

Mini Review on Managing Fishponds to Climate-Proof the Mai Po Inner Deep Bay Ramsar Site, and Implications for the East Asian-Australasian Flyway

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Abstract:

Coastal wetlands are important stepping stones and wintering sites for migratory birds along the East Asian-Australasian Flyway (EAAF). But wetlands are being extensively converted throughout Southeast and East Asia, and continued loss can disrupt the long-distance migrations, and result in species population declines and extirpations. Wetlands are also under threat from global climate change; sea level rise can inundate coastal wetlands, and the two forces of coastal development and climate change can subject the remaining wetlands to coastal squeeze. Therefore important wetlands along the flyway should be assessed for the impacts of climate change to implement proactive climate adaptation strategies. The Mai Po Inner Deep Bay Ramsar site in Hong Kong is an important staging and wintering site along the EAAF. A climate model for this wetland showed that by 2100 some of the wetlands and mudflats used by migratory birds could become inundated. In the future, under climate change scenarios, fishponds further inland, now within the 'wise-use' compartment of the Ramsar site, could represent supratidal wetlands for migratory birds. Therefore, these fishponds should be maintained and managed without the threat of conversion by providing economic incentives for fishpond operators. This analysis represents a case study for climate proofing the EAAF by engaging fishpond owners and operators for sustained management of coastal fishponds as an integrated approach for wetland management that includes aquaculture, sustainable livelihoods, bird habitat conservation, and climate-proofing coastal area.

Keywords: Mai Po; Ramsar; Hong Kong; Migratory birds; East Asian-Australasian Flyway; Water birds

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Introduction

Coastal wetlands are important stepping stones and wintering sites for migratory birds that use the East Asian-Australasian Flyway (EAAF) [1-4]. But these wetlands are being extensively and rapidly converted throughout Southeast and East Asia for development [5]; for example, over 65% of the intertidal mudflats in the Yellow Sea, one of the more important staging areas along the flyway, have been lost in recent decades [6]. Continued loss can disrupt the migration that has evolved over millennia, and species population declines and extirpations. But these wetlands are also under threat from global climate change and its consequences, notably sea level rise (SLR) and extreme storms that are accompanied by stronger wave and tidal surges [7,8]. The two forces of coastal development and climate change can subject the remaining wetlands to coastal squeeze [9-11]. Thus, important, existing wetlands along the flyway should be assessed for the impacts of climate change to plan and implement proactive climate adaptation strategies. These analyses should be conducted at site scales to identify site-scale conservation strategies based on habitat availability, current and planned land use, and restoration opportunities before options for conservation and restoration disappear.

The Mai Po Inner Deep Bay Ramsar site in Hong Kong (**Figure 1**) is one such important staging and wintering site along the EAAF. Rising sea levels and stronger storm surges expected with climate change [12,13] and shrinking mudflats because of declining coastal nourishment caused by upstream sediment trapping [14] can combine to decrease the availability of these coastal habitats for the waterbirds in Mai Po in the future. In order to inform a climate adaptation plan for the Ramsar site, Wikramanayake et al. [15] modelled the impacts of climate change and decreasing sedimentation rates on the important bird habitats in the Mai Po Inner Deep Bay Ramsar site. The authors used the SLAMM (Sea Level Affecting Marshes Model) version 6.7 [16] to simulate habitat conversion under selected sea-level rise scenarios for coastal areas in the Mai Po Inner Deep Bay Ramsar site and the adjacent areas.

Literature Review

Model outputs

The model outputs indicate no significant impact to the habitats in Mai Po until after 2075, but the 2100 projection shows an overall impact on the mangroves, marshes and tidal flats. Under a conservative 1.5 m sea level rise (SLR) scenario, at low tide there was little change in the tidal

mudflats and coastal mangroves if the current accretion levels of 8 mm/yr or more continues into the future (**Figures 2 and 3**). However, if accretion levels decrease to 4 mm/yr, as expected because of sediment trapping behind major dams on the Pearl River [14], the tidal flats are expected to be inundated even during low tide, with over 77% being lost as habitat for wading and shorebirds (**Figures 2 and 3**). Mangroves, however, will remain relatively unaffected. If accretion levels drop to 2 mm/yr >50% of the coastal mangroves could be lost because of permanent inundation of the coastal areas, even during low tide. Under the high tide scenarios, with 1.5 m SLR, over half of the regularly flooded marshes inside the nature reserve will also be inundated even with an 8 mm/yr accretion rate and less (**Figures 2 and 4**).

Under a more extreme 2 m SLR scenario, during low tide, there could be 77% and 57% loss of tidal flats and coastal mangroves, respectively, with an 8 mm/yr accretion rate (**Figures 2 and 3**). The regularly flooded marshes in the nature reserve will also lose 56% of area. During high tide most of the marshes, mangroves, and tidal flats will be underwater (**Figure 4**).

Discussion

As an important steppingstone and wintering wetland for waterbirds along the EAAF, Mai Po Inner Deep Bay Ramsar site represents a case study of how impacts of climate change and sea level rise can affect the coastal wetlands along the EAAF. The 1,500 ha Ramsar site is comprised of tidal mudflats, coastal mangroves, marshes, and fishponds with a 380 ha nature reserve zoned as a core area (**Figure 1**). Currently there are several active, commercial fishponds that surround the nature reserve, in an area designated as a Wetland Conservation Area (**Figure 1**). As part of the wise-use compartment of the Ramsar Site, these fishponds are meant to add ecological value to the nature reserve while providing sustainable livelihoods to the pond operators from the local communities.

But the climate model analysis shows that much of the existing wetland habitats in the nature reserve and tidal flats could become unavailable by the end of the century even under conservative projections of change, reduce the capacity of the Ramsar site to support the numbers of waterbirds that currently use it. The climate model also shows that some fishponds in the Ramsar site will be relatively less impacted by SLR (**Figures 3 and 4**). Managing these fishponds, rather than converting them to other land uses, should be a climate change adaptation strategy for Mai Po, since they would represent the wetland

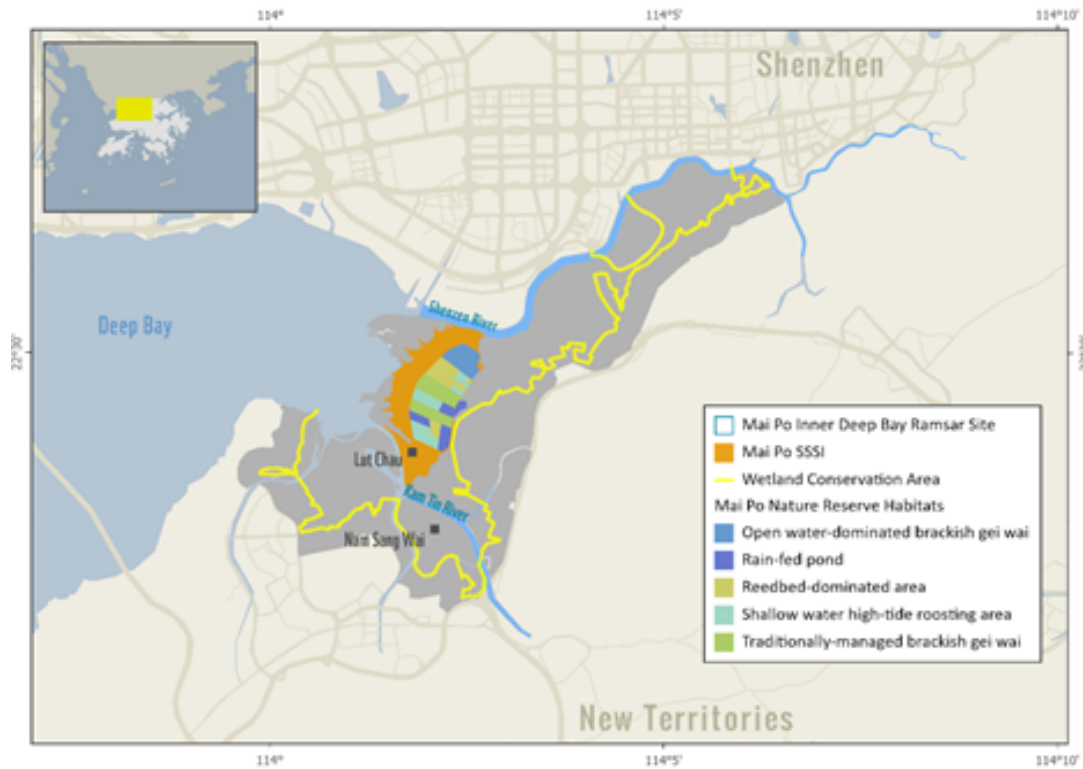


Figure 1A: Is the locator map for the Mai Po inner deep bay Ramsar site in relation to the deep bay. The Shenzhen River borders the northern boundary of the Wetland conservation area.

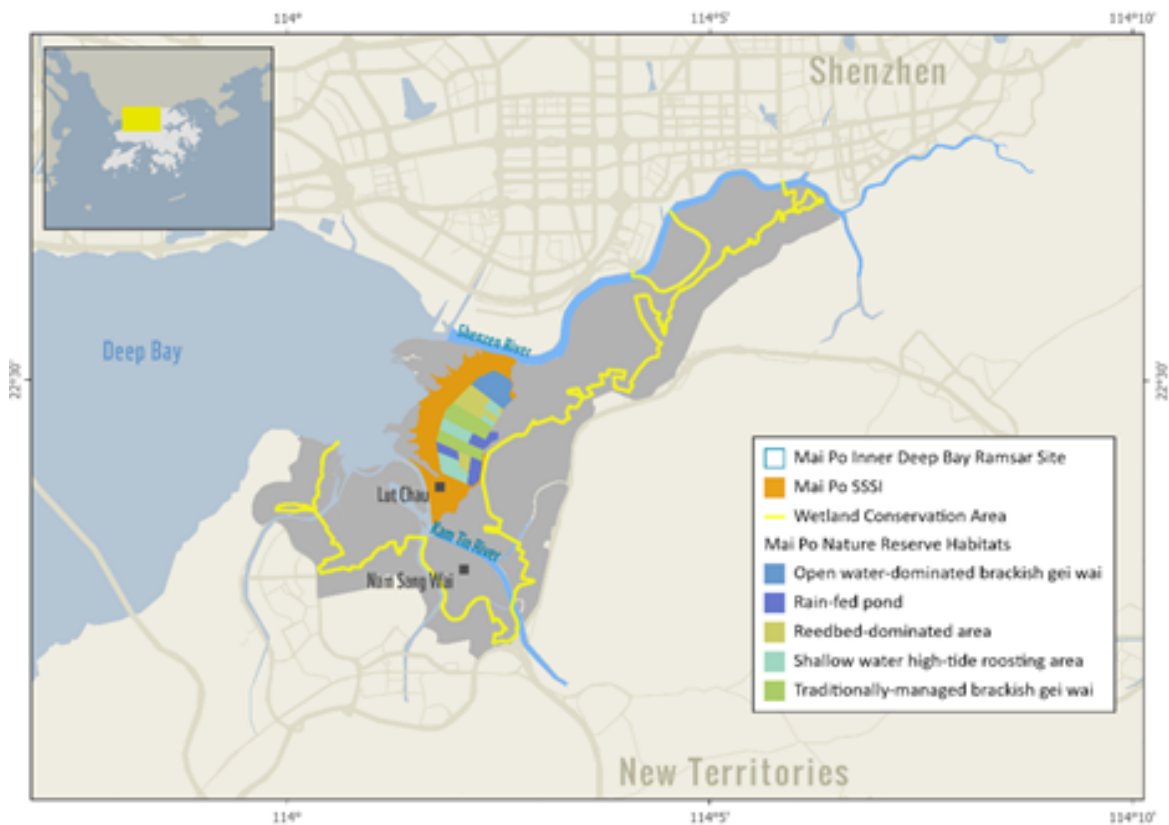


Figure 1B: Shows the major habitat types used in the SLAMM analysis.

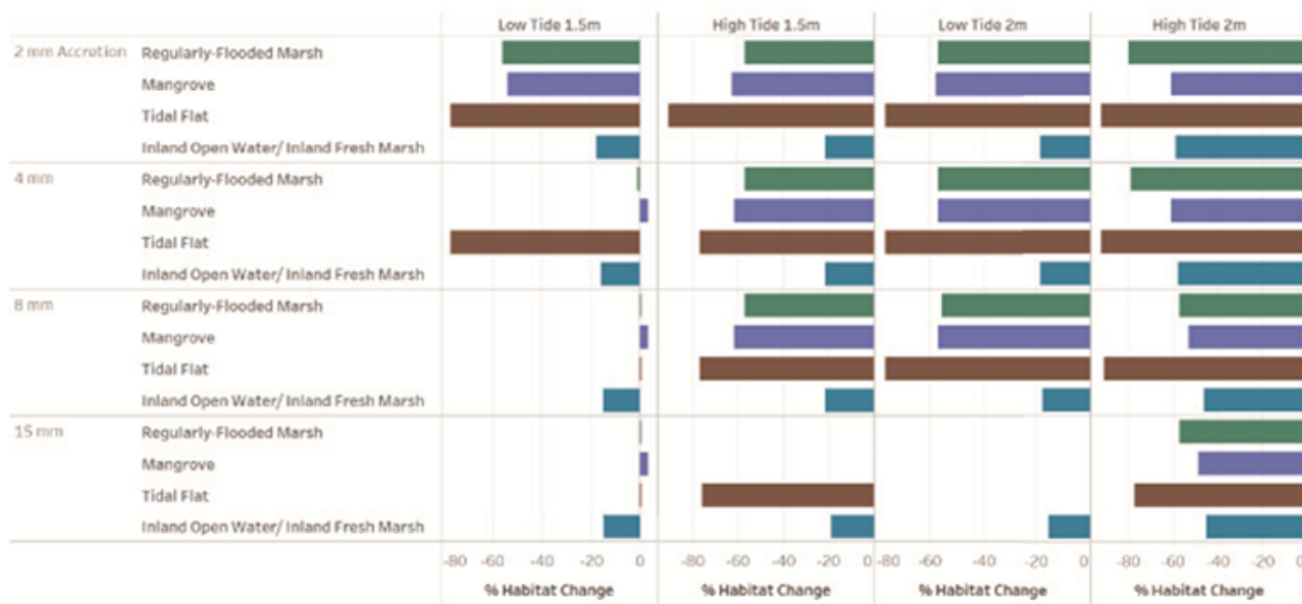


Figure 2: Changes to wetland habitats in the Mai Po inner deep bay Ramsar Site under 1.5 and 2 m sea level rise (SLR) scenarios and different sediment accretion rates in the offshore mudflats as projected by the SLAMM. Percent losses are given for low and high tide. Projection is for 2100.

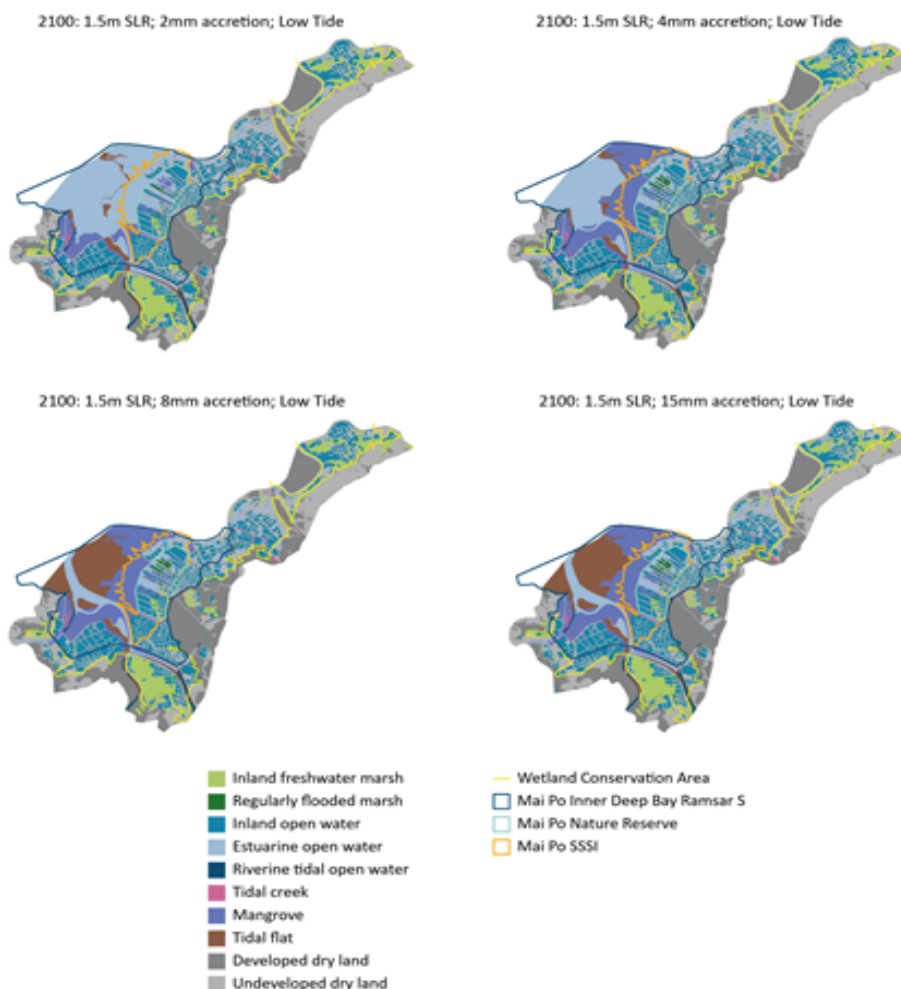


Figure 3: Climate model outputs for low tide changes to habitats under 1.5 m sea level rise and 15 mm, 8 mm, 4 mm and 2 mm/year accretion rates by 2100.

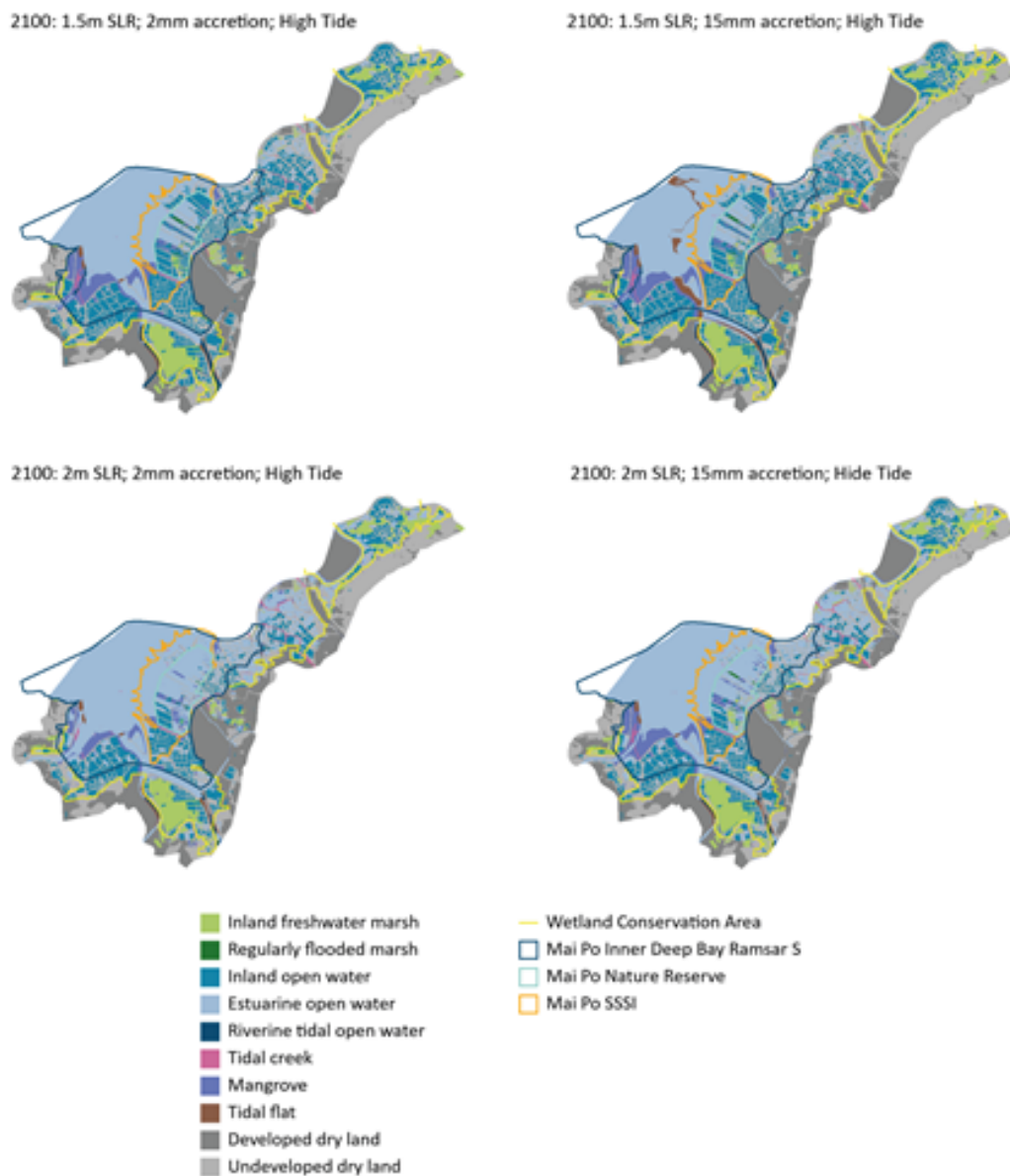


Figure 4: Climate model outputs for high tide changes to habitats under 1.5 m sea level rise and 15 mm, 8 mm, 4 mm and 2 mm/year accretion rates by 2100.

habitats for birds under future climate change scenarios. With the conversion of natural wetlands to fishponds, even now the latter serve as supratidal habitats for waterbirds during high tide in many stopover sites and wintering areas across the flyway [17]. But most of these fishponds are privately owned and operated. With increasing price competition for pond fisheries, the operators are beginning to abandon maintenance and management of fish ponds. Without the necessary management, the fishponds can be overgrown with reeds and sedges, and eventually undergo natural succession into dry lands.

The relevance to the flyway

Mai Po is only one steppingstone along the vast flyway.

There are hundreds of other such wetlands that are also threatened by encroaching infrastructure and climate change [4,6,18,19]. Strategically located wetlands are essential steppingstones to make the flyway functional for bird migrations [2-4]. Therefore, we recommend that this analysis be applied to other wetlands that serve as important staging or wintering sites along the EAAF to inform flyway-scale climate adaptation strategies that will enable the migrations to persist.

Wetlands are important for more than bird migrations.

Coastal ecosystems are among the most productive and important ecosystems in the world [20]. But they are being extensively converted to other anthropogenic land uses in

Hong Kong and throughout the region [6]. In addition to supporting high biodiversity and being important to support bird migrations, they also provide a range of ecosystem goods and services, including reducing flooding, protecting shorelines from wave and tidal surges expected from severe weather events due to climate change [21]. Therefore, climate-smart land use strategies that prevent the conversion of wetlands and promote effective management of supra tidal artificial wetlands can increase coastal resilience and reduce the vulnerability of coastal communities and infrastructure from the consequences of SLR and storms [21-27].

Conclusion

In the Greater Bay Area of the Pearl River, rapid economic development and population growth over the past four decades have resulted in extensive conversion and fragmentation of natural coastal habitats. Thus, forward-looking, proactive land-use planning to conserve the existing coastal wetlands and preventing further conversion as an integrated climate response can be facilitated and informed by similar climate impact analyses at scale. However, this should happen now, before available options become lost to the coastal squeeze of anthropogenic drivers of land use change and SLR from the landward and seaward sides, respectively.

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