs on provincial level in China. In this section, we will demonstrate how ICZM is implemented in Shandong.

3.1. Legislation and policies

In China, there are a number of laws, either national or provincial, specifically regulate sea-based and coastal activities, e.g. harbors, fishery and tourism (Ocean and Fishery Department of Shandong Province, 2009a). The national laws certainly take the prior than local regulations. Accompanying with the establishment and consummation of legal system, there are more and more comprehensive laws and regulations rather than concerning only a limited extent of coastal management. These national laws and regulations almost cover all aspects of coastal zone management ranging from natural resources to human activities. Table 1 gives an overall picture of the major laws and regulations related to coastal zone in China (Shandong is undoubtedly included). In particular, the “Law of Sea Area Use Management” and “Law of Marine Island Protection” are enacted to strength integration in coastal zone management. In China, the laws must be made and approved by the National Congress. But the provincial people's congress can also make and approve provisions that are only available within the province. To promote the integration in coastal zone management, Shandong promulgated “Provisions on Sea Areas Administration” and “Marine environment protection regulation of Shandong Province” as complementarities of national laws (Table 1).

In China, sustainable development is a state strategy. Shandong also effectively implements this strategy in coastal zone management and makes policies to reduce energy consumption including energy conservation, energy efficiency improvement, development and utilization of solar energy and wind energy, etc. In coastal zones, economic structure is first adjusted and optimized. Traditional raw material industries are not supported, but hi-tech

Table 1

The national and provincial laws (regulations) related to the coastal zone management.

Law/Regulations	Year	Level
Law of Territorial Sea and the Contiguous Zone	1992	National
Law of the Exclusive Economic Zone and Continental Shelf	1998	National
Law of Sea Area Use Management	2001	National
Law of Land Administration	1997	National
Law of Marine Island Protection	2009	National
Law of Fisheries	1986	National
Law of Maritime Traffic Safety	1983	National
Regulations of River Navigation Administration	1987	National
Law of Water	1988	National
	2002	
Law on Prevention and Control of Water Pollution	1984	National
	2008	
Law of Forest	1998	National
Law of Wildlife Protection	2004	National
Law of Mineral Resources	1986	National
Provisions on Sea Areas Administration	1998	Provincial
Marine environment protection Regulation of Shandong Province	2004	Provincial

industries that are energy-saving are encouraged. In order to eliminate irregular land reclamation, Shandong provincial government requests that land reclamation must be undertaken in a concentrative and intensive way, while widespread and small-scale land reclamation projects are ceased (Ocean and Fishery Department of Shandong Province, 2009b). Moreover, the planar structure of newly reclaimed land, such as artificial islands, is also optimized to minimize its negative effect on marine environment.

3.2. Institutions and responsibilities

The institutions that participate in ICZM include governmental agencies, independent assessment institutions, advisory committees and some support groups. The governmental agencies dominate the integrated coastal management and play the role of administrator and organizer. The assessment institutions are authorized by government and the advisory committees consist of experts of environmental sciences, social sciences, economics from research institutions and universities. The support groups usually provide advices and collect data for decision-making.

We first introduce the governmental agencies that participate in ICZM on the national level. Although China has drawn up many laws regarding to ocean and coast management, there is no specific agency or institution that is responsible for all aspect of ICZM on the national level. The authority of ICZM has been subdivided into different agencies, which are all subordinated to the State Council (also referred to as Chinese Central Government). The State Oceanic Administration (SOA) was established in 1964 and subordinated to the Ministry of Land and Resources (MLR). SOA is the leading agency for coastal zone management, because the emphasis of its jurisdiction is on the whole country's marine zone (Lau, 2005). Other agencies include Ministry of Water Resources (MWR), Ministry of Housing and Urban–Rural Development (MOHURD), National Tourism Administration (NTA), Maritime Safety Administration (MSA, subordinated to Ministry of Transportation), Ministry of Agriculture (MOA), National Bureau of Forestry (NBF), and Ministry of Environmental Protection (MEP). The obligations of these national agencies are to make guidance and standards for coastal management on the national level and coordinate inter-provincial ICZM issues.

Governmental agencies on provincial/local level take more responsibility to coastal management, and ICZM is usually implemented on provincial level in China. Although there is no newly established agency to undertake the mission of ICZM in Shandong

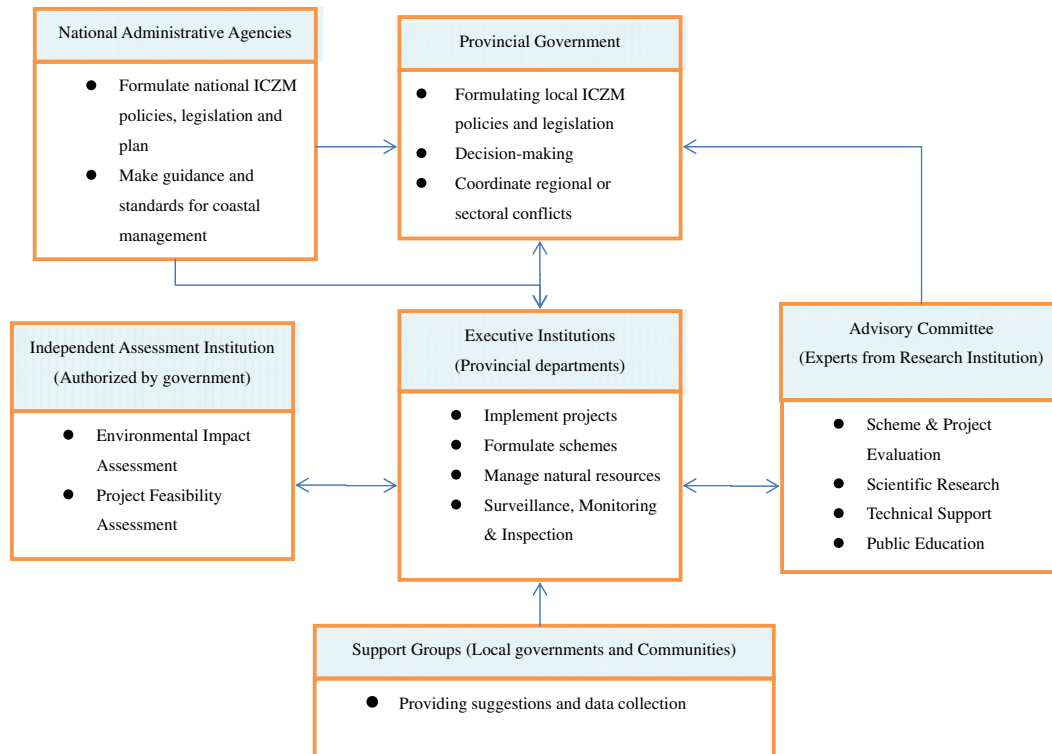


Fig. 4. Participants those are responsible to ICZM in Shandong and their basic responsibility.

Province, various sectors have been bundled together under the leadership of the provincial government that plays the role of coordinator and decision maker. The provincial departments, which work under the double leadership of provincial government and national ministries, undertake the tasks of all aspects of ICZM. The directors of provincial departments are nominated by the governor and approved by the provincial people's congress. In other words, provincial departments are also sections of the provincial government. But there is no one-to-one correspondence between the provincial departments and national ministries. The governmental agencies that are responsible for coastal zone management and their major responsibilities are demonstrated in Fig. 4.

The assessment institutions are responsible for Environmental impact assessment (EIA) and Feasibility assessment (FA) of all kind of projects ranging from engineering to scientific research. These institutions are authorized by government, and the engineers must be certified by the national ministries such SOA, or MEP. The advisory committee is either temporary or permanent institution depending on the task that they undertake. Some permanent advisory committee may provide proposals to ICZM administrative agencies based on the research. But some temporary advisory committee consists of experts who are randomly nominated for evaluating the schemes or projects. For ICZM on provincial level, lower level governments and local communities merely play the role of supporters. Their responsibility is to provide advices and collect data to the executive institutions.

4. Practice of coastal zone management

The practice of integrated coastal zone management in Shandong include formulating schemes for allocating coastal space, controlling land-sourced pollution and improving marine environment, and restoring degraded ecosystems etc. All these

practices aim to solve the current coastal problems in Shandong within the framework of ICZM (Table 2).

4.1. Integrated spatial planning

Spatial planning is an essential tool for managing the land use. Comprehensive land-use planning has been commonly considered

Table 2

The coastal problem and countermeasures within the framework of ICAM in Shandong.

Coastal problems in Shandong	Response and practice
Coastal pollution	<ul style="list-style-type: none"> coastal zone land-use planning; <p>Integrated watershed management</p> <ul style="list-style-type: none"> controlling the land-sourced pollution; restricting near-shore mariculture to improve marine water quality; dismantle illegal infrastructures that affect the water exchange;
Excessive land reclamation	<ul style="list-style-type: none"> marine functional zoning; coast protection and utilization planning; coastal zone land-use planning; port and harbor planning; sea area management system; video monitoring system of sea area;
Overfishing	<ul style="list-style-type: none"> setting fishing ban period and the stock enhancement; building artificial reef and planting sea-grass to restore the seabed habitat;
Seawater intrusion	<p>Integrated watershed management</p> <ul style="list-style-type: none"> adaption to seawater intrusion;
Coastal erosion	<ul style="list-style-type: none"> increase sediment transport and freshwater discharge; rehabbing damaged seawall and jetty; artificial beach nourishment; geological heritage protection (including lagoon and marine abrasion landform)

as a central component of developmental and environmental planning in terrestrial areas (Gangai and Ramachandran, 2010). To manage the multi-use of marine and coastal space, integrated spatial planning has also been applied in ICZM. The integrated spatial planning in Shandong aims to coordinate the conflicts caused by land or sea use including both spatial zoning and sectoral development planning. With this spatial planning programme, all sea area, coastline and coastal land in Shandong are allocated for utilization or protection. Integrated spatial planning is a measure to implement ecosystem-based coastal management.

4.1.1. Marine functional zoning

To regulate and guide rational use of the sea area, the system of marine functional zoning was established, under which the sea is divided into different types of functional zones (Xue et al., 2004; SOA, 2002). Any use of sea areas must comply with the marine functional zoning scheme. In other word, marine functional zoning scheme is the legal basis of the management of sea use and marine protection. The formulation of the marine functional zoning is based on five principles: 1) the functions of the zoned sea area must be in accordance with the natural attributes such as the geographical locations, natural resources and natural environment; 2) the arrangement of functional zones must balance the needs of various sectors such as aquaculture, transportation, tourism and salt industry; 3) the sea area must be utilized in a sustainable fashion and the marine environment must be protected; 4) the maritime traffic safety must be ensured; and 5) the sea use cannot affect the state security and national defense. Managing the sea area based on marine functional zoning is a new and important measure to strengthen integrated coastal management in China. The aim of marine functional zoning is to promote rational development and sustainable utilization of marine areas.

According to the law of sea use management of China, the national marine functional zoning scheme was firstly formulated. The categories of basic marine functional zones are listed in Table 3. Based on the national marine functional zoning scheme, local governments will refine their own marine functional zoning scheme. The local marine functional zoning schemes should be reviewed and approved by local governments. Shandong's marine functional zoning scheme was firstly approved and put into force in 2001. To satisfy the needs of rapid economic and social development, the marine functional zoning scheme on provincial level is rectified every five or six years. The second revision of marine functional zoning is ongoing. The basic procedures of formulation and revision of marine functional zoning scheme on provincial level are demonstrated in Fig. 5.

4.1.2. Coast protection and utilization planning

According to 'National Maritime Development Programme 2008', SOA decided to formulate a scheme about the protection and

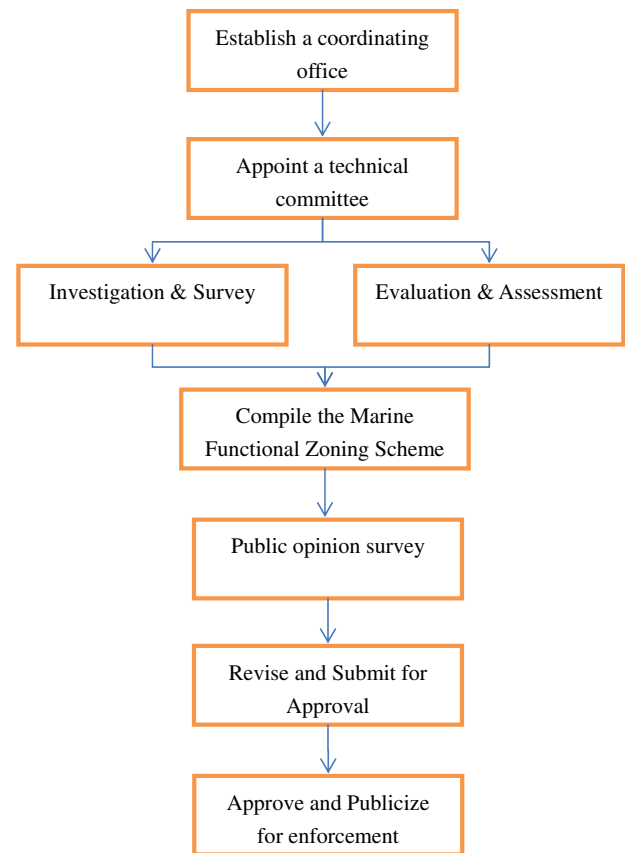


Fig. 5. The basic procedures of formulation and revision of marine functional zoning scheme.

utilization of coast/coastline on provincial levels as a response to coastal problems such as excessive land reclamation and coastal erosion (SOA). In 2009, Shandong Province began to compile 'coast protection and utilization scheme', in which the coast is categorized into 8 types and the coastline is divided into segments of different types. In this scheme, activities that alter the natural attributes of the coastline such as sea filling and reclamation are strictly controlled. Then natural coastline can be protected from occupation by artificial infrastructures after the implementation of the coast protection and utilization scheme. The 'coast protection and utilization scheme' is considered to be the counterpart of 'Marine functional zoning scheme'. The utilization of coastline should be compatible with that of the adjacent marine functional zone. The correspondence between marine functional zone and coastline subsection is illustrated in Table 3. The compilation of coast protection and utilization plan is completed and submitted to provincial government for approval (Ocean and Fishery Department of Shandong Province, 2010b).

4.1.3. Coastal zone land-use planning

Coastal zone land-use planning is an essential element of coastal spatial planning within the framework of integrated management of coastal zone. Its purpose is to allocate the limited land resources to different departments allowing for orderly and well-planned urban development and the sitting of coastal-dependent and coastal related industry, on the promise that coastal environment is sufficiently protected (Stewart et al., 2003; North Carolina Division of Coastal Management, 2002). Shandong Province assigned "Chinese Academy of Urban Planning & Design" to complete the coastal zone land-use plan for Shandong Province. In 2006, the

Table 3
The categories of Marine functional zoning and Coast Protection & Utilization Plan.

Marine functional zoning	Coast Protection & Utilization Plan
Marine transportation Zone (Harbor, Sea-route, Anchorage)	Port/Harbor
Industrial and Urban Settlement Zone	Urban/Rural Settlements
Mineral and Energy Zone (Oil/Gas/Coal/Salty Water/Renewable Energy)	Salt plan
Agriculture/Fishery/Mariculture Zone	Fishery/Aquaculture Reclamation (Agriculture)
Recreation/Tourism Zone	Recreation/Tourism
Marine Protection Area/Conservation Zone	Protection/Conservation
Special Utilized Zone (Military, Scientific Research)	Special Utilization

provincial government approved the coastal land-use planning, which was made up of coastal land zoning, urban/town planning and regional development planning.

First, the farmland is strictly protected from urban construction, but cultivating new farmland is also prohibited. Vegetation in headwater area of rivers is also protected to reduce soil erosion. The sprawl of megacities is restricted in coastal zone, but the developments of small cities/towns are encouraged. The allocation of coastal land among urban infrastructure, industry, agriculture and tourism is also included in this planning. The ultimate objective of coastal land-use planning is to solve the problem of land-use conflicts.

4.1.4. Marine protected area planning

Marine protected areas (MPAs) play a key role in protecting marine biodiversity and the sustainable utilization of marine resources (Qiu et al., 2009). The Chinese government has always attached great importance to marine environmental protection. There are three types of marine protected areas in China: marine nature reserve, marine special reserve, natural marine parks and aquatic germplasm reserve.

Marine nature reserves are only reserved for study or research. But activities that do not alter the natural attributes are allowed in marine special protected areas such as tourism and recreations. Currently, there are 34 MPAs (Fig. 6) in Shandong and this number will increase to 100 by 2020. In order to designate and manage the MPAs well, Shandong Province also formulated a scheme for MPAs within the framework of ICZM. Shandong has made a time table to designate and upgrade 58 MPAs by the end of 2020, and 95% of important marine and coastal ecosystems will be covered (Ocean and Fishery Department of Shandong Province, 2010c). Special funds from national and provincial governments are located for daily operation and management of these MPAs. The responsibilities of the administrative agencies of MPAs include surveillance and monitoring.

4.1.5. Port and Harbor planning

The Port and Harbor planning is also an important part of integrated spatial planning in coastal zone. Currently, Shandong has 6 large ports, with an annual throughput capacity exceeding 400 million tons (Transportation Department of Shandong Province, 2006). However, the shipping ability of contemporary port/harbor cannot meet the requirement of rapid economic development yet. Therefore, Shandong plans to extend 15 wharfs and newly construct 2 modern ports in the next five years. However, ports or harbors will occupy more natural coastline and bring potential environmental risk such as oil or chemical liquid spill. That will harm the public interest. Moreover, sea-route and anchorage will also take up more sea area that will influence marine fishery and mariculture. To balance potential competing uses of sea area and coastline, Shandong Province has also accomplished a port and harbor planning, which mainly includes the spatial distribution and construction plan of all ports in Shandong. The provincial department of transportation is the leading institution accomplishing the port and harbor planning. With this plan, the disordered competition among coastal prefectures for shipping has been avoided. In addition, the environmental impacts of harbor constructions are assessed by an independent institution so that the marine environment in adjacent areas is not affected.

4.2. Informative management and joint law enforcement

Shandong has established an informative management system for coastal land and sea area management. All applications and licensing of land or sea area use can be completed through these management systems. Moreover, Shandong is now building the video monitoring system of sea area so that illegal activities during sea area use can be detected immediately. With these management and monitoring systems, the efficiency of land and sea area management can be significantly improved. Other regular work of ICZM is also completed with the aid of information systems and

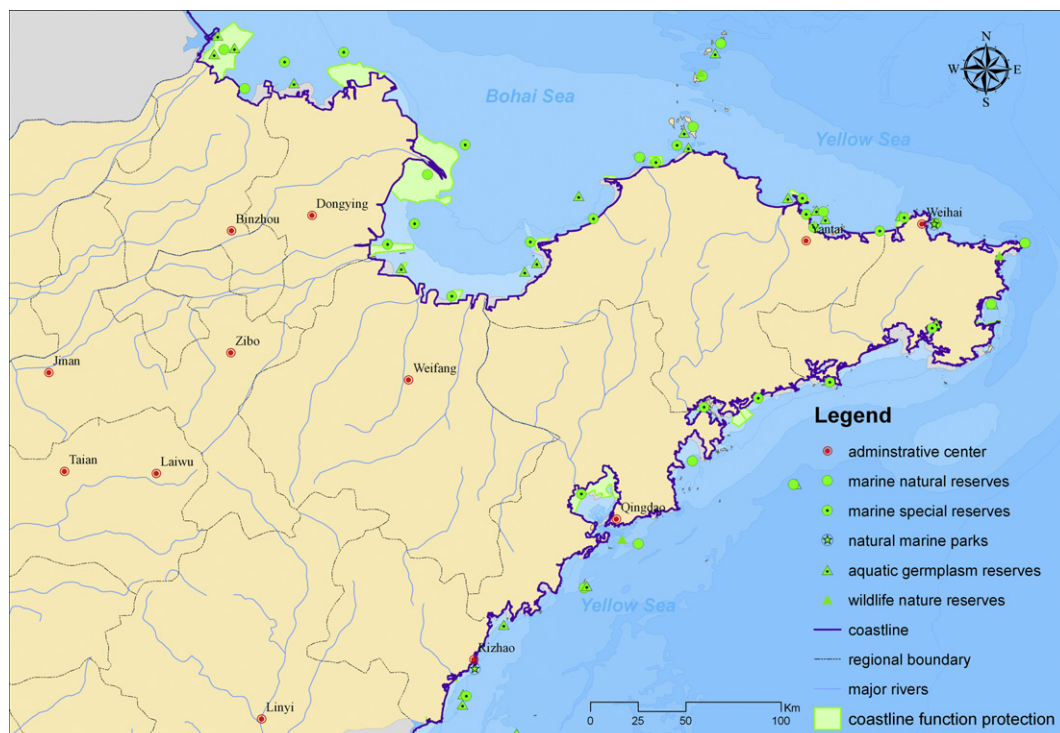


Fig. 6. The spatial distributions of Marine Protected Areas in Shandong.

technology. For example, the data collection in marine environment monitoring and coastal disaster forecasting are automatically recorded and processed.

In order to resolve environmental problems in coastal zone, laws and regulations are usually enforced jointly. The departments that participate in joint law enforcement include Land Administration, Environmental Protection, Sea Surveillance, Fishery Administration, Maritime Safety etc. The joint law enforcement is coordinated by the provincial government within the framework of ICZM. By cross-sectoral law enforcement, many illegal activities such as sand mining and illegal fishing have been thoroughly prohibited.

4.3. Integrated watershed management

Since most rivers cover many man-made administrative divisions and the natural integrity of watershed, integrated watershed management is the primary choice (Shi and Bi, 2007). The objective of integrated watershed management in Shandong includes: controlling the land-sourced pollution; controlling sediment transport and freshwater discharge; and adaption to seawater intrusion.

The most representative and successful example of integrated watershed management in Shandong is the 'Xiaqinghe River Integrated Renovation Programme'. Xiaqinghe River rises in Jinnan, the capital prefecture of Shandong Province, flows through three prefectures, and drains into the Bohai sea (Fig. 1). Xiaqinghe River used to be severely polluted since a lot of untreated agricultural and industrial sewage water was directly discharged. In agricultural system, the excessive usage of fertilizer and pesticide are restricted now. In civil living, phosphorus-containing detergent was fully prohibited to reduce marine eutrophication. In industry, all obsolete and polluting enterprises were closed or upgraded. Any entity that violates the provision will be fined. In public management, many sewage processing plants have also been constructed

and put into service. Currently, the water quality of Xiaqinghe River has been improved remarkably.

The Yellow River has an international reputation as a flood-prone river with too much silt (YellowriverNet). However, the main stream of the Yellow River usually stopped flowing in 1990s resulting in decreased sediment transport. Thus, the coast around the inlet of Yellow River is subject to coastal erosion and ecosystem function in the delta wetland was severely affected. In 2000, the Chinese government established 'Yellow River Water Conservancy Committee' that was designated to manage the whole Yellow River. Through controlling the water flow, the quantity of silt and freshwater that is discharged into Bohai sea is guaranteed. Then the erosion of Yellow River estuary is reduced and the ecosystem function of the wetland has recovered (Zuo et al., 2006).

The response to seawater intrusion is not successful, and the adaption to seawater intrusion in Shandong is more or less passive. Because the scientific research of seawater intrusion is not adequate, then people can hardly find an effective engineering measure to reduce seawater intrusion. The adaption measures include water-saving and water-transferring.

4.4. Marine ecosystem restoration and coast protection initiative

Because the pressures on marine ecosystem are from many aspects, then marine ecosystem restoration and coast protection are likely to require unique collaboration among managers, scientists, and other stakeholders. In particular, synthetic measures must be undertaken. In 2010, Shandong started an initiative marine ecosystem restoration and coast protection. It aims to restore the degraded coastal and marine habitats and ecosystems, and to protect the eroded coastline. The investment was from national, provincial and local governments. The first 3 pilot projects have already been completed by the end of 2011, and the second 15 projects were initiated in 2012. For marine ecosystem restoration, the measures include:

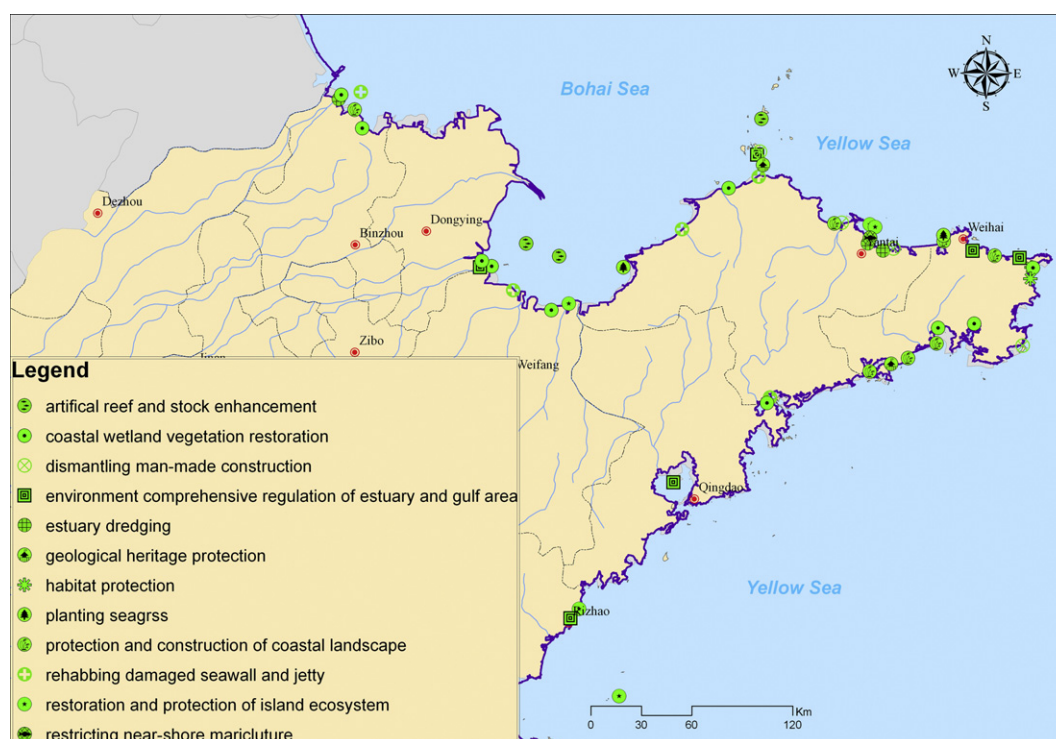


Fig. 7. The locations of marine ecosystem restoration & coast protection projects.

- Restoring fish populations through setting fishing ban period and the stock enhancement;
- Building artificial reef and planting sea-grass to restore the seabed habitat;
- Restricting near-shore mariculture to improve marine water quality;
- Dismantle illegal infrastructures that affect the water exchange;
- Restoring wetland vegetation;
- Restoring estuary function by dredging.

For coast protection projects, the engineering measures include:

- Rehabbing damaged seawall and jetty;
- Artificial beach nourishment;
- Geological heritage protection (including lagoon and marine abrasion landform).

Shandong will complete these projects by the end of 2015. The locations of these marine ecosystem restoration and coast protection are shown in Fig. 7.

5. Conclusion and discussion

As a coastal province of China, Shandong has encountered many coastal problems during the last three decades. However, these coastal problems were not fully recognized until these problems brought troubles to people living in the coastal zone. Facing these problems, actions were undertaken in a sectoral way to solve the coastal problems at first. However, it is finally realized that these actions did not work well in alleviating the environmental and social stress. Then, the provincial government has to resort to integrated management instead the sectoral management to solve coastal problems. Although it is not a long time since the concept of ICZM is recognized by decision-makers in China, its importance and effectiveness have been realized and accepted. Both the national and regional governments started to manage China's coastal zone in an integrated way currently. In this paper, we have merely introduced the framework and practice of ICZM in Shandong Province and the coastal zone management experience is most representative of China's coastal management. The experience of coastal zone management in Shandong deserves to be expanded to other areas in China.

The framework of Shandong's ICZM is nothing special compared with that of other provinces. There is no newly established agency yet. However, as long as the practice of ICZM, Shandong is in the forefront in China. From spatial planning to implementation, Shandong has made great effort to improve the "integration level" in coastal zone management. However, there also exist some challenges within the current ICZM framework. In this study, we will outline five drawbacks of the current ICZM framework on provincial level.

- (1) The coordination mechanism does not always work well. Especially, the inter-provincial conflicts and personal conflicts are not included within the current ICZM framework. This drawback is due to the ICZM framework itself. Because the current framework is on provincial level, then it emphasizes the interest of the province but neglects the conflicts on higher or lower levels. Therefore, adding more coordination mechanisms to the provincial ICZM framework is necessary.
- (2) Land-sourced pollution is not effectively controlled. As the results of urban expansion and low-tech agriculture in coastal zone, the control of non-point pollutions remains a challenge task. There is room for improvement of coastal and marine

environment. The countermeasures include upgrading industrial technologies, changing the current agricultural production mode, and consummating urban garbage recycling and sewage treatment system.

- (3) The preparation for emergent environmental incidents, such as oil spill and harmful algal blooms, is not satisfactory. Taking oil spill incidents as an example, the tracking of perpetrators, the identification of stakeholders, and the compensation standards are not well presented in the current ICZM framework.
- (4) The potential impact of global climate change on coastal zone is not fully considered. For example, the risk caused by global warming and sea-level rise is not properly assessed for coastal engineering. Expanding the scope of current EIA to adequately assess the long-term impact is one possible solution (Lau, 2006).
- (5) Public participation is lack. The institutional organization of current ICZM framework does not benefit local residents to participate in planning and decision-making. Their interest cannot be effectively defended in the face of powerful coast managers. This is also the common problem of top-down management system. Exploring more ways besides public hearing that permit local residents to participate in ICZM is also needed.

ICZM is the unique solution to achieve sustainable development in coastal zone. The ultimate objective of coastal management in Shandong is to create a harmonized development environment, but there is a long way to go in future.

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References

- Anker, H.T., Nellemann, V., Sverdrup-Jesen, S., 2004. Coastal zone management in Denmark: ways and means for further integration. *Ocean & Coastal Management* 47, 495–513.
- ChinaTravelNet. www.chinatravel.net/china-destinations/shandong/provinceintroduction-27.html. (in Chinese).
- Chua, T.-E., 1993. Essential elements of integrated coastal zone management. *Ocean & Coastal Management* 21, 81–108.
- Clark, J.R., 1997. Coastal management for the new century. *Ocean & Coastal Management* 37 (2), 191–216.
- Communication from the Commission to the Council and European Parliament, 2000. On Integrated Coastal Zone Management: a Strategy for Europe.
- Fubara Dagago, M.D., Bell-Gam, W.I., Alabo Evans, H., 1984. Physical description and management of Nigerian coastal and offshore environment. Technical Paper: Institute of Flood, Erosion, Reclamation and Transportation. University of Science and Technology, Port Harcourt.
- Gangai, Irene Preeti Divien, Ramachandran, S., 2010. The role of spatial planning in coastal management — a case study of Tuticorin coast (India). *Land Use Policy* 27, 518–534.
- IOC. Steps and Tools Towards Integrated Coastal Area Management, vol. 2, Manuals and Guides, No. 24.
- Jin, X., 2004. Long-term changes in fish community structure in the Bohai Sea, China. *Estuarine, Coastal and Shelf Science* 59, 163–171.
- Lau, M., 2005. Integrated coastal zone management in the People's Republic of China — an assessment of structural impacts on decision-making processes. *Ocean & Coastal Management* 48, 115–159.
- Lau, M., 2006. Adaptation to sea-level rise in the People's Republic of China — assessing the institutional dimension of alternative organizational framework. In: 'Decision-making in Relation to Climate and Climate Change in the People's Republic of China: from Adaptation to Sea-level Rise to Destination Choice in Chinese Tourism'. PhD Dissertation, Universität Hamburg, pp. 52–78.
- North Carolina Division of Coastal Management, 2002. Technical Manual for Coastal Land Use Planning.

- Ocean and Fishery Department of Shandong Province, 2009a. Marine Condition of Shandong (in Chinese).
- Ocean and Fishery Department of Shandong Province, 2009b. The Development Plan of Blue Economy in Shandong Peninsula (in Chinese).
- Ocean and Fishery Department of Shandong Province, 2010a. Marine Environment Quality Communique of Shandong.
- Ocean and Fishery Department of Shandong Province, 2010b. Coast Protection and Utilization Plan of Shandong (in Chinese).
- Ocean and Fishery Department of Shandong Province, 2010c. The Marine and Fishery Protected Area Plan of Shandong (in Chinese).
- Paka, A., Farajzadeh, M., 2007. Iran's integrated coastal management plan: Persian Gulf, Oman Sea, and southern Caspian Sea coastlines. *Ocean & Coastal Management* 50, 754–773.
- Qilunet. www.news.iqilu.com/shandong/shandonggedi/20091231/153700.html. (in Chinese).
- Qiu, W., Wang, B., Jones, P.J.S., Axmacher, J.C., 2009. Challenges in developing China's marine protected area system. *Marine Policy* 33, 599–605.
- Shi, Z., Bi, L., 2007. Trans-jurisdictional river basin water pollution management and cooperation in china: case study of Jiangsu/Zhejiang Province in comparative global context. *China Population, Resources and Environment* 17 (3), 3–9.
- Shi, C., Hutchinson, S.M., Xu, S., 2004. Evaluation of coastal zone sustainability: an integrated approach applied in Shanghai Municipality and Chong Ming Island. *Ocean & Coastal Management* 71, 335–344.
- SOA, 2002. National Marine Functional Zoning Plan. SOA, Beijing (in Chinese).
- SOA. www.soa.gov.cn/hyjww/zwgknew/zcfg/webinfo/2008/05/1210062818407961.htm. (in Chinese).
- Stewart, P.L., Rutherford, R.J., Levy, H.A., Jackson, J.M., 2003. A Guide to Land Use Planning in Coastal Areas of the Maritime Provinces.
- Tang, Q., 1989. Changes in the biomass of the Yellow Sea ecosystem. In: Sherman, Kenneth, Alexander, Lewis M. (Eds.), *Biomass Yields and Geography of Large Marine Ecosystems*. AAAS Selected Symposium, vol. 111. Westview Press, Boulder, pp. 7–35.
- Transportation Department of Shandong Province, 2006. The Port and Harbor Plan of Shandong (in Chinese).
- UNESCO, 2002. UNDP. Guidelines for Integrated Management of Coastal and Marine Areas, with Special Reference to the Mediterranean Basin. In: *UNEP Regional Seas Reports and Studies*, vol. 161. Nairobi.
- Xie, E., Wei, Y., Gao, X., 2006. Marine environment monitoring in Shandong Province: state and policy, unpublished data.
- Xue, X.Z., Hong, H.S., Charles, A.T., 2004. Cumulative environmental impacts and integrated coastal zone management: the case of Xiamen, China. *Journal of Environmental Management* 71, 271–283.
- YellowriverNet. <http://www.yellowriver.gov.cn/>.
- Zuo, S., Li, J.F., Chen, S., Shi, L.Q., 2006. Study of delta coastal erosion and protection engineering measures in China-taking the Yellow River delta and the Yangtze River delta as examples. *The Chinese Journal of Geological Hazard and Control* 17 (4), 77–82 (in Chinese).