

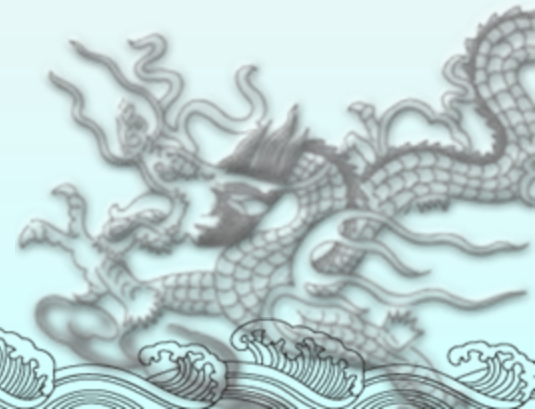
**Monetary Valuation of Damage to Coastal Ecosystem
Services Caused by Sea Reclamation
—— Concept, Methodology and Case Study**

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- ◆ **Concept and Classification of Ecosystem Services**
- ◆ **Methods to Evaluate the Damage of Coastal Ecosystem Services**
- ◆ **Case Study**
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Introduction

- ◆ Coastal zone: a unique ecosystem different from the oceanic or terrestrial ecosystem
- ◆ Variety of characteristics: abundant resources, multiple environmental services, ecological fragility, and frequent occurrence of natural disasters



Introduction

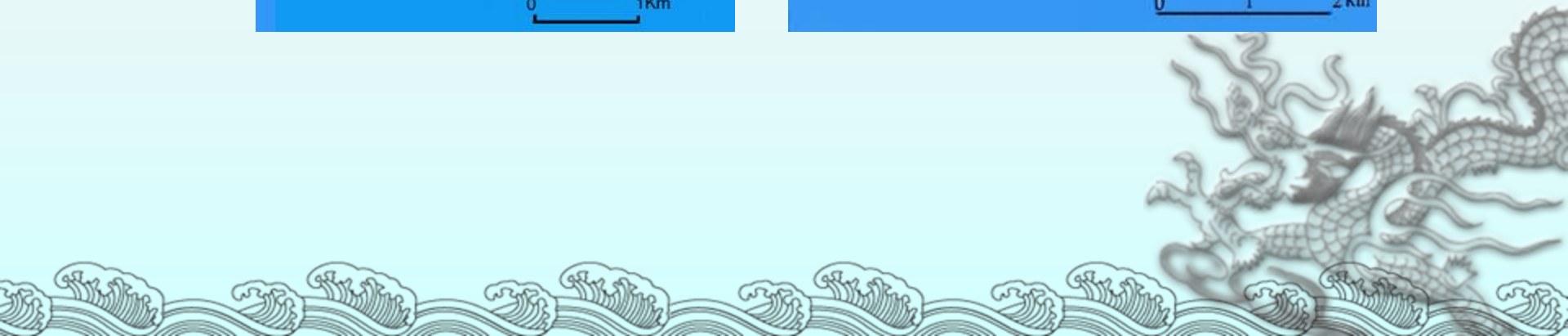
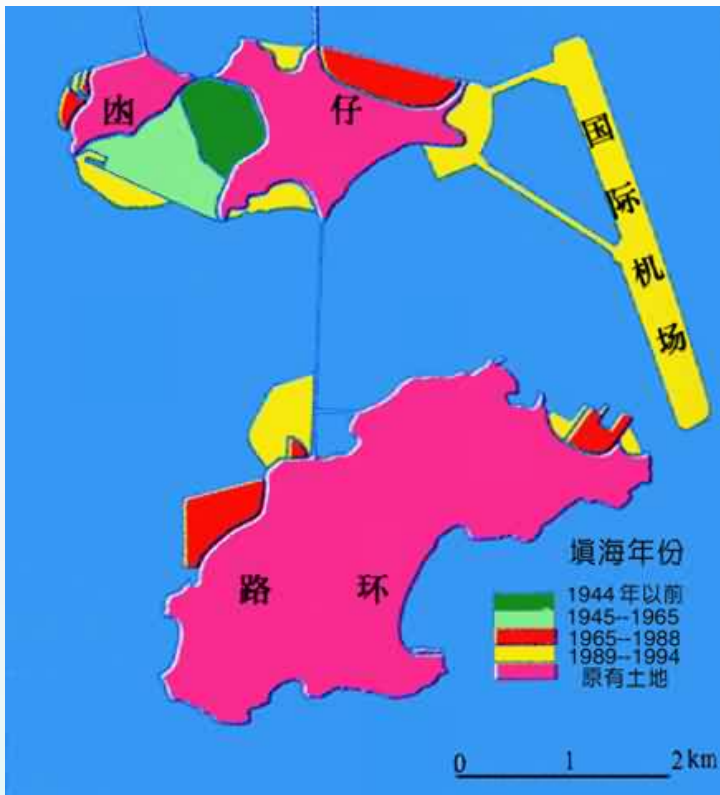
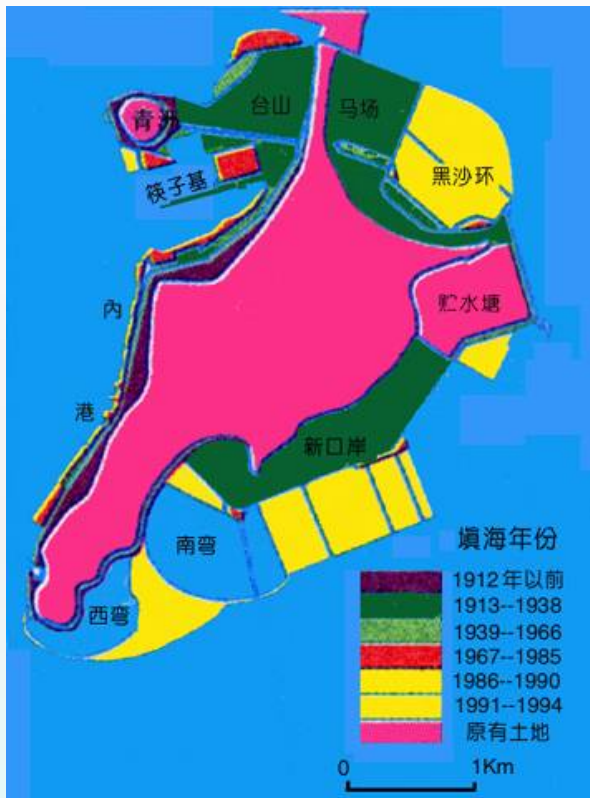
- ◆ The most concentrated region of diverse human activities
 - ◆ It covers only 10% of the earth's surface but is inhabited by over 50% of the world's population.
 - ◆ In regions such as Southeast Asia, over 70% of the population lives in coastal areas.
- ◆ Reclaiming land from the sea -- resolve the conflict between economic development and land shortage
 - ◆ The total area reclaimed reached 540 km² by the end of 2007.





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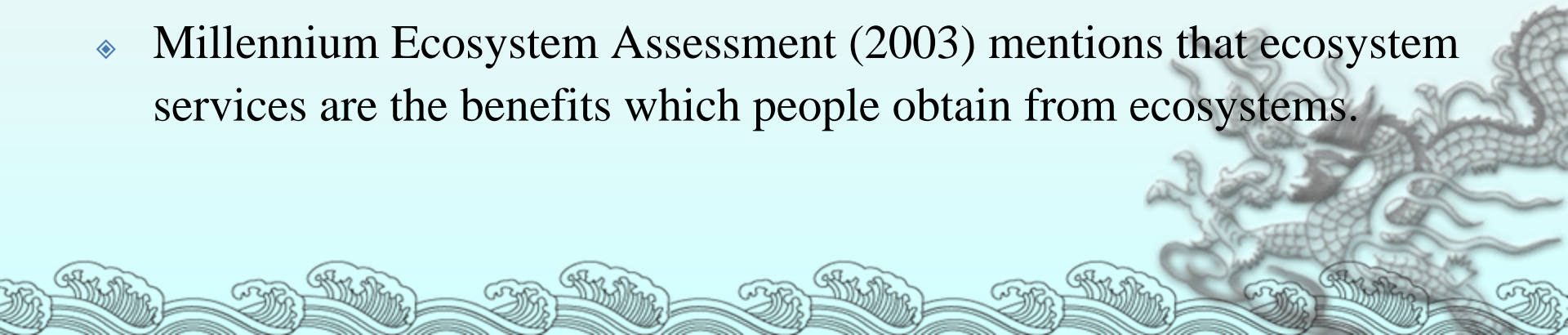
Introduction

- ◆ Pay more attention to short-term direct economic benefits, and ignore the ecological damage and environmental degradation.
- ◆ An important reason: coastal ecosystem services are not fully ‘captured’ in commercial markets, which has left them largely as open access resources to be exploited by anyone.
- ◆ It is necessary to monetarily value the damage to coastal ecosystem services incurred by sea reclamation and to integrate the evaluation information into the exploitation and management decisions.
 - ◆ Provide a theoretical basis for the user fee of sea areas;
 - ◆ Facilitate the use of market-based mechanisms to manage coastal resources and ecosystems;
 - ◆ Promote sustainable development of the coastal zone.



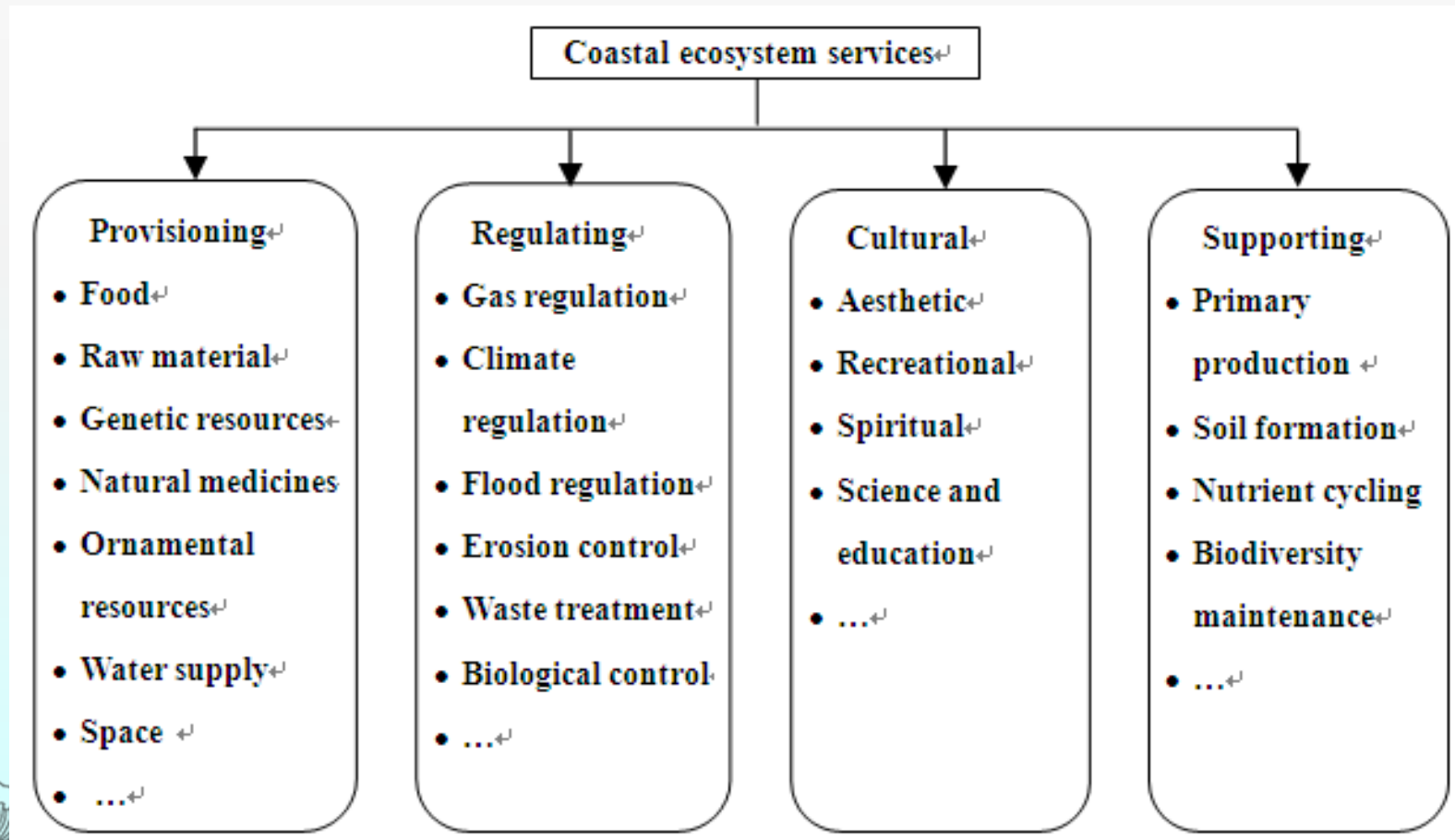
Concept and Classification of Ecosystem Services

- ◆ Costanza (1997) defines ecosystem goods and services as the benefits human populations derive from ecosystem functions.
- ◆ Daily (1997) considers that ecosystem services are the conditions and processes through which natural ecosystems sustain and fulfill human life.
- ◆ De Groot (2002) defines ecosystem functions as “the capacity of natural processes and components to provide goods and services that satisfy human needs”.
- ◆ Millennium Ecosystem Assessment (2003) mentions that ecosystem services are the benefits which people obtain from ecosystems.



Concept and Classification of Ecosystem Services

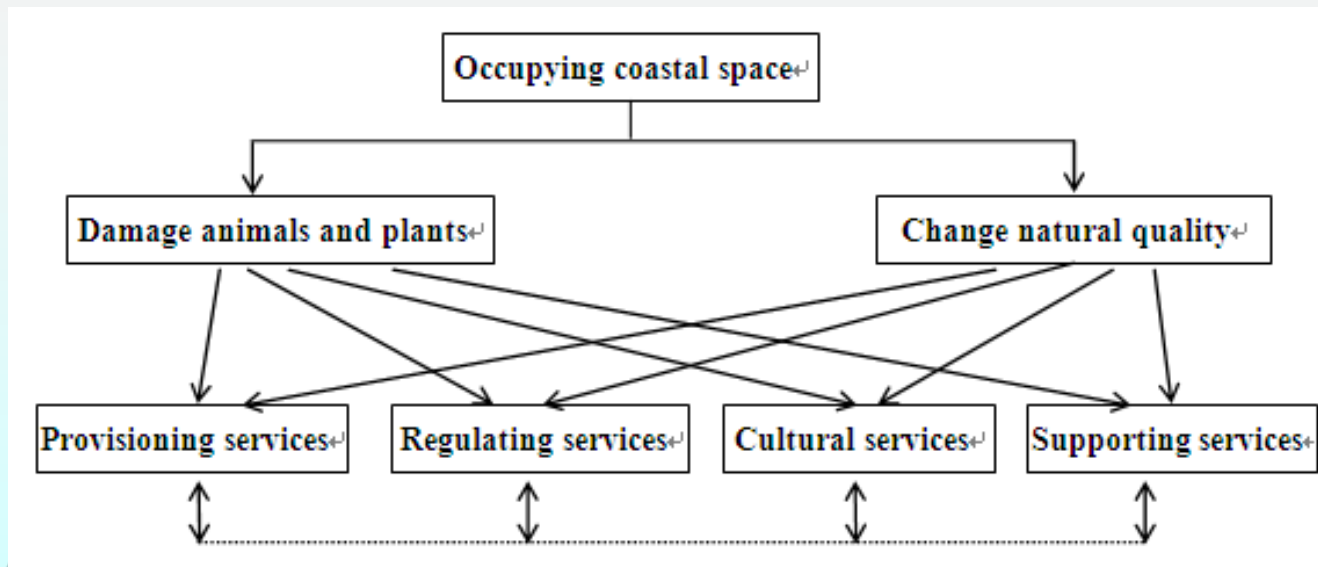
- various sea-foods and materials are derived from coastal ecosystems;
- phytoplankton play an important role in gas regulation through photosynthesis;
- mangroves and coral reefs are natural defense against storm surges;
- marine ecosystems can filter out and decompose organic wastes;
- seaside, sandy beaches and islands are the best choices for recreation.



Methods to Value the Damage to Coastal Ecosystem Services

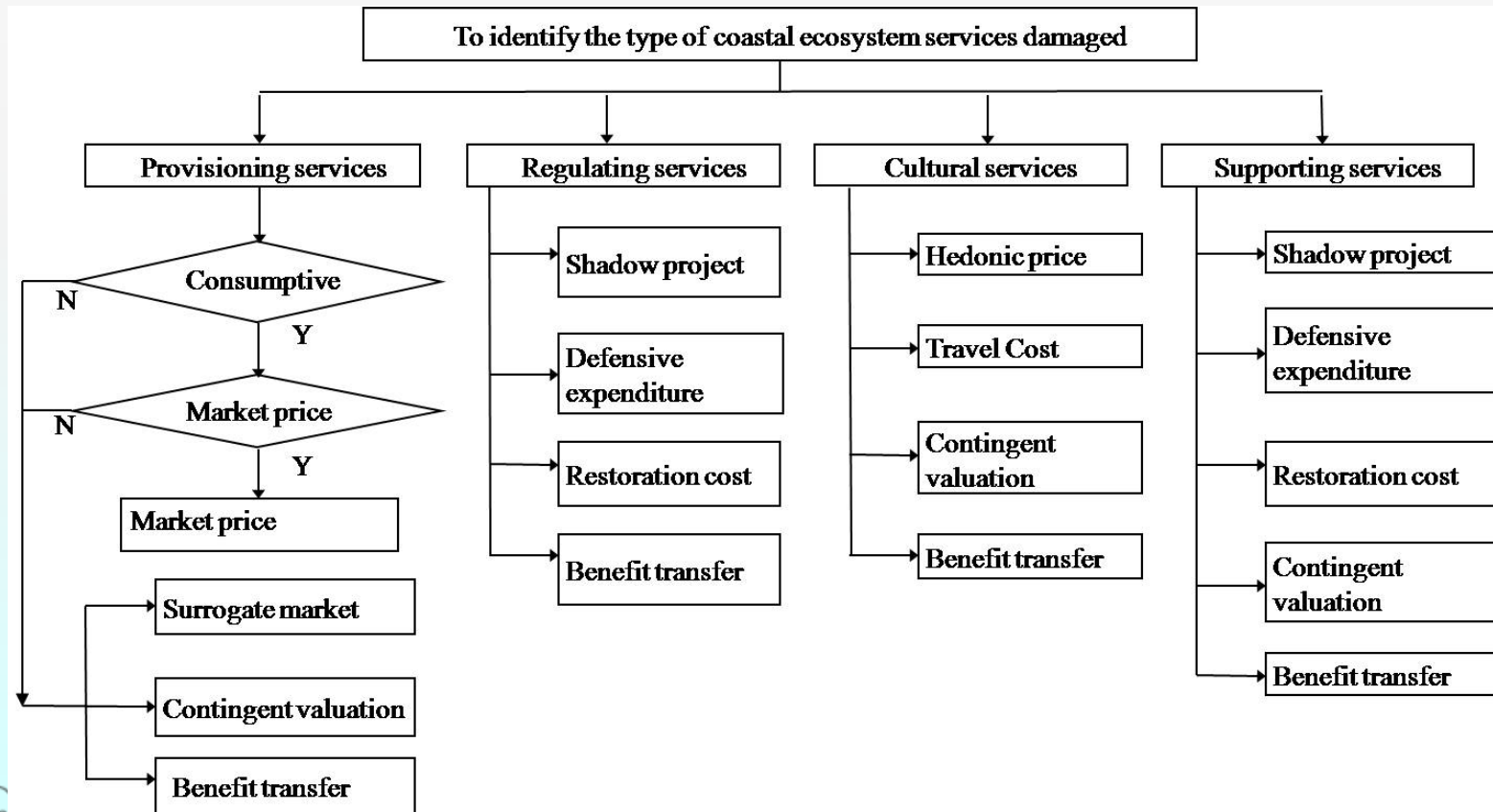
The negative impacts of sea reclamation on coastal ecosystem services:

- occupy coastal space
- permanently change the intrinsic natural quality of a coastal ecosystem: topography, physiognomy, shoreline;
- influence the hydrodynamic effect of sediment transport or alter inshore current systems;
- endanger the animals and plants (e.g. benthic organisms, mangroves, etc.);
- damage the provisioning, regulating, cultural and supporting services.



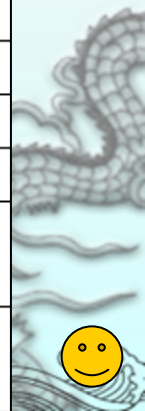
The framework for selecting valuation methods

- ◆ **Direct market approach:** productivity losses method, production function method
- ◆ **Surrogate market approach:** shadow project method, defensive expenditure method, restoration cost method, travel cost method, hedonic price method
- ◆ **Pseudo-market Approach:** contingent valuation method (CVM)
- ◆ **Benefit transfer approach**

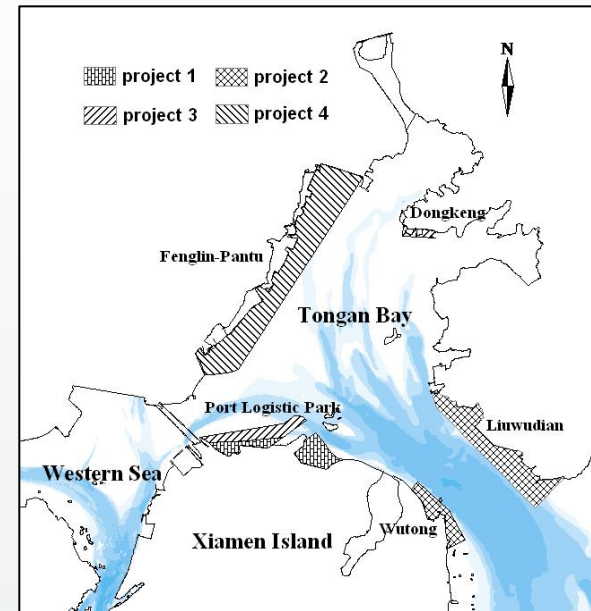


The Monetary Valuation Models

Costal Ecosystem Services [⊕]		Methods or equations [⊕]
Provisioning services [⊕]	Food [⊕]	$D_f = \frac{R_f \cdot \alpha}{S_0} \times S$
	Raw materials [⊕]	$D_r = [v - (E + T) - M \times i] \times Q \times r$
	Gene resources [⊕]	$D_g = V_g \times S$
	Ornamental resources [⊕]	$D_{or} = Q_{or} \times P \times \alpha$
	Water supply [⊕]	$D_{ws} = Q \cdot (C_2 - C_1) \cdot S$
	Maritime transport resources [⊕]	$D_{hts} = \frac{R - (1 + \rho)(I + O)}{S_{hts}(1 + \rho)} S$ $D_{\hat{a}} = M_{\hat{a}} \times C_{\hat{a}}$
	intertidal zones and shallow seas [⊕]	$D_{is} = \sum V_i \cdot S_i$
Regulating services [⊕]	Gas regulation [⊕]	$D_{ga} = (C_{co2} + 0.73C_{o2}) \sum P_{ico2} \cdot S_i \times 10^{-6}$
	Erosion control [⊕]	$D_{ec} = \frac{C \times L(1 + 2\%n)}{n}$
	Waste treatment [⊕]	$D_{wt} = \sum M_i \cdot \Delta V \cdot C_i \times 365 + \sum (\Delta N_i \cdot V - \Delta N'_i \cdot V') \cdot C_i \times \frac{24}{t} \times 365$
	Biological control [⊕]	$D_{bc} = V_{bc} \times S$
Cultural services [⊕]	Recreation and tourism [⊕]	CVM [⊕]
	Science and education [⊕]	$D_{se} = V_{se} \times S$
Supporting services [⊕]	Primary production [⊕]	$D_{pp} = \frac{P_0 E}{\delta} \sigma P \rho S \times 10^{-3}$
	Biodiversity maintenance [⊕]	$D_{bm} = S \cdot \sum \alpha_i \cdot \frac{WTP_i (WTA_i) \times U_i}{S_i}$



Case Study



Locations and areas (km²)

Schemes	Port Logistics Park	Wutong Harbor	Liuwudian Harbor	Dongkeng	Fenglin-Pantu	Total
1	1.98					1.98
2	1.98	1.32	4.43			7.73
3	3.37	1.32	4.43	0.26		9.38
4	3.37	1.32	4.43	0.26	9.86	19.24



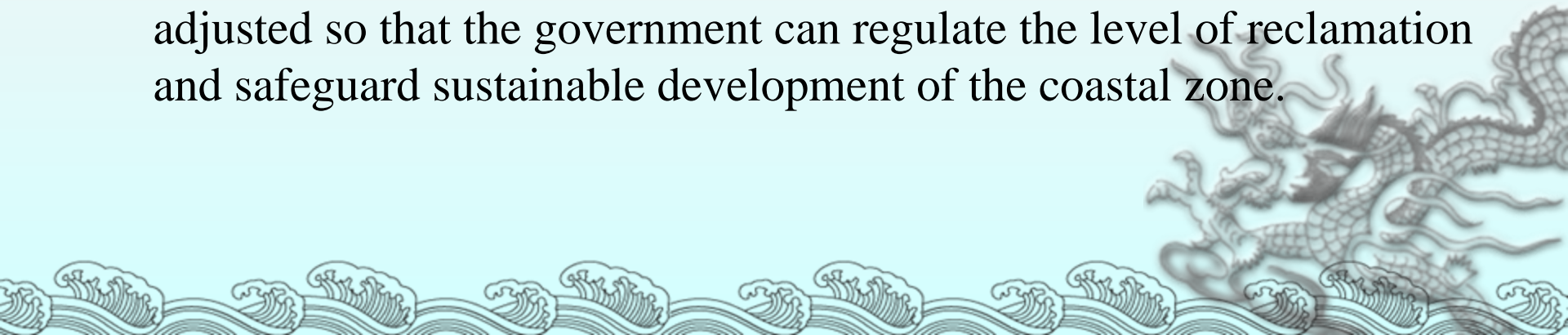
Results

Losses of Coastal Ecosystem Service Caused by Sea Reclamation Schemes (10⁴ US\$ a⁻¹)

Costal Ecosystem Services		Sea Reclamation Schemes			
		1	2	3	4
Provisioning services	Food	8.91	34.79	42.21	86.58
	Gene resources	1.17	4.56	5.53	11.35
	Maritime transport resources	0.00	0.00	0.00	2.14
	intertidal zones and shallow seas	89.90	350.98	425.90	873.59
Regulating services	Gas regulation	7.63	29.80	36.16	74.17
	Erosion control	6.56	18.16	19.60	35.30
	Waste treatment	1754.47	6916.94	8672.37	18971.44
Cultural services	Biological control	0.77	3.01	3.66	7.50
	Recreation and ecotourism	22.08	86.19	104.59	214.53
Supporting services	Science and education	1.23	4.79	5.82	11.93
	Primary production	26.11	101.93	123.69	253.71
	Biodiversity maintenance	19.58	199.77	242.39	502.62
Total losses		1938.40	7750.92	9681.91	21044.87
Losses per m² (US\$ m⁻² a⁻¹)		9.79	10.03	10.32	10.94

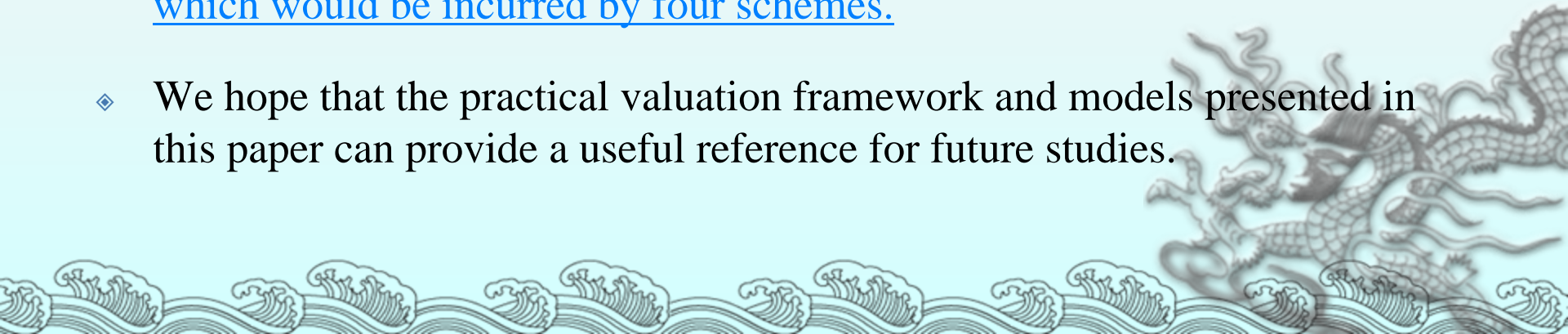
Discussion

- ◆ The actual losses may be greater due to the limitations of methods and data.
- ◆ The associated annuity of the project cost is US\$ 5.74 m⁻²a⁻¹ ---- the ecological costs are larger than the project costs and they increase with the sea reclamation area.
- ◆ The user fee for sea reclamation in Tong'an bay: RMB 7.5 m⁻² ~ RMB 22.5 m⁻² ---- too low to reflect the external cost, and cannot curb excessive sea reclamation and protect the coastal environment.
- ◆ Therefore, the user fee standards for sea reclamation should be adjusted so that the government can regulate the level of reclamation and safeguard sustainable development of the coastal zone.



Conclusion

- ◆ Analyze the negative impacts of sea reclamation on the coastal ecosystem.
- ◆ Summarize the different methods available to calculate the monetary damage to coastal ecosystem services.
- ◆ Put forward a framework for selecting feasible valuation approaches according to the characteristics of different ecosystem services.
- ◆ Establish the valuation models relevant to each of the coastal ecosystem services.
- ◆ Apply valuation models to the case of sea reclamation planning in Tong'an Bay, Xiamen, and evaluate the damages to coastal ecosystem services which would be incurred by four schemes.
- ◆ We hope that the practical valuation framework and models presented in this paper can provide a useful reference for future studies.



Acknowledgements

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Thank you

for your attention!

