

Achieving Sustainable Development of Chongming Island, China

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Abstract

As the world's largest alluvial island, Chongming Island of China owns unparalleled ecological values. Nevertheless, the inherent vulnerability, as well as the conflicts between social & economic development and environmental conservation, must be paid keen attention to. This paper discusses promising pathways that could lead Chongming Island toward sustainable development, and in-depth elucidation is provided from the perspectives of ecological planning, water management and low-carbon society. In certain sections, it also features advanced experiences and technologies of Japan, from which Chongming Island could benefit. The result is considered a useful reference for the relevant decision/policy makers, and contributes to the realization of the 'eco-island' notion in Chongming Island.

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Introduction

The concept of sustainable development has been come up with for quite a few decades, which is defined as "development that meets the need of the present generation without compromising the ability of future generations to meet their own need" (WCED, 1987). Ever since then, it has been reminding human beings to regulate our behaviors, so that the social and economic progress could be achieved simultaneously with environmental conservation. In fact, the sustainable society contains three aspects, i.e., low-carbon society (specific focus of Section 4 of this paper), society in harmony with nature, and society with sound material cycle (Nakagami, 2010).

Regarding how to put the notion of sustainable development into practice, here a Chinese island, Chongming Island, is selected as study area. It is actually the largest alluvial island in the world, and under the administration of Shanghai city, the economic center of China. Since the beginning of this century, the Chinese central government and Shanghai municipal government have been taking substantial actions, aiming at building Chongming Island an 'eco-island'.

Like all the islands on the earth, the sustainable development of Chongming Island could be handicapped by limited physical range, ecological distinctiveness and vulnerability, limited storage of terrestrial natural resources, susceptibility to natural disasters and so on (Ghina, 2003; Huang et al., 2008). Moreover, compared to these influences mainly caused by natural factors, anthropogenic activities have far bigger impact. Once it goes wrong, the sustainable future of Chongming Island could be in suspense.

In this study, we discuss the promising pathways that could lead Chongming Island toward sustainable development. In-depth elucidation is made from the aspects of ecological planning, water management and low-carbon society. In certain sections, it also features Japan as a model, as Chongming could benefit from some advanced experiences and technologies of Japan. This paper is considered a useful reference for the relevant decision/policy makers, and contributes to the establishment of Chongming Island as an eco-island.

1. The Environment and Development of Chongming Island

Chongming Island is located at the lowest point downstream of Yangtze (Changji-ang) River, between $121^{\circ} 09' - 121^{\circ} 54'$ East and $31^{\circ} 27' - 31^{\circ} 51'$ North. As it lies right on the mouth of Yangtze River and faces the East China Sea (Western Pacific Ocean), the water of Yangtze River bypasses Chongming Island from its northern and southern coastlines. Shanghai city, the thriving economic center of China, is situated at the opposite side of the southern Yangtze River branch (Figure 1). Since 1958, the government of Shanghai municipality has been taking the administrative role of Chongming Island (County). Being the world's biggest alluvial island, Chongming Island covers an area over 1200 km^2 , and is still expanding by approximately 500 ha per year due to the deposition of water-borne sediments of Yangtze River (Ni et al., 2012). As the local climate is of subtropical and oceanic types, Chongming Island enjoys moderate temperature (annual average: 15°C), plenty of precipitation (annual average: 1025 mm) and distinct four seasons throughout a year.

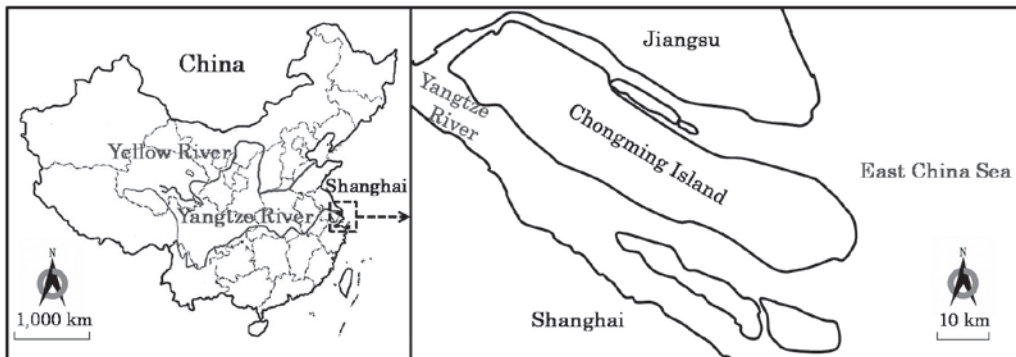


Figure 1 The location of Chongming Island

In terms of eco-environmental circumstance, Chongming Island is characterized by agro-ecosystems and natural wetlands. Agro-ecosystems dominate the land use of the entire island, and hence Chongming County becomes one of the most important suppliers of agricultural products for Shanghai residents. Natural wetlands widely exist in this island, especially along the coastlines. These estuarine and coastal wetlands provide valuable ecosystem services, such as shoreline defense, water conservation and purification, fishery resources, recreational site, etc. Among all the natural wetlands, Dongtan (Eastern Beach) wetland draws most attention worldwide. It is a fertile place owning large amount of aquatic animals of high economic value. It also functions as an indispensable staging and wintering habitat for Asia-Australia migra-

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tory birds, as well as an important spawning and feeding ground for 63 species of fish. On 2002, Chongming Dongtan Nature Reserve was officially adopted into Ramsar Convention as Wetlands of International Importance (rsis.ramsar.org/ris/1144).

Regarding the socio-economic condition of Chongming Island, for quite a long period of time, the local people have not profited much from the booming economy of Shanghai, and the secondary and tertiary industries have not left a significant mark on it (Yuan et al., 2003; Wang et al., 2005). Geographically, Chongming Island is surrounded and isolated by the water of Yangtze River, and the consequent traffic inconvenience explains its relatively slow development in the past. This problem was finally solved in 2009 when the Shanghai Yangtze River Bridge (including bridge and tunnel) was completed. Because of the improvement of accessibility, however, a considerable number of young residents move house to or work at Shanghai city for earning a better life, which results in a loss of local labor force to a certain extent. Currently there is about 700,000 total population on Chongming Island, approximately 75% of who are involved in agricultural sector (Huang et al., 2008). As the last 'clean' space in Yangtze River Delta, tourism is another source of income for Chongming Island, which is becoming increasingly significant.

In the history of its development, Chongming was once on a very dangerous road. Till the end of 20th century, there has never been any effective master plan proposed by either the local government or Shanghai municipal government. Certain wrong actions and inappropriate behaviors drastically degraded the ecological value of Chongming Island (Zhao et al., 2004; Huang et al., 2008). Fortunately, the advent of 21st century means a turning point. Complying with the Chinese central government's instructions of building Chongming Island a national ecological demonstration zone, Shanghai municipal government adopts some advanced notions and determines to build Chongming an 'eco-island'. A series of package plans have been formulated and implemented for achieving the sustainable future of Chongming Island. However, all those plans were not proposed in a very detailed manner, rather they showed a promising direction of development. Therefore, the expertise from relevant scientists, engineers and policy-makers must be provided to put the beautiful dream into practice. Here from the aspects of ecological planning, water management and low-carbon society, feasible suggestions are come up with.

2. Ecological Planning of Chongming Island

Due to the relatively isolated location away from the mainland of Shanghai, the exchange of population, materials and information of Chongming with the outside

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world has been lagging far behind, which makes the region's overall competitive power does not match with the level of Shanghai. On the other hand, just because of the negative factors for economic development, Chongming remains as an unexploited land enjoying the predominant geographical and ecological resources, which enables it the strategic hinterland of Shanghai's future sustainable development.

In the last decades, Chongming was at the primary stage of urbanization, with very low population density and industries dominated by agriculture. While with the construction of the linking bridge and tunnel between Shanghai mainland and Chongming (Shanghai Yangtze River Bridge), a lot of chances and challenges keep on coming to this island in the recent years. In the master plan for the whole island, authorized by the Shanghai municipal government in 2005, the ultimate goals of Chongming is to become an eco-island with beautiful landscape, self-contained urban functions, sustained economy, and civilized society. To realize the targets, some necessary processes have been put forward, which are divided into three stages as follows.

1) Near-term plan (To establish a tentative framework for the eco-island construction before 2005). In detail, to strengthen the ecological construction and environmental protection, so that important ecological function areas receive effective protection. To adjust the industrial structure transition toward a green economy, and to increase the construction of infrastructures so as to improve the quality of life of local people.

2) Mid-term plan (To achieve the development shape of eco-island before 2010). To give a full play to the advantage of ecological resources, accelerate the adjustment of industrial structures, and greatly improve local people's well-being.

3) Long-term plan (To realize the eco-island before 2020). To complete the transition from the pattern development to the function development, and realize the integrity of production, life, and eco-environment with harmonious environment, diverse biological species, and rich landscape.

For the detailed ecological plan of the island, Chongming is divided into 6 ecology functional areas together with 1 natural reservation district, as shown in Table 1.

Table 1 Ecology functional divisions of Chongming Island

Functional area	Major ecological functions	Supporting industries
West water ecological tourism and harbor logistics service area	Economic and tourism center	Water tourism, harbor logistics services
Mid-west ecological agricultural area	With good agricultural foundation	Modern ecological agriculture

Mid-north forest ecological tourism	Abundant natural resources	Ecological agriculture and tourism
Mid-south urban area, ecological industrial park	Modern urbanization, green industry and comfortable eco-environment	Urban construction, green industrial park, and tertiary industry
Mid-east ecological agriculture area	Ecological agricultural park	Green industry and agriculture, small town construction
East harbor logistics service area, wetland ecological tourism area	Good economic foundation, abundant natural landscape	Harbor logistics services, ecological tourism
East beach natural conservation area	Important natural conservation and ecological sensitive area	Maintain natural and semi-natural ecological landscape

All in all, the completion of the cross-sea Shanghai Yangtze River Bridge brings a new development era for Chongming Island. Ecological construction and environmental conservation are the two key development principles for the whole island's planning. Livable eco-environment and sustainable development will be the premises for Chongming to become an international eco-island adjacent to a mega city.

3. Water Management of Chongming Island

Due to the eco-land master plan, the manufacture industry has been declining under strict constrains. Hence, domestic/commercial sector and agricultural sector take up most of the water demand in Chongming Island. There are currently more than 10,000 waterways that intake and deliver water from the Yangtze River into Chongming Island. Since water flow of Yangtze River is swallowed, Chongming Island is rich in water resource from the view point of water quantity. However, because of the saline water intrusion and pollutant discharge, water quality has always been seriously influenced. It is largely alleviated since March of 2014, as Dongfeng Xisha Reservoir located in the southwestern Chongming Island started to supply water stably to Chongming.

Regarding the current status of potable water supply in Chongming Island, the coverage rate is almost 100%. There are two major water purification plants (Chenqiao and Chenjiazhen) and more than 30 medium-sized water purification stations. By 2015, all small water purification plants will be permanently shut down, and another two

major water purification plants (Buzhen and Chongxi) will be completed. The total capacity of water supply will reach 200,000 m³/day, which is sufficient for the total population in Chongming Island. At the same time, 75% of the distribution pipes in central area are to be replaced. As they were constructed 20 years ago, replacement and renewal is supposed to assure the water quality and solve the leakage problem. In the near future, the concentrated water supply system, which consists of one big reservoir and four major purification plants, will guarantee the drinking water security thoroughly for domestic and commercial use in Chongming.

About wastewater treatment, around 83% of the total amount is currently treated by the four centralized wastewater treatment plants (Chenqiao, Xinhe, Buzhen and Chenjiazhen), eleven medium-sized treatment stations and several simple treatment facilities. It means still around 1/5 of the 150,000 tons/day generated wastewater is discharged without sound treatment and management. Besides, operation and maintenance are not sufficient, due to lack of technical and financial capabilities. Moreover, the fluidity of many waterways in rural areas is low, which also adds up to poor water quality. Apparently, introduction and upgrade of water treatment facilities and systems are essential for conserving and restoring desirable water environment in Chongming Island. In the 12th 5-year Plan of Chongming Water Affairs Bureau, the coverage rate of the centralized sewer system should reach 80% by 2015. However, if the number needs to be further increased, decentralized sanitation systems should be taken into consideration. For example, septic tank and constructed wetland are considered cost-efficient alternatives for those remote rural areas. Several up-scale and low-density resort housing zones are to be constructed apart from central areas, where Johkasou, one of the most popular Japanese technologies, could be adopted. According to the master plan, the land use of Chongming Island will be diverse. Therefore, it is important to introduce appropriate wastewater treatment system with a combination of various technologies.

Building low-carbon society is one of the most focused topics in the eco-island master plan, which also requires energy-saving in water utilization system. Reducing water demand and wastewater volume, as well as efficient utilization of water resource is consistent with the energy-saving requirement. Firstly, it is recommended to introduce rainwater utilization system and water-saving equipment. The rainwater harvesting facilities are suitable for public facilities, while water-saving equipment can be applied to the new houses. Secondly, water reclamation and recycle may be another alternative to achieve water use with less demand. Wastewater condition, running cost and energy consumption must be considered when designing such water reclamation system, since advanced treatment technologies such as membrane biore-

NAKAGAMI Ken'ichi, CHEN Xiaochen, QIAN Xuepeng, SHIMIZU Toshiyuki, LI Jianhua, HAN Ji, NIU Jia, NAKAJIMA Jun actor (MBR) can be embedded. Besides, the combination of the technologies and systems mentioned above may provide more effective and efficient solutions to save both water and energy. Additionally, since it is sometimes reported that the local residents have dissatisfaction with cost burden related to water treatment, environmental education for arousing residents' understanding, consciousness and cooperation would be indispensable too.

Agriculture has always been the foundational industry in Chongming Island. The demand of water for agricultural purposes is not clear, since the irrigation water is drawn directly from the waterways by around 2000 pumping stations. A possible way for estimation is to figure out water footprint based on the types of agricultural crops, the areas and the production. Investigation of the impacts of fertilizers and pesticides on public water environment should also be conducted. According to the master plan, the intensive agriculture will continue to be promoted. Types of agriculture with high added value, such as organic farming, are bound to increase. This will for sure bring new challenges to agricultural water management. Proper water treatment, such as using constructed wetland technologies, will be needed to reduce the exiting and the risk of agricultural non-point source pollution.

4. Development of Chongming Island towards Low-carbon Society

Certain human activities, especially anthropogenic emission of greenhouse gas (GHG) represented by carbon dioxide (CO₂), are considered as the major driver to the 'global warming' in the modern era. Some terrible phenomena have already occurred due to the temperature increase. If this continues, eco-catastrophe may spread across the world (IPCC, 2013). Before it is too late, the concept of 'low-carbon society' was put forward, which refers to a society with minimized GHG emission. The society fights against global warming, and meanwhile through conserving and restoring environment, it can coexist with nature harmoniously (Ministry of the Environment Japan, 2007).

For the sake of constructing Chongming an eco-island featuring 'low-carbon', comprehensive strategies must be proposed. As one of the pioneering countries seeking for route to 'low-carbon society', Japan has lots of precious experience that could be shared and used as a reference. A decade ago, Japan launched its 'Low-carbon Society' project, with the explicit goal of reducing 70% of CO₂ emission by the year 2050, compared to the level of 1990 (NIES et al., 2008). Subsequently, 'a dozen actions' that could substantially make contributions was put forward (see Table 2).

When it comes to putting 'low-carbon' concept into practice, almost all these ra-

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Table 2 A dozen actions towards low-carbon societies (NIES et al., 2008)

	Action	General description	Sector
1	Comfortable and green built environment	Efficiently use of sunlight and energy efficient built environment design. Intelligent buildings.	Commercial & residential sector
2	Anytime, anywhere appropriate appliances	Use of Top-runner and Appropriate appliances. Initial cost reduction by rent and release system resulting in improved availability.	
3	Promoting seasonal local food	Supply of seasonal and safe low-carbon local foods for local cuisine.	Industrial sector
4	Sustainable building materials	Using local and renewable buildings materials and products.	
5	Environmentally enlightened business and industry	Businesses aiming at creating and operating in low-carbon market. Supplying low-carbon and high value-added goods and services through energy efficient production systems.	
6	Swift and smooth logistics	Networking seamless logistics systems with supply chain management, using both transportation and ICT infrastructure.	Transportation sector
7	Pedestrian friendly city design	City design requiring short trips and pedestrian (and bicycle) friendly transport, augmented by efficient public transport.	
8	Low-carbon electricity	Supplying low-carbon electricity by large-scale renewables, nuclear power and CCS-equipped fossil (and biomass) fired plants.	Energy transmission sector
9	Local renewable resources for local demand	Enhancing local renewable use, such as solar, wind, biomass and others.	
10	Next generation fuels	Development of carbon free hydrogen- and/or biomass-based energy supply system with required infrastructure.	
11	Labeling to encourage smart and rational choices	Publicizing of energy use and CO ₂ costs information for smart choices of low-carbon goods and service by consumers, and public acknowledgement of such consumers.	All sectors
12	Low-carbon society leadership	Human resource development for building "Low-carbon Society" and recognizing extraordinary contributions.	

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tional and effective 'dozen actions' could be adopted by Chongming Island, with consideration of the specific local circumstances. In fact, some actions have already been taken from different perspectives. Several examples regarding the current achievements and further development proposals for Chongming Island are described as follows.

In terms of commercial and residential sector, an 'eco-office' demonstration building was designed and constructed in Chenjia Town of Chongming Island by the joint efforts of Shanghai Chenjia Town Construction Development Co., Ltd. and Shanghai Research Institute of Building Sciences (Group) Co., Ltd. On 2013, 'National Green Building Innovation Award (1st Prize)' was granted for appreciating all the green notions and technologies involved in this building, including green construction materials, natural ventilation & lighting, renewable energy, wastewater reclamation & reuse, eco-planting, low-energy consumption, intelligent control system and so on. In the future, population density of Chongming Island is expected to increase, especially in its conventional residential community and potential up-scale communities for business, leisure and retirement. Hence, this 'green building' movement should be promoted continuously, so as to minimize the environmental impact of those buildings throughout their life cycles.

From the perspective of transportation, Shanghai municipal government and the local government of Chongming County should find a way to effectively reduce people's dependence on private automobiles burning fossil fuel. One suggestion for urban planning is establishing the communities more compact, i.e., shortening the distance between apartment buildings, so that residents can reach the nearest marketing center and public transportation station within a few minutes of walk or bicycle ride. Besides, it is reported that new rail line will be constructed to connect Chongming Island directly to the downtown area of Shanghai city, which is bound to further reduce people's use of private cars. Furthermore, integrated technological and managing strategies/regulations can be formulated and implemented in a compulsory manner, as a result, conventional fossil fuel could be efficiently replaced by clean power. For example, the government can enforce the replacement of all conventional buses by new types using pollution-free fuel-cell. Residents should be urged to use hydrogen-powered or motor-driven cars; otherwise, they must park their (conventional) cars outside the boundary of Chongming Island (Normile, 2008).

With regard to energy conversion sector, local renewable energy resources must be fully taken advantage of, instead of conventional fossil fuel. As for Chongming Island, four types of promising renewable energy must be emphasized. First is solar radiation energy for the photothermal and photovoltaic use, which is estimated to be

about 1.567 million GWH per year (Huang et al., 2008). Second is wind energy which, if fully utilized, could lead to a power generation of 3000 GWH per year or more (Yu, 2006). Third is biomass energy which, if half of the agricultural residue is used by a biomass power plant as fuel, could produce approximately 253 GWH per year (Huang et al., 2008). Fourth is tidal and wave energy which could be equal to 6000 GWH per year (Yu, 2006). Huang et al. (2008) suggested that wind energy and biomass energy be developed first due to relatively low cost, and solar energy and tidal & wave energy be gradually enhanced in the future.

Last but not least, people's awareness must be improved. During our field survey in the summer of 2014, it is discovered that the local people's consciousness about environmental conservation are very weak, and they do not have sufficient sense of urgency for pursuing 'low-carbon society'. Without the understanding and support from the general public, the aforementioned technological and institutional evolution is hard to be realized. The government officials and relevant decision-makers must keep in mind that environmental education plays an indispensable role, if long-term success in 'low-carbon society' practice is expected. Promotion of the 'low-carbon' education by mass media, as well as through regular community campaigns with appropriate reward/incentive mechanism, could be an effective way.

Conclusion

As the world's largest alluvial island and an important part of Shanghai metropolitan region, Chongming Island owns valuable ecological functions. However, the inherent problems, as well as the conflicts between social & economic development and nature conservation, must be paid keen attention to. This paper discusses how to achieve sustainable development of Chongming Island from the perspectives of ecological planning, water management and low-carbon society. In terms of ecological planning, the three-stage plan, together with the division of six-ecology functional areas with one natural reservation district, provides a practical way. As for water management, introduction and upgrade of treatment facilities and systems are essential. Besides, new technologies for the purposes of rainwater use, energy-saving and water reclamation & recycle should be taken into consideration, together with wastewater condition, running cost and energy consumption. Furthermore, water utilization for agricultural sector must be further studied and optimized so as to avoid agricultural non-point source pollution. With regard to low-carbon society, 'a dozen actions' proposed by Ministry of the Environment Japan could be adopted by Chongming Island, with consideration of the specific local circumstances. Note that if long-term success

NAKAGAMI Ken'ichi, CHEN Xiaochen, QIAN Xuepeng, SHIMIZU Toshiyuki, LI Jianhua, HAN Ji, NIU Jia, NAKAJIMA Jun in low-carbon society practice is expected, environmental education is of vital importance.

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