**Low Lying Agricultural Lands and Coastal Squeeze: Seawater Intrusion and Subsidence**

Coastal habitats adapt to environmental and climate change, e.g., sea-level rise by migrating inland to retain their relative function and structure. Coastal squeeze occurs where coastal armoring or other barriers prevent this natural migration creating fixed margins between the land and sea.1, 2 Coastal squeeze may lead to the loss of intertidal habitats or even entire intertidal zones. The rate at which the loss takes place is dependent on factors such as the geographical formation of the coast. 1

Coastal armoring changes the natural dynamics of shoreline sediment transport. In coastal and riverine areas, sustained sediment supplies are important for maintaining shoreline position and for offsetting surface subsidence. Surface subsidence is the decline in surface elevation due to the loss of sediment deposits. 3 Trapped behind sea defense systems, wetlands, mangrove, and marshes become increasingly vulnerable to accelerated surface subsidence, erosion, and decline. 4

Subsidence may also occur due to different forms of underground failure.3,8 In many areas, large tracks of wetlands have been converted to agricultural use. 5  that have been protected behind coastal defense structures such as flood banks.6 Supporting such agricultural enterprises has meat adopting irrigation practices that involve extracting potable water from deep underground aquifers. This leads to groundwater fluxes, saltwater intrusion, and deep subsidence. 7 This process is manifested on the surface of agricultural lands as tilting, sinking, and slumping of the soil surface. Deep subsidence has also been attributed to tectonic activity and deep basin processes that have destroyed agriculture infrastructure. 8,9

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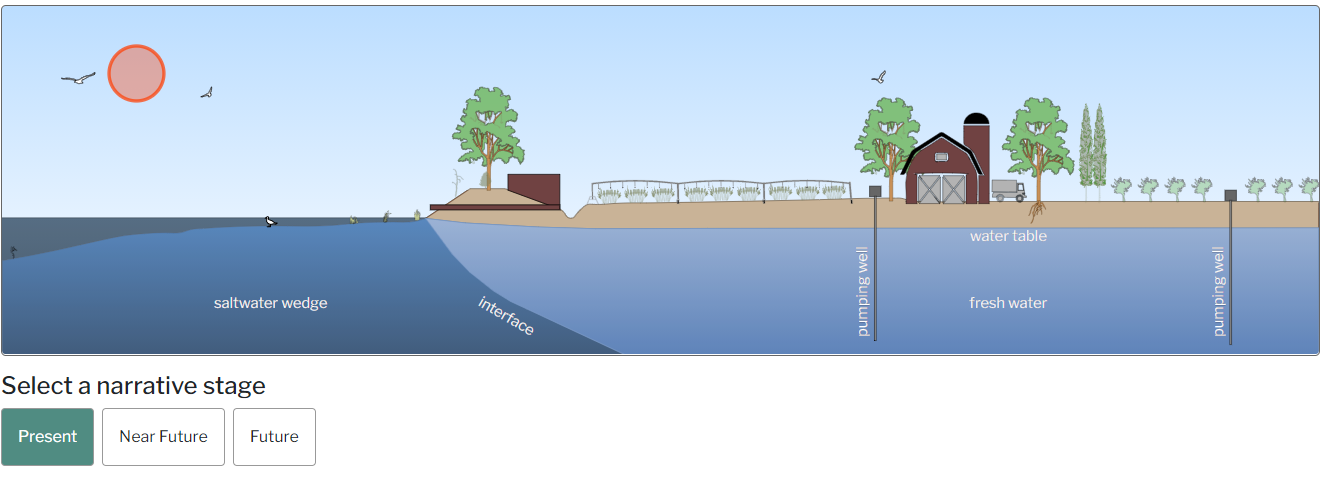
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Zone 1

Zone 3

Zone 2

**Zone 1 (present)**

Coastal squeeze has led to the loss of the intertidal zone. Hence, a flood wall was constructed to protect the remaining farmlands in zone 2.

**Link to article**

Morley, S. A., Toft, J. D., & Hanson, K. M. (2012). Ecological effects of shoreline armoring on intertidal habitats of a Puget Sound urban estuary. *Estuaries and coasts*, *35*(3), 774-784. https://link.springer.com/article/10.1007/s12237-012-9481-3

**Zone 2 (near future)**

Overtime, higher rates of the removal of ground water from aquifers (for farming) compared to natural rates of recharge leads to saltwater intrusion into underground aquifer.

**Link to article**

Duan, Y. (2016). Saltwater intrusion and agriculture: a comparative study between the Netherlands and China. <https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1060822&dswid=-7709>

**Zone 3 (future)**

Further removal of ground water exacerbates the process of saltwater intrusion and leading ultimately to subsidence, i.e., slumping of the soil surface.

**Link to articles**

Tully, K., Gedan, K., Epanchin-Niell, R., Strong, A., Bernhardt, E. S., BenDor, T., ... & Weston, N. B. (2019). The invisible flood: The chemistry, ecology, and social implications of coastal saltwater intrusion. *BioScience*, *69*(5), 368-378. <https://academic.oup.com/bioscience/article/69/5/368/5487218>

Corbau, C., Simeoni, U., Zoccarato, C., Mantovani, G., & Teatini, P. (2019). Coupling land use evolution and subsidence in the Po Delta, Italy: Revising the past occurrence and prospecting the future management challenges. *Science of the Total Environment*, *654*, 1196-1208. <https://doi.org/10.1016/j.scitotenv.2018.11.104>

Gambolati, G., Putti, M., Teatini, P., & Stori, G. G. (2006). Subsidence due to peat oxidation and impact on drainage infrastructures in a farmland catchment south of the Venice Lagoon. *Environmental Geology*, *49*(6), 814-820. <https://idp.springer.com/authorize/casa?redirect_uri=https://link.springer.com/content/pdf/10.1007/s00254-006-0176-6.pdf&casa_token=XoydP2nKyVcAAAAA:U9bZbWghOp_sOZdyAzuAiNb3dztbMN3V2NL7Ky-YprCeqBuY6oq9W6h-VymlHReQs2ebtigjJ4MUSCijdw>

Piesse, M. (2019). The Mekong Delta: land subsidence threatens Vietnam’s “food basket”. *Strategic Analysis Paper*. <https://www.futuredirections.org.au/wp-content/uploads/2019/07/The-Mekong-Delta-Land-Subsidence-Threatens-Vietnams-Food-Basket.pdf>

**Critical infrastructure, Drainage and Utilities: Shipping and Communications**

Coastal urban agglomerations are supported by critical infrastructures such as communication networks, port facilities, and transportation systems that are important for sustaining social and economic activities. 1 When these systems malfunction, negative effects feedback to local and national economic activity.

Many low-lying coastal areas will face significant risks from the current and future impacts from SLR and storm surges that would in turn create negative effects on road networks and marine port operations and communication systems that support these operations. 1, 2 For example, coastal disasters may affect micro power grids because sustaining power supplies may be dependent on road networks through which diesel or other fuel is delivered to power plants. 3

Failures in micropower grids caused by coastal storms may also affect marine ports by disrupting power supplies that sustain port operations. Responding to these impacts may require policy prescriptions that focus on building resilient port infrastructure that enhances capacity during times of disasters and that address both the frequency and magnitude of coastal disasters. 4 Responses also need to consider the context of future urban development trajectories and the emergence of new technologies. 5, 6

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**Coastal squeeze: Habitat Loss, Erosion**

In many coastal cities, population growth has meant a concomitant loss of coastal subtidal and intertidal habitats but also coastal armoring to protect important economic assets. 1, 2 The increase in SLR and storm surges and the impacts in coastal areas has also caused an acceleration in erosion rates in exposed areas. In other areas that have been reinforced with hard defense structures, erosion has led to the failure of flood defense systems.

Coastal defense systems, e.g., groins, breakwaters, and jetties have the effect of changing the dynamics of water movement with attendant effects on rates of erosion and deposition. Likewise, built development in the form of ports and harbors have exacerbated erosive processes and longshore sediment transport. 3 At the same time, coastal defense systems have been impacted by the increasing intensity and frequency of storm surges that have led to site specific flood defense failure. For example, storm surges hydrodynamics might cause toe scours or crown amour failure in sea walls.

Some of the factors that might trigger failure in coastal structures include beach bathymetry, onshore coastal topography, coastal geomorphology, wave conditions, and sediment characteristics. 4 When coastal defense systems fail this often leads to failure of critical coastal infrastructure including road, building, and bridges and related economic loss. 5

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**Infrastructure at Risk: Waste Treatment and Electricity**

Critical infrastructure face high levels of exposure to meteorological hazards such as storm surges. These hazards are expected to increase in intensity and frequency due to climate change negative impacts on electricity networks. 1 Disruption to electricity networks causes blackouts at power plants which in turn disrupt the operations of key industries, such as manufacturing and agriculture, and support services such as wastewater management systems. 2

Wastewater treatment plants are critical conveyance systems of grey and black water that protect human health and environmental safety. In coastal communities, treatment plants may be constructed at low elevations near the coastline to facilitate the movement of wastewater using gravity flow. This minimizes the need for wastewater pumping stations (Hummel et al., 2018). 3 Location of wastewater pumping stations near the coast also facilitates the discharge of wastewater into the ocean. However, locating wastewater plants near the coast poses several risks.

Firstly, wastewater plants may be susceptible to flooding and silting as a result of storm surges that may disrupt mechanical and electoral components. Secondly, storm surge events usually trigger power failure hence wastewater treatment plants may be rendered inoperable during a coastal disaster. A plausible solution to this problem could be the construction of wastewater treatment plants above the predicted storm surge level. 3 This will, however, add to the cost of wastewater conveyance. 4

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