Estuarine, Coastal and Shelf Science 183 (2016) 271–274

Contents lists available at ScienceDirect

Estuarine, Coastal and Shelf Science

journal homepage: www.elsevier.com/locate/ecss

Sustainability of future coasts and estuaries: A synthesis

Coasts are at the nexus of the Anthropocene, where land, marginal seas and atmosphere meet along a thin strip that is inhabited by nearly half the human population (Wolanski and Elliott, 2015). Coasts are often fringed by rich habitats such as mangroves, saltmarshes, inter-tidal mud and sand flats, seagrass meadows, kelp forests and coral reefs that provide a valuable range of ecosystem services to humans and to the adjacent marginal seas (Van den Belt and Costanza, 2011). It is the highly dynamic system that is constantly being reshaped by changing natural forces and anthropogenic activities. Coastal systems and human societies form coastal social-ecological systems that increasingly face multiple pressures, which threaten their ecological and economical sustainability. Common pressures include changes to land use and hydrology, land reclamation, coastal sand mining, harbour dredging, pollution and eutrophication, overexploitation such as overfishing, all in the context of climate change. During the 20th Century, coastal scientists studied the problems and issues arising along the coasts (Ramesh et al., 2015). Now, in the 21st Century, their focus must increasingly be about how to solve these problems and issues through better management and innovative approaches. To study these matters, two workshops were held in Yantai, P.R. China, in September 2015, hosted by the Yantai Institute of Coastal Zone Research, CAS. The outcome of these workshops is this special issue of Estuarine, Coastal and Shelf Science.

Our Special Issue has unprecedented international coverage, providing an extensive series of papers with an extraordinary variety of case studies worldwide (Fig. 1). These papers describe sustainability issues in Australia (Brodie and Pearson), Bangladesh (Nicholls et al.), China (Li et al.; Wu et al. – 2 papers), Guam (Shelton and Richmond), India (Benthou et al.), Japan (Matsuda and Kokubu), Pakistan (Kidwai et al.), Portugal (Sampath and Boski), USA (Day et al.; Kemp et al.), Vietnam (Nhan), West and East Africa (Diop and Scheren), Nigeria (Abgoola et al.) and about world-wide delta sustainability (Day et al.). All the estuaries, deltas and coastal waters in those study sites suffer environmental damage from a wide range of human activities that include changing land-use in the watershed, dams and irrigation projects and river diversion changing the hydrology and the sediment transport of rivers, changing uses and often over-development of the coast, land reclamation in the estuaries and tidal wetlands, dredging and pollution, coastal squeeze of the remaining coastal wetlands, overfishing, climate change, and others. However, the outcome for the ecosystem health varies from site to site, from doom and gloom stories to possibly hopeful stories and even some bright spots. These lessons to be extracted are thus what determine the commonalities and the differences between biophysical and socio-economic processes that determine the different ecosystem health at these sites, and their likely evolution in the foreseeable future.

The papers in this special issue all highlight the impact of multiple pressures, something that complicates management due to historical, political and legal reasons. The impacts of these pressures are often acting in cumulative and synergistic manners, and readily affecting the overall health and stability of the estuarine and coastal ecosystem, and threatening their resilience over the short- and long-term. This is exemplified in the paper by Diop and Scheren that highlights the enormous challenges now faced by the coastal states of Eastern and Western Africa to restore and manage their estuarine and coastal resources after decades of benign neglect when the multiple stressors were allowed to grow unchecked. A major overhaul of the governance and management of the coastal and marine environment at national to regional scales in East and West Africa is needed.

The importance of multiple stressors is also illustrated in the paper by Brodie and Pearson about the Great Barrier Reef (GBR) in Australia. While the GBR is a World Heritage site, many of the species and ecosystems of the GBR are in poor condition and continue to decline due to catchment pollutant runoff, the effects of fishing and climate change impacts (e.g. resulting in coral bleaching). The current management regime is clearly inadequate to prevent further decline. Brodie and Pearson propose a management largely based on 'triage' to strengthen management in the areas where ecosystems are still in good condition, as well as cross-boundary management to include terrestrial, freshwater and marine ecosystems. This requires two major commitments to bridge the science-policy gap (Borja et al., 2016): (i) funding to effectively solve land-based pollution issues before climate change impacts fully on the GBR ecosystems; and, (ii) that Australia adopts greenhouse gas emissions control at a scale relevant to protecting the GBR.

The construction of dams and reservoirs since the 1950s has caused an average 44% decline in sediment supply to 33 of the world's major river deltas, and reductions in sediment loads coupled with rising sea level are affecting sustainability of deltaic ecosystems worldwide (Syvitski et al., 2009). Papers in this special issue quantify these effects for the estuaries of the Guadiana, Indus, Mississippi, Yellow and Changjiang rivers. The issue of multiple pressures that include dams is addressed in the paper of Sampath and Boski, on the morphological evolution of Guadiana estuary in Portugal during the 21st century. The effects of a dam-induced reduction in river discharge and projected sea-level rise has resulted in a net loss of sediment in the estuary. The results indicate that the legal requirement to maintain a minimum environmental flow are insufficient to maintain the ecosystem. Thus the European

http://dx.doi.org/10.1016/j.ecss.2016.11.017

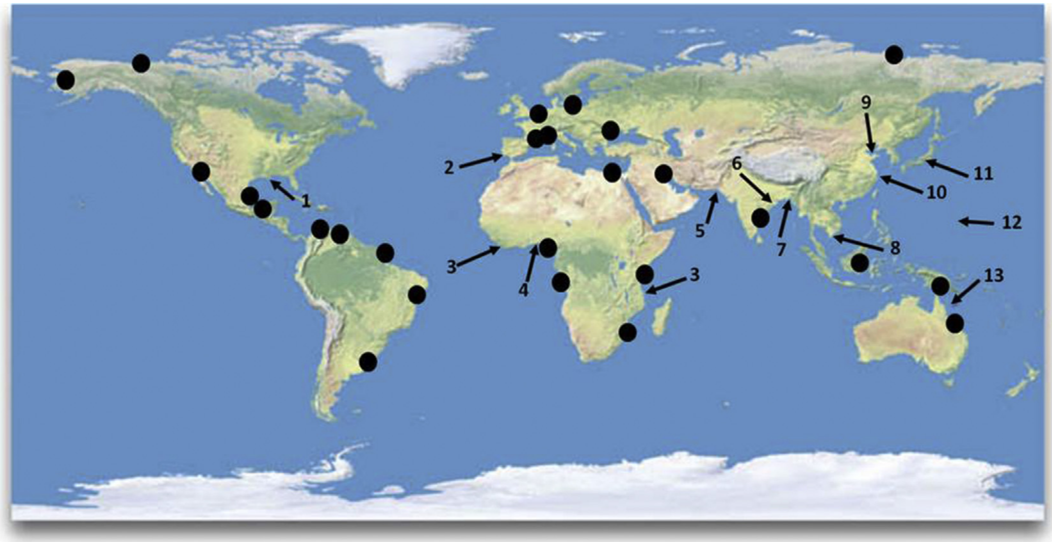

Fig. 1. World map showing (arrows) the location of the study sites in the papers in this special issue and (filled circles) the sites the deltas evaluated for their sustainability in the review by Day et al. (this issue). 1. Mississippi River delta, USA. 2. Guadiana Estuary, USA. 3. East and West Africa. 4. Lagos lagoon, Nigeria. 5. Indus River delta. 6. Chilika lagoon, India. 7. Ganges-Brahmaputra-Meghna delta, Bangladesh. 8. Mekong River delta, Vietnam. 9. The Yellow River delta and the western Bohai Sea, China. 10. The Changjiang River delta, China. 11. Ago Bay, Japan. 12. La Sa Fu'a watershed, Guam. 13. The Great Barrier Reef, Australia. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

legislation needs to be updated to include the full spectrum of natural flows and their temporal variability in order to better cope with future sea-level rise.

Multiple human-induced stressors including dams are also impacting the Indus River delta in Pakistan as is described in the paper of Kidwai et al. These stressors are the severe decrease of freshwater flow in the Indus River as a result of extraction of water for irrigation, industrial and potable water. This is causing hypersalinity, destroying coastal wetlands on which the coastal fisheries depend, and impacting the direct exploitation of the delta ecosystems and its coastal fisheries by local delta communities and external users. Proposed remedial measures include the creation of Marine Protected Areas and ecosystem-based management of the Indus River delta resources.

The paper of Kemp et al. documents the rapid shrinking of deltaic wetland area in the Mississippi River delta (USA), which has lost nearly 5000 km^2 to open water since 1932, much of the loss due to the human activities of building dams, flood control levees and dredging navigation and oil/gas/pipeline channels while strong, natural meteorological and oceanographic drivers continue to also impact the delta. The Yellow River freshwater discharge has been declining steadily since the 1950s, and is now almost entirely regulated. Man-made floods are generated in summer. These floods are a primary contributor of the terrestrial materials to the Bohai Sea in China, as discussed in the 1st paper of Wu et al. The high concentrations of nutrients from these man-made floods play a significant role in sustaining phytoplankton growth in coastal waters of the western Bohai Sea off the Yellow River delta. In February to May, when the river flow is very low, strong winds and large waves re-suspend and vertically mix the nutrient-rich riverine sediment deposited after the man-made river floods in summer, resulting in higher chlorophyll-a concentrations. Even with such a large human impact in the Yellow River catchment, natural events occasionally remind us that we cannot forget nature either. Indeed, as discussed in the 2nd paper of Wu et al., the passage of typhoon Meari caused significant surface cooling and an abnormal increase in sea surface elevation along that same coast, and also resulted in an increase of 2–3 °C in temperature, a decrease of 0.3 in salinity and a two-fold increase of Chl-a concentration in the middle layer.

The Yellow River delta degradation story mirrors that of the Changjiang River delta, also in China. In their paper about the Changjiang River delta, Li et al. report that dams have cut off about 2/3 of the sediment flux to the sea and 60% of the dissolved silicate load, while total phosphorous and total nitrogen transport to the delta are many times more than they were a few decades ago due to wastewater from urban and rural areas. They describe the details of the estuarine degradation since the 1950s, by using sedimentary biological silicate and total organic carbon as environmental proxies. The whole ecosystem has been degraded and it is unclear what management solutions maybe possible for remediation.

A somewhat similar story of historical degradation is also reported by Abgoola et al. for the wetlands of the Lagos lagoon, in Nigeria. Large-scale land reclamation, refuse and sewage dumping have had a substantial impact on the ecological health of these wetlands. Nevertheless Abgoola et al. find that the Lagos wetland ecosystems still have some semblance of natural habitat. Thus the destruction and unwise use of the resources must be prevented to avoid destroying what remains of these wetlands, even if they are degraded, if only because the livelihood of local communities and their lifestyle depend on these wetlands.

In view of such degradation, what are the solutions? Any solution must start from our willingness to define our future vision of the coast and our coastal aspirations. Day et al. in their paper on delta sustainably demonstrate that the impact of land-use and dams in the catchment, together with climate change and the cost of energy, will make achieving delta sustainability increasingly difficult the more we delay action to restore natural delta functioning through the use of an ecological engineering approach to manage human activities in deltas. Day et al. have elaborated a hierarchical model of deltaic sustainability as a function of geomorphic, ecological, and economic sustainability. This can be used to assess the effectiveness of various decision making scenarios, including methods of numerical modeling such as used by Sampath and Boski for future projection of morphological evolution of the Guadiana Estuary. Thus, scientists are providing assessment tools to support sustainability, but this can only be successful if the