CoastAdapt

Case Study

A case study of good coastal adaptation on the Hunter River, NSW

Background

The history of wetland decline on the Hunter River is profound, making the area a unique case study for understanding climate change adaptation by saline coastal wetlands. Commencing in the mid-19th century, European intervention has significantly altered the hydrology and vegetation of the coastal floodplain, largely through the construction of drainage and flood mitigation systems, dredging of channels, and reclamation for other purposes (Winning and Saintilan 2009). Saltmarsh was predominant on the coastal floodplain until about the 1950s; by 1980, the NSW Public Works Department (1980) had established extensive levees and spillways (160 km), floodgates (175), flood canals (111 km), bank protection (14 km), and diversion banks (40 km) in the Lower Hunter River floodplain.

Following community concern, in 1983 the Kooragang Nature Reserve, an area of 2926 ha, including Tomago Wetlands, was gazetted for management by the NSW National Parks and Wildlife Service (NPWS). In 1984 it was listed as a wetland of international significance under the Ramsar Treaty (NPWS 2015). Additions of Hexham Swamp Nature Reserve (900 ha) in 1990 and Ash, Campbell and Hexham Islands (723 ha) in 2010 increased the NPWS management area in the lower Hunter region.

The 4549 ha of protected coastal floodplain, now known as the Hunter Wetlands National Park, includes 29 km of estuarine foreshore and intertidal zone down to the mean low water mark and the bed of Fullerton Cove and components include the North Arm of the Hunter River and the broad swamp areas of Tomago wetlands, Hexham Swamp, and Kooragang, Ash, Hexham, and Campbell Island (NPWS 2015). In recognition that reinstating the original wetland environment is not achievable, the management objectives for the Hunter Wetlands National Park focus on protecting the Ramsar-listed wetlands and on providing for sustainable visitor use and enjoyment (NPWS 2015).

Problem: Saline coastal wetlands on the Hunter River floodplain undergoing ‘coastal squeeze’ due to land use conversion and sea-level rise.

The historic network of flood mitigation structures on the lower Hunter River floodplain and land use conversion for port development and expansion of industrial and urban land uses resulted in conversion of significant areas of the floodplain for grazing and industrial purposes (Winning and Saintilan 2009, Winning 1996). Since this time, land use has become increasingly marginalised as exposure of drained soils has facilitated the oxidation of acid sulphate soils, the release of acid products, and a reduction in water quality (Winning and Saintilan 2009). In addition, subsidence attributed to degradation of soils and limited sediment delivery has caused the conversion of large areas of the floodplain to freshwater wetland or low-lying pasture. Together with the 41% decline in saltmarsh area since the Ramsar listing of the site in 1984 (Brereton and Taylor-Wood 2010), natural resource managers have noted significant expansion of mangrove into saltmarsh habitats. This alteration is probably related to tidal changes within the estuary, which may have been driven by relative sea-level rise (eustatic sea-level rise and subsidence), or engineering works within the catchment (dredging of channels, fortifying banks, training of the entrance) (Williams et al. 1999). The consequence was a decline in the preferred saltmarsh habitat of migratory wader birds, and a risk for management of the internationally important wetlands.

Projection: Ecosystem services getting 'lost in translation'.

Modelling of the adaptive capacity of saline coastal wetlands on the Hunter River based on measurements of vertical accretion and wetland elevation adjustment since 2000 demonstrated that coastal wetlands on the Hunter River have some capacity for autonomous adaptation by increasing their vertical position in situ (Rogers et al. 2013). However, this measure is insufficient for the degree of sea-level rise projected for the latter part of the 21st century due to an imbalance in the rate of sediment supply and sea-level rise. Their ability to grow across the landscape (horizontal translation) was projected to be limited by a network of levees and floodgates that limit tidal exchange. Without management intervention the future of these coastal wetlands may be bleak, with nearly all of the existing wetlands projected to be lost by the end of the 21st century under high rates of sea-level rise.

Integration of modelling outcomes with management regimes indicated that current approaches to coastal wetland conservation, which are largely based on wetland boundaries delineated on maps, fail to recognise that coastal wetlands have an autonomous adaptation capacity. Specifically, saline coastal wetlands are dynamic and exist in four dimensions with a length, width, elevation and a trajectory through time (Rogers et al. 2013). Without appropriate planning and management that fully recognises this dynamic nature, many of the ecosystem services provided by the wetlands on the Hunter River will be 'lost in translation' due to the effects of coastal squeeze.

Solution: Tidal inundation restoration, saline coastal wetland rehabilitation and realignment of management boundaries.

Natural resource managers identified an opportunity to restore tidal exchange across the coastal floodplains in areas that were impacted by flood mitigation works. Commencing with the Kooragang Wetlands Rehabilitation project in 1993, reinstatement of tidal flows was established as a long-term objective for the lower Hunter estuary in 1998 (Russell et al. 2012). These efforts commenced with the approval of plans in 2006 for the restoration of wetlands at Tomago and Hexham Swamps. Restoration was complex and costly, requiring extensive public consultation, vegetation surveys, hydrodynamic modelling and the purchase of low-lying land behind levees and floodgates. Restoration at each location was controlled in stages to minimise deleterious impacts to water quality and wildlife. For each restoration site, management was retained by the Hunter Local Land Services (LLS) or transferred to the NPWS; wetland management boundaries were adjusted accordingly.

The *Hexham Swamp Rehabilitation Project* was achieved at a total cost of $7 million for land acquisition behind levee banks, bund construction, hydrodynamic modelling, and vegetation and wildlife surveys (Chapman and Hyde 2012). Floodgates and levee banks were constructed in 1971 at Ironbark Creek – the main tributary of Hexham Swamp (Figure 1) – to mitigate flooding and improve grazing outcomes (Winning and Saintilan 2009). Hydrodynamic modelling indicated that opening floodgates would inundate a greater area of Hexham Swamp and elevate the inundation depth. It was

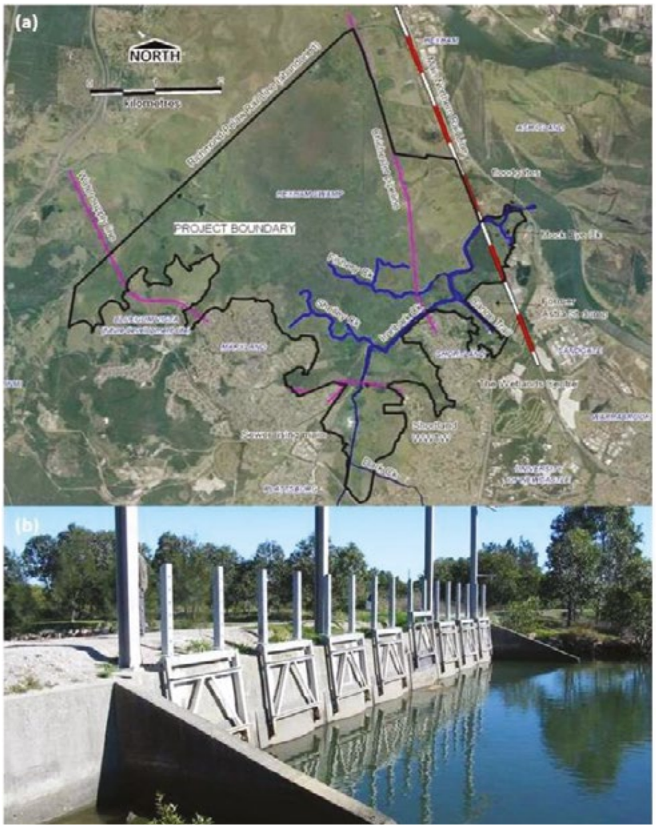

Figure 1: (a) Hexham swamp project boundary and (b) one of the floodgates where opening is managed to reinstate a more natural regime of tidal inundation. Source: Haines 2013.

projected that this would facilitate the reconversion of the brackish wetlands dominated by *Phragmites australis* and *Casuarina glauca* to a condition typical of saline coastal wetlands (Haines 2013). Floodgates were opened in three stages, with the first of eight floodgates opened in December 2008. The final two floodgates were opened in July 2013 (Hodgkinson 2013). The project has restored tidal inundation to 650 ha of land in Hexham Swamp, and there are notable transitions from a *Phragmites*-dominated wetland to a wetland mosaic with mangroves, saltmarsh, open water, and *Phragmites* (Chapman and Hyde 2012). The restoration has improved habitat for juvenile fish, prawns (Boys 2015), and waterbirds (Chapman and Hyde 2012), and this will have an economic benefit in the region. The restoration project is being managed by the Hunter Local Land Services.

The *Tomago Wetland Rehabilitation Project* restored tidal inundation to land behind levee banks that was transferred to the NPWS in 1985 from BHP for nature conservation (Russell et al 2012). The project reinstated tidally isolated land dominated by pasture grasses and weeds and impacted by cattle to a functioning wetland mosaic that provides important habitat and passage for fish and waterbirds (Winning 1996). The three-stage project (Figure 2) was underpinned by hydrodynamic modelling and monitoring of water levels, water quality, flora, and fauna surveys and assessments of flood area. It included the construction of levees, culverts and swing gates that enabled hydrological control of inundation. Commencing in 2008 with the opening of four floodgates, the project is now nearing completion after the opening of the final floodgates in August 2015. Monitoring indicates that the project has, and will continue to increase saltmarsh area, migratory bird feeding and roosting habitat, improved fish passage and access to wetland habitats, improved water quality, and a reduction in acid sulphate soil problems (Russell et al. 2102). Recent land additions at Tomago will allow for saltmarsh migration to higher elevations in the landscape as the landscape becomes impacted by sea-level rise. The restoration project is being managed by the NPWS.

Adaptation outcome: Improvement of ecosystem services.

The primary objective of enhancing current waterbird and fish habitat has been achieved for the Hunter Wetlands by tidal restoration. Restoration has also increased the adaptive capacity of wetlands in this region by allowing horizontal translation across the coastal floodplain. This will be achieved by creating a pathway for habitat migration behind levee banks that now receive regular tidal inundation through floodgate management. Tidal restoration has also improved the capacity for vertical translation by creating a pathway for sediment to be delivered behind levee banks, thereby increasing the potential for wetlands to increase elevation at rates that offset sea-level rise.

Realignment of management boundaries following restoration ensures that this adaptation pathway is protected from future land use conversion and impacts. Projections based on a low sea-level rise scenario, as shown in Figure 3a, indicate that autonomous adaptation achieved through tidal reinstatement and both vertical and horizontal

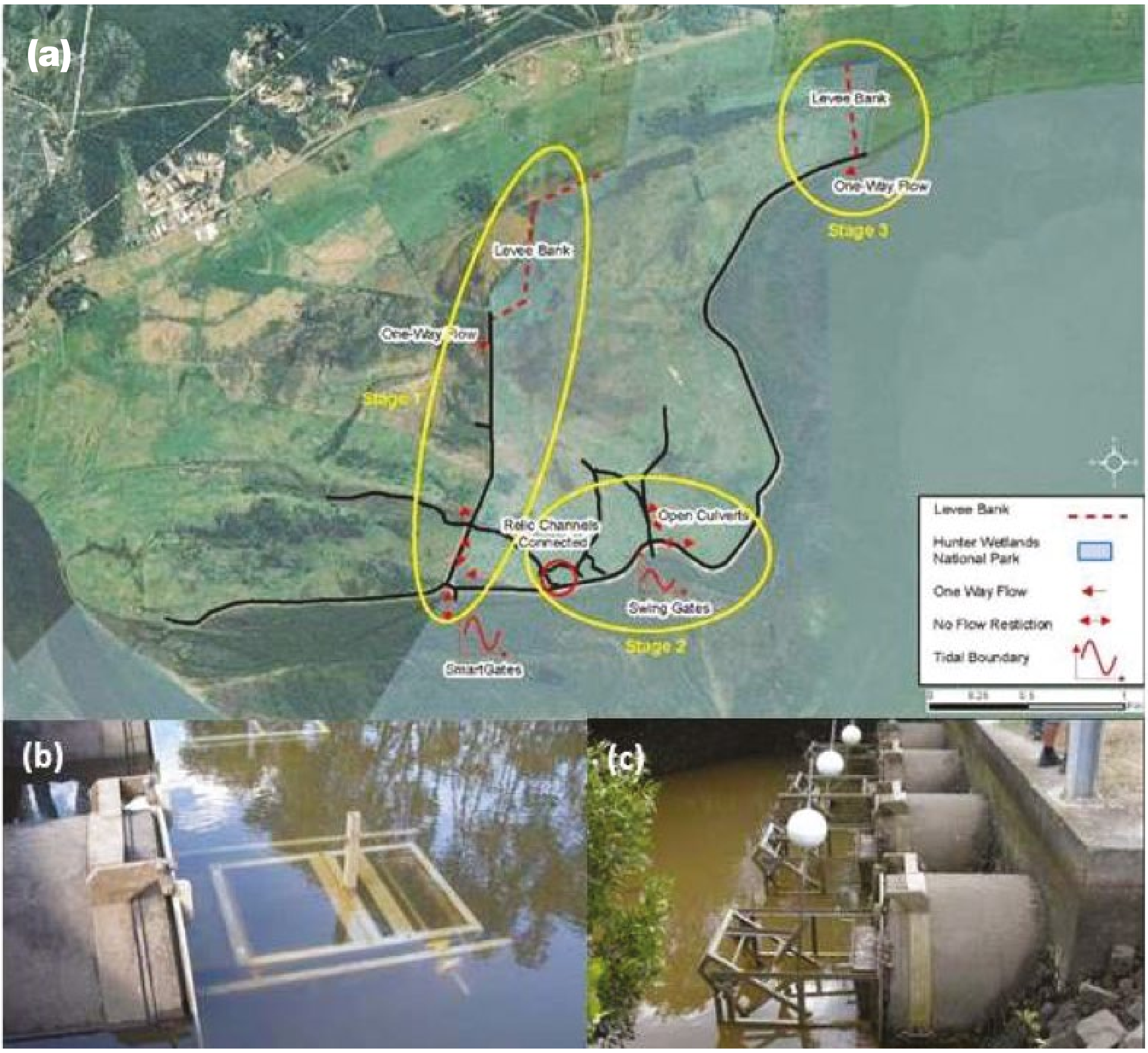

Figure 2: (a) Staged works plan for Tomago Wetland Restoration Project, and (b-c) open and closed swing gates installed as part of the Tomago Wetland Restoration Project. Source: Russell et al. 2012.

translation of saline coastal wetlands can effectively offset increases in sea level (Rogers et al. 2013). These projections indicate that there are many opportunities for restoring the natural vegetation of the coastal floodplain through tidal reinstatement and targeted land acquisitions.

Continuing acquisition of land and tidal reinstatement to the coastal floodplain becomes more pertinent under conditions of high sea-level rise, with projections (Figure 3b) indicating that existing land acquisitions and restoration projects, particularly at Tomago Swamp, may not be sufficient to offset high rates of sea-level rise (estimated to occur at rates exceeding 9 mm/y) (Rogers et al. 2013).

To ameliorate these effects, the NPWS plan to make strategic additions of land to the Hunter Wetlands National Park and to further promote extensions of saltmarsh and shorebird habitat across adaptation pathways (NSW NPWS 2015). This will be further facilitated by cooperative arrangements with neighbouring landholders to encourage protection and enhancement of existing native vegetation, key habitats, and habitat corridors.

Under both low and high sea-level rise scenarios, there is a need to maintain or enhance adaptation capacity, particularly sediment supply. To this end, actions in the upper catchment that limit sediment delivery to the lower catchment, such as increased

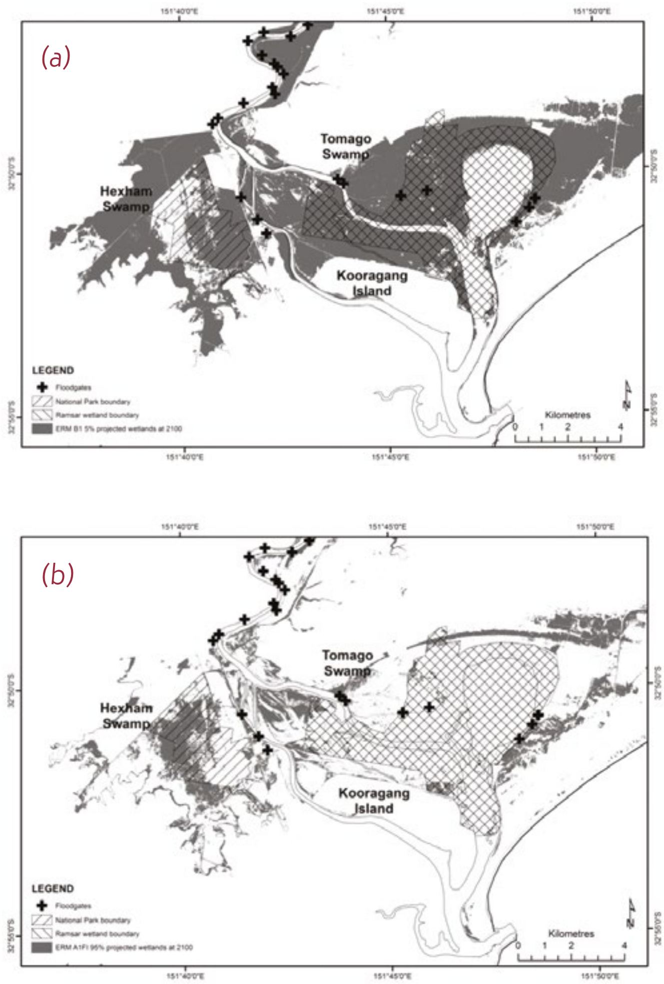

Figure 3: Projections of saline coastal wetland distributions on the Hunter River, NSW, at 2100 using an ecosystem response model based on a (a) low sea-level rise scenario; and (b) high sea-level rise scenario, and assuming no barriers to horizontal translation. Source: Rogers et al. 2013.

river regulation and damming, may have detrimental effects on coastal wetland adaptation by reducing available sediment for vertical translation (Lovelock et al. 2015). Declines in saline coastal wetland extent may be exacerbated by activities in the lower catchment that increase the wave and tide energy (e.g. dredging and its effects on the tidal prism) affecting mangrove shorelines causing erosion of sediments.

The gain in ecosystem services achieved by facilitating wetland adaptation can be significant. Increasing the area exposed to tidal inundation correspondingly increases the fisheries and habitat services provided by saline coastal wetlands, increases the area that can store flood waters after extreme weather events, and enhances shoreline protection from erosive wave action. Water quality will improve in restored areas as subsurface acid sulphate soils have less opportunity to oxidise and release acid products. Carbon storage improves by virtue of increased habitat area and plant productivity achieved through tidal reinstatement and the addition of carbon-laden sediments delivered on tidal waters. The carbon store is projected to increase by up to 280 000 tonnes by the end of the century under a scenario of high sea-level rise, thereby having an effect on the carbon mitigation (Rogers et. al 2013, Rogers et al. 2014).

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