Assessment of Ecosystem Services of Rudong Mudflat and Aoshan Bay Coastal Area

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Background

Large Marine Ecosystems (LMEs) are relatively large areas of ocean space of approximately 200,000 km² or greater, adjacent to the continents in coastal waters where primary productivity is generally higher than in open ocean areas. The LMEs produce about 80% of the annual world's marine fisheries catch. Globally they are centers of coastal ocean pollution and nutrient over enrichment, habitat degradation (e.g. sea grasses, corals, mangroves), overfishing, biodiversity loss, and climate change effects. The $12.6 trillion in goods and services contributed annually by LMEs to the world's economy is at risk from unsustainable utilization practices.

Component 4 of the YSLME Phase II Project addresses improving ecosystem carrying capacity with respect to supporting services. To maintain the current habitats of critical global and regional importance and reduce the loss of coastal and marine habitats and associated species in support of achieving SDG 14 and implementing CBD, RAMSAR and other relevant Conventions, we conducted the assessment of ecosystem services both of Rudong Mudflat and Aoshan Bay which is subject to reclamation with different approaches.

Research methods

Rudong County possess great wetland resources. The total wetland area above 0 m in Rudong is about 800 km², which equals to 1/9 of total wetland area of Jiangsu Province. This study used the Rapid Assessment of Wetland Ecosystem Services (RAWES) for Rudong's assessment. It is an analysis method that lies between qualitative and quantitative analysis. A qualitative investigation of the subject is conducted by field trips and extensive interviews. The list of services (Table 1.) in RAWES is modified and adapted to the local context through dialogue and consultation with local stakeholders who are familiar with the Rudong mudflat. Each ecosystem service will be assessed using the following relative scale:

Score	Assessment of ecosystem service
++	Potential significant positive contribution
+	Potential positive contribution
0	Negligible contribution
-	Potential negative contribution
--	Potential significant negative contribution
?	Gaps in evidence

According to the Technical Guidelines for Marine Ecological Capital Assessment, which is used as China national standards, the marine ecosystem services of Aoshan bay are divided into four categories: provisioning services, regulating service, cultural services and supporting service. Among them, the provisioning services consist of 3 indicators: aquaculture production, fishing production and oxygen production; regulating services include 2 indicators: climate regulation and waste disposal; cultural services include 2 indicators: recreation and research services; supporting services consist of 2 indicators: species diversity maintenance and ecosystem diversity maintenance. Considering the availability of data, the practicality of evaluation methods and the functions of ecosystem services actually provided in the waters of Aoshan Bay, market value approach, results reference approach, and replacement cost method were used in this study.

Table 1. The list of Rudong mudflat ecosystem services considered by the RAWES approach and examples of the indicator questions considered

	Ecosystem service	Example	Questions assessors can ask about this service
Provisioning services	Provision of freshwater	Water used for domestic drinking supply, for irrigation, for livestock, etc.	• Does the wetland provide a source of fresh water? • Does the wetland store fresh water for human use?
	Provision of food	Crops, shellfish, fish, etc.	• Is the wetland a net source of pollution, degrading fresh water provision? • What is grown in the wetland, either formally or from informal harvesting? • Are animals are harvested from the wetland? • Are livestock using the wetland?
	Provision of fiber	Timber for building, etc.	• Are any natural materials such as wood, fibre, straw, animal fibre (wool/hide/sinew/antler/other) taken from the wetland?
	Provision of fuel	Fuelwood, peat, etc.	• Is any material taken from the wetland and used as fuel for domestic or other uses?
	Provision of genetic resources	Rare breeds used for crop/stock breeding, etc.	• Are any native or rare strains of plants and animals, wild and domesticated, which could contribute genetic diversity for human uses?
	Provision of natural medicines and pharmaceuticals	Plant used as traditional medicines, etc.	• Are there any plants, animals or their parts derived from the wetland which are harvested and used for their medicinal properties?
	Provision of ornamental resources	Collection of shells, flowers, etc.	• Are there any plants, animals, or their parts are derived from wetland that are collected and used/sold for their ornamental properties?
	Clay, mineral, aggregate harvesting	Sand and gravel extracted for building use, clay extracted for bricking-making, etc.	• What substances are extracted or dug up from the wetland for construction or other human uses?
	Waste disposal	Dumping of solid waste, discharge of waste water, etc.	• Does the wetland provide a location for the disposal of liquid, solid or other waste materials?
	Energy harvesting from natural air and water flows	Water wheels driven by flowing water, windmills driven by the wind, etc.	• Are any technologies (water wheels, wind turbines, etc.) used to capture natural flows of energy through or across wetland?
Regulating services	Air quality regulation	Removal of airborne particles from the exhaust of cars, chimneys of industry, dust from agricultural land, etc.	• Is there a source for airborne pollutants? • Does the wetland habitat structure help to settle out airborne pollutants? • Does the state of the wetland make it a source of air pollutants (microbial, particulate or chemical)?
	Local climate regulation	Regulation of the local microclimate, through shading, reducing air temperature, etc.	• Does the wetland habitat structure provide shade for humans? • Does the wetland have areas of standing water with or without vegetation that will be generating evapotranspiration and consequently reducing air temperature?
	Global climate regulation	Regulation of the global climate through control in greenhouse gas emissions, the sequestration of carbon, etc.	• Does the wetland store and/or sequester carbon? • Does this balance with generation of methane and other greenhouse gases?
	Water regulation	Regulation of flows of surface water during high and low flows, regulation of recharge of groundwater, etc	• Does the topography, permeability and roughness of the wetland enable it to store water during high rainfall/discharge and top slowly release it back to surface waters or to groundwater? • Does the wetland regulate discharges during dry periods to buffer low flows during dry weather?
	Flood hazard regulation	Regulation and storage of flood water, regulation of intense rainfall events, etc.	• Does the wetland regulate, store and retain floodwaters?
	Storm hazard regulation	Regulation of tidal or storm surges, regulation of extreme winds, etc.	• Does the wetland store rainfall and surface water that might contribute to flooding and damage to property or ecosystem downstream? • Does the complexity of habitat, particularly trees, tall reeds and other vegetation and surface topography, absorb energy from extreme events such as storms and waves that might otherwise damage property or adjacent ecosystems?
	Pest regulation	Control of pest species such as mosquitoes, rats, flies, etc.	• Do natural predation and other ecological progresses in the wetland regulate and control pest organisms?
	Regulation of human diseases	Presence of species that control the species (vectors) that transmit human diseases.	• Is the wetland a source of pests (for example rats thriving in dirty water systems)? • Do natural predation and other ecological progresses in the wetland regulate organisms that may cause human diseases? • Are faecal deposits, bacteria or other potentially pathogenic microbes immobilized by processes in the wetland?
	Regulation of diseases affecting livestock	Presence of species that control the species (vectors) that transmit diseases to livestock.	• Is the condition of the wetland contributing to the negative spread of populations of disease vectors (such as mosquitoes)? • Do natural predation and other ecological progresses in the wetland regulate organisms that may cause diseases in livestock? • Are faecal deposits, bacteria or other potentially pathogenic microbes immobilized by processes in the wetland?
	Erosion regulation	Regulation of energy environment to reduce risk of erosion, presence of dense vegetation protecting soils, etc.	• Is the condition of the wetland contributing to the negative spread of populations of disease vectors (such as mosquitoes or snails)? • Does the wetland vegetation provide protection from erosion for the soils? • Are there any signs of erosion, such as bare earth, in the wetland?
	Water purification	Cleaning of water, improvement of water quality, deposition of silts, trapping of contaminants and pollutants, etc.	• Do physico-chemical (sunlight exposure in the shallow waters, detention of water in the aerobic and anaerobic microhabitats) and biological processes in the wetland result in the breakdown of organic, microbial and other pollutants in the water passing through? • Are suspended solids deposited? • Is there a noticeable change in the quality, such as the turbidity, of water entering and leaving the wetland?
	Pollination	Pollination of plants and crops by pollinators such as bees, butterflies, wasps, etc.	• Do populations of pollinating organisms (butterflies, wasps, bees, bats, etc.) in the wetland contribute to pollination within the wetland? • Do pollinators using the wetland also help to pollinate nearby crops, gardens, allotments, etc.?
	Salinity regulation	Freshwater in the wetland provides a barrier to saline waters.	• Does the hydrology of the wetland help prevent saline water contaminating freshwaters? • Does the presence of freshwater in the wetland prevent the salinization of soils?
	Fire regulation	Providing physical barriers to the spread of fire, maintaining wet conditions to prevent fires spreading, etc.	• Does the configuration of waterbodies (ditches, streams, etc.) help to prevent the spread of fires? • Is there water at or near the soil surface that restricts the spread of the fires? • Are organic rich or peat soils drained and susceptible to fire and burning?
	Noise and visual buffering	Wetland trees or tall reeds absorbing and buffering the impact of noise.	• Is there a source (busy road, industry, construction, etc.) and receptor (house, wildlife, etc.) for noise pollution? • Does wetland ecosystem structure, particularly tall trees and reeds, provide visual screening as well as suppress noise transmission?
Cultural services	Cultural heritage	Importance of the wetland for historical or archaeological value, as an example of traditional uses or management practices, as a cultural landscape, etc.	• Does the wetland system have cultural importance, either due to its natural character or traditional uses?
	Recreation and tourism	Importance of the wetland for providing a location for recreation such as fishing, watersports or swimming, or as a tourism destination, etc.	• Is the wetland used for organized or informal recreational purposes? • Is there infrastructure provided for access and recreation?
	Aesthetic value	The wetland is overlooked by properties, is part of an of known area of natural beauty, is used as a subject for painters and artists, etc.	• Are their wider tourism/ecotourism benefits flowing from these uses? • Does the wetland provide aesthetic benefits through the desirability of sitting houses of commercial development adjacent to it? • Does the presence of a wetland have a significant impact on property prices? • Is the wetland depicted in many works of art?
	Spiritual and religious value	The wetland holds plays a role in local religious festivals, the wetland is considered as a sacred site, the wetland forms part of a traditional belief system, etc.	• What spiritual and/or religious values do people derive from the wetland? • Does the wetland hold any important spiritual or cultural value to people? • Does the wetland play any part in traditional religious ceremonies?
	Inspirational value	Presence of local myths or stories relating to the wetland, traditional oral or written histories about the wetland or wetland animals, creation of different art forms associated with the wetland, development of distinct architecture based on the wetland, etc.	• Are there any traditional wetland management practices (such as the timing of planting and cropping of rice to Buddhist or other traditions and teachings) associated with the wetland? • Are there any particular myths or other folklore associated with the wetland? • Do any wetland animals appear or are featured in local stories and myths? • Does the wetland inspire people to create music or other forms of art?
	Social relations	Presence of fishing, grazing or cropping communities which have developed within and around the wetland.	• Have particularly ways of designing and building developed which reflect the wetland? • Have communities formed around the wetland and its uses, including for example fishing (substance, commercial and recreational), cropping or stock management, walking and jogging, birdwatching and photography, etc?
	Educational and research	Use of the wetland by local school children for education, site of long-term research and monitoring, site visited by organized educational study tours, etc.	• Is the wetland used for any educational purposes, organized or informal, ranging from school-level visits to university research and teaching? • Are there any public awareness or educational materials present?
Supporting services	Soil formation	Deposition of sediment, accumulation of organic matter, etc.	• Do accretion processes (both sedimentation of mineral material and the buildup of organic material) on the wetland result in the formation of soils?
	Primary production	Production of primary producers such as plants, algae, etc.	• Do photosynthetic process on the wetland produce organic matter and store energy in biochemical form?
	Nutrient cycling	Source of nutrients present from inputs from agricultural land, internal cycling of plant material, inputs of nutrients from floodwaters, presence of fauna to recycling nutrients, etc.	• Do wetland processes biochemically transform nutrients (for example nitrification/denitrification)? • Are nutrients settled out in particulate forms, changing the characteristics of water passing through the system? • Are there abundant invertebrates and detritivores that are decomposing and cycling organic material?
	Water recycling	Presence of wetland vegetation and open water result in evapotranspiration and local recycling of water, relatively closed canopies and low exposure to winds retains water in local cycles, sandy or coarse substrates allow exchange with groundwaters, etc.	• Does the structure of the wetland retain water in tight cycles (for example recapture of vapour produced by evapotranspiration)? • Does the wetland enable exchanges with groundwater (either discharge or recharge)?
	Provision of habitat	Presence of locally important habitats and species, presence of species and habitats of conservation concern, etc.	• Does the wetland support a diversity of locally representative biodiversity (plants and animals)? • Does the wetland support species which humans consider of conservation concern or as charismatic interests?

Results

Rudong Mudflat

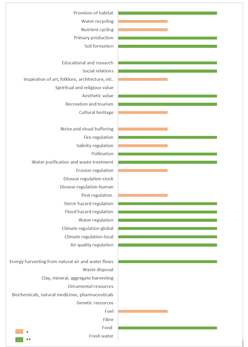

Fig 1. Relative importance of individual ecosystem services (orange +, green ++)

For all 37 ecosystem services, there were no negative contributions recorded. Eighteen ecosystem services made significant positive contributions, nine ecosystem services made positive contributions, and ten ecosystem services made negligible contributions.

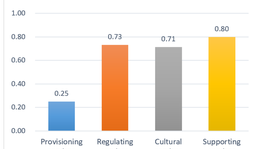

Fig 2. The ecosystem services index (ESI) of four categories of ecosystem services

The benefits derived from the ecosystem services are delivered across a range of scales, from locally in the immediate vicinity of a wetland (soil formation) through regional (food production) to those that contribute at a global scale (climate regulation) . According to our analysis, the distribution of benefits derived from the Rudong mudflat is strongly skewed towards the local level.

Aoshan Bay Coastal Area

Based on the survey results of offshore economic biological resources in 2017 and the average market price in 2017, the value of biological resources in Aoshan bay was $315,910.89, and the regional average was 643.52 dollars/km² in 2017.

In 2017, the total value of ecosystem services in Aoshan bay was about 812.04 million dollars.

Table 2. Value and composition of ecosystem services in Aoshan bay in 2017

Ecosystem services	Value/million dollars	Proportion/%	Indicators	Value/million dollars	Proportion/%
Provision services	373.01	45.93	Marine aquaculture	346.80	42.71
			Fishing production	26.19	3.23
			Oxygen production	0.02	0.0021
Regulating services	4.72	0.58	Climate regulation	0.01	0.0002
			Waste treatment	4.72	0.58
Cultural services	414.14	51.00	Recreation and entertainment	413.84	50.96
			Scientific services	0.30	0.0375
Supporting services	20.17	2.48	Species diversity maintenance	0.98	0.12
			Ecosystem diversity maintenance	19.19	2.36
Total	812.04				

Fig.3. shows the distribution of ecosystem service value in Aoshan bay. It can be seen from the figure that the high value area of the ecosystem service value in Aoshan bay was concentrated in the central and southern waters of the assessment area, with a maximum value of 226.88 million dollars/km² and a minimum value of 23.29 million dollars/km².

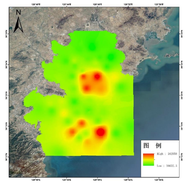

Fig 3. Distribution of ecosystem service value in Aoshan bay (×10⁴ yuan/km²)

Conclusions

The RAWES approach assesses value in purely nominal terms, with no intent to convert this into a quantifiable or monetary metric. Our result highlighted significant environment-livelihoods aspects in Rudong. The identification of 37 different and diverse ecosystem services can broaden the discussion around the importance of wetlands within Rudong and presents values based on ecosystem services rather than values based solely on natural conservation. The ability to recognize a multiplicity of wetland ecosystem services has made a significant contribution to discussions around the future wise use of wetlands in Rudong.

For Aoshan Bay, the assessment results in this study represented the baseline conditions at a point in time. The information provided by this study will have great assistance in the decision-making for local government within the urban planning context.

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For further information

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