



PERSPECTIVES



The ancient Great Wall.

ECOSYSTEMS MANAGEMENT

Rethinking China's new great wall

Massive seawall construction in coastal wetlands threatens biodiversity

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China's position as the world's second largest economy is largely due to its rapid economic growth in the coastal region, which composes only 13% of China's total land area, yet contributes 60% of the gross domestic product (GDP). To create extra land for the rapidly growing economy, coastal wetlands

have been enclosed by thousands of kilometers of seawalls, whose length exceeds that of China's famous ancient "Great Wall" (see photos and map). This new "Great Wall," covering 60% of the total length of coast-

line along mainland China (1), caused a dramatic decline in internationally shared biodiversity and associated ecosystem services and will threaten regional ecological security and sustainable development. Here, we outline these problems, analyze the drivers behind wetland reclamation, and propose measures for effective wetland management.

IMPORTANCE OF COASTAL WETLANDS.

China's coastal wetlands, with an area of 5.8 million ha, support abundant biodiversity and provide the foundation for regional development. For example, 230 waterbird species, over 25% of the global total, inhabit China's coastal wetlands. Millions of migrating birds refuel on the wetlands that connect countries in the south with those

in the north (2). The wetlands produced 28 million tons of fishery products in 2011, nearly 20% of the global total, as well as providing spawning and nursery grounds for many aquatic organisms that maintain marine ecosystem health and serve as the base for offshore fisheries. Coastal wetlands help to absorb pollutants that are increasingly discharged from land and are ecological barriers against extreme weather events, such as typhoons, protecting people living along the coast (3). Coastal wetlands also provide enormous direct and indirect ecosystem services, including nutrient cycling, carbon storage, and tourism and recreation. Although the area of coastal wetlands accounts for <1% of all ecosystem area in China, the values of ecosystem services they provide amount to U.S. \$200 billion annu-

ally for the country, accounting for a 16% share of the country's total (4).

CHANGING COASTLINES AND CONSEQUENCES. Globally, coastlines have undergone enormous change. Seawall construction has played a crucial role since ancient times (5). Although the seawalls were used traditionally for coastal defenses, such as erosion control and protecting human habitation from tides and waves, they have

constructing industrial zones, ports, and other infrastructure (see chart). The length of such seawalls has increased 3.4 times (from 18 to 61% of the total 18,000 km) over the past two decades, reaching 11,000 km in 2010 (1).

Such massive coastal reclamation, often implemented by introduction of sedimentation-promoting exotic plants (e.g., *Spartina alterniflora*) and sand pumping, has severely reduced biodiversity and associ-

DRIVERS BEHIND WETLAND RECLAMATION. Multiple drivers contribute to the loss of China's coastal wetlands. They include the lack of national legislation for wetland conservation, overemphasis on GDP growth, conflicting goals among government agencies and between central and local governments, underappreciated values of wetlands, and inappropriate definitions of wetlands in laws and regulations.

China's central government has taken



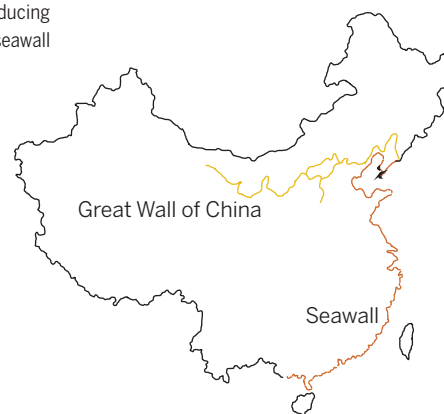
The “new Great Wall.” A seawall that is being built in the Yangtze estuary. Seawalls such as this are creating land and reducing ecosystem services along the coastal wetlands of China. (Right) The ancient Great Wall (yellow line) and the 11,000-km seawall on the coasts of mainland China (red line). The discontinuity of the walls is not visible because of the map resolution.

been increasingly used to enclose coastal wetlands for agricultural and industrial uses over the past several centuries (6, 7). This has caused a great loss of coastal wetlands and their myriad of ecological services.

Over the past decades, the importance of coastal wetlands has been increasingly recognized by the public and governments. Management policies have been established in some countries, e.g., the “Integrated Coastal Zone Management” strategy in Europe and the “no-net-loss” policy in the United States, resulting in a decreasing rate of loss and even an increase in wetland area in certain countries (6, 8).

In contrast, reclamation of coastal wetlands has been accelerating in China. From 1950 to 2000, the enclosed wetland area increased by an average of 24,000 ha year⁻¹, which led to a loss of 50% of the coastal wetlands (9). The reclamation rate has increased dramatically to 40,000 ha year⁻¹ during 2006–2010 to support rapid urbanization and economic development through

ated ecosystem services, and more serious consequences are expected in the foreseeable future. The loss of coastal wetlands in China has contributed to the rapid decline of waterbird populations in the East Asian–Australasian flyway, which currently is the migratory path for the highest proportion (19%) of threatened waterbird populations among the global flyways (2). Upon reclamation, coastal wetlands are converted from pollutant sinks to sources, producing pollutants from ports and factories; nutrients and pesticides from croplands; and chemicals, such as antibiotics, from aquacultures; resulting in deterioration of inshore and oceanic environments (10). Loss of coastal saltmarsh wetlands makes people highly vulnerable to extreme weather events, especially in times of predicted climate change and sea level rise. Reclamation of China's coastal wetlands is estimated to cause a loss of U.S. \$31 billion of ecosystem services annually, about 6% of the gross marine products in China (10).

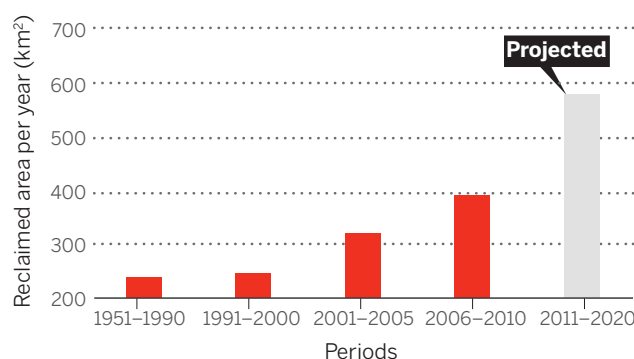


measures to conserve the wetlands. For example, the National Wetland Conservation Action Plan was promulgated in 2000, and the National Wetland Protection Plan was approved in 2004. Thirty-five national nature reserves were established along China's coasts and 14 coastal wetlands have been designated as Wetlands of International Importance (Ramsar sites) (table S1). However, China's coastal wetlands are managed by multiple agencies (table S2). This “fragmentation of bureaucratic authority” (11) results

in conflicts and overlapping functions. Moreover, relevant laws and regulations are often inadequate to protect coastal wetlands. In practice, wetland destruction carries no or negligible penalties; land administration law still classifies coastal wetlands as “unused lands,” and, thus, exploitation of coastal wetlands is encouraged. In addition, environmental impact assessments for coastal wetland reclamation projects focus on the potential loss of fisheries, environmental pollution, and other direct impacts on people but largely ignore the loss of biodiversity or associated ecosystem services.

Since China's reform in the late 1970s, GDP growth has been the main criterion for assessing the achievements of local governments, and, hence, local officials favor projects that result in immediate and direct economic benefits. Although the central government has recently proposed to add environmental performance to the assessment criteria, the effectiveness of such a proposed change remains to be seen. Coastal wetlands provide essential services, most of which are indirect and long-term, and are therefore vastly underappreciated. By contrast, enclosing coastal wetlands to create land for various enterprises produces direct and immediate economic benefits. Moreover, because land is owned by the state in China, local governments can obtain huge profits from selling the use right of land created by coastal reclamation.

The huge economic returns from reclamation have prompted local governments to “bypass” regulations issued by the central government. For example, the State Council of the People's Republic of China ruled that reclamation projects over 50 ha must be approved by the central government. To evade this, local governments simply divide large projects into smaller ones (1, 9). Some local governments have com-



The extent of Chinese seawall building. The amount of reclamation of coastal wetlands divided into time periods (1, 9, 10, 12).

pelled coastal nature reserves to change their boundaries so that wetlands previously within the reserves can be legally reclaimed. Because of a lack of integrated planning at the national level and coordination between coastal provinces, there are substantially redundant and overlapping development projects, making macroregulations difficult at the national level (9).

FUTURE TRENDS AND COUNTER MEASURES. In 2012, the State Council of China approved National Marine Function Zoning (2011-2020) “to strengthen the management of reclamation projects and to rationally control the reclamation scale.” However, according to the Marine Function Divisions formulated by coastal provinces, 250,000 ha of coastal wetlands will be enclosed for infrastructure development and more wetlands for other purposes (e.g., agriculture) by 2020 (12). The reclamation rate is expected to increase to 60,000 ha year⁻¹ during 2010-2020 (see the chart). The loss of coastal wetlands is unlikely to slow down unless more effective measures are urgently taken.

First, legislation is required to set a mandatory minimum area for coastal wetlands at both national and local levels to achieve a target of “no net loss.” This should be based on comprehensive research on ecological, hydrological, and socioeconomic conditions of coastal regions to clarify the importance, sensitivity, and vulnerability of each region and to answer the questions of where, when, and how much coastal wetland can be enclosed without damaging the integrity of coastal wetlands.

Second, an effective agency directly under the State Council is needed to coordinate the functions and responsibilities among the many government agencies involved in wetland management. Overall, reclamation projects should be planned at the national level to achieve the target of sustainable development. Strict environmental impact assessments must be performed on reclama-

tion projects, in which cumulative ecological impacts of multiple reclamations for different regions should be considered.

Third, mechanisms must be established for government authorities to be accountable for ecological losses. For the local governments, it is important to change the model of economic development to decrease their heavy dependence on increasing land area but to increase the added value and the efficiency of existing land.

Finally, outreach and education about ecosystem services and sustainable development are needed to raise public awareness and compliance for conserving coastal wetlands.

In conclusion, adverse socioeconomic and ecological consequences of over-reclamation of coastal wetlands have already emerged (2). To meet the targets of “ecological civilization” (13) and to support sustainable development, Chinese governments at all levels must place a high priority on the conservation of coastal wetlands and their ecosystem services. It is time to think again about China's new “Great Wall” that is built on the coastal wetlands. ■

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SUPPLEMENTARY MATERIALS

www.sciencemag.org/content/346/6212/912/suppl/DC1

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