



Pride and prejudice of the anthropocene coasts

Dhritiraj Sengupta^{a,b,*}, Dominique Townsend^c, Sally Brown^b, Ivan D. Haigh^d, Ian Townend^d

^a Plymouth Marine Laboratory, Prospect Place, Plymouth, PL1 3DH, UK

^b School of Geography and Environmental Science, Highfield Rd, Southampton, SO17 1BJ, UK

^c National Institute of Aquatic Resources, Technical University of Denmark, Section for Coastal Ecology, Kemitorvet, Kgs Lyngby, DK-2800, Denmark

^d Ocean and Earth Science, National Oceanography Centre, University of Southampton Waterfront Campus, European Way, Southampton, SO14 3ZH, UK

ARTICLE INFO

Keywords:

Coastal land reclamation
Cultural significance and view from space

ABSTRACT

This short communication highlights the emergence of complex design coastal reclamation for high-end property development, which we term 'prestige reclamation'. The prestige reclamation planiforms are typically symbols, showcasing national pride, or highly crenulate designs to maximise the perimeter: area ratios, ensuring the greatest waterfront potential on the newly constructed artificial shores. Numerous questions arise as these new coasts are built: 1) what is the ecological impact of such developments, and does it differ from existing industrial and agricultural reclamations; 2) how might the complex designs affect the water quality within and around the reclamations; and finally 3) for these developments geared towards high end real-estate, recreation and tourism, how have the developments affected people living in and near these new coasts? We recognise that we stand at a crucial point in time to study these prestige reclamations, with rising sea levels, a global biodiversity crisis and a tempestuous financial climate. Therefore, this topic demands further attention and global collaboration to collectively study impact and provide alternatives to the growing demand of coastal land.

1. Introduction

Growing up in the nineties we were told that the Great Wall of China was so huge you could see it from space. Fifteen years later, and the introduction of Google Earth allowed easy and free access to images of the Earth's surface as never seen before (Woodcock et al., 2008; Wulder et al., 2012). This platform has inspired showcase designs for mega-structures including land reclamation projects. Natural coastlines have been transformed into vast urban metropolises projecting out from the sea confined within abstract shapes. This is an extreme example of anthropomorphism carried out at a landscape scale. This article aims to bring attention to the rapid development and growth of up-market coastal reclamations, their symbolic designs and vast expense, and puts forward three key topics for further investigation.

2. The birth of prestige reclamation

With more than 1 billion of the world's population living within 10 km of the shoreline (Cosby et al., 2024), the coastal strip is one of the most highly populated zones in the world. Congested coasts contribute vast amounts of wealth to the global economy each year, for instance in

2018, the 10 largest companies covering 8 ocean and coastal industries contributed 1.8 trillion USD to the global economy (Viridin et al., 2021). Coasts support both light and heavy industries, agriculture, fishing, raw material extraction, tourism and recreation, while international seaports also act as export/import trading hubs (Martínez et al., 2007; Sengupta and Lazarus, 2023). In such economically productive regions, where the demand for the low-lying coastal land exceeds what is available, coastal reclamation occurs (Sengupta et al., 2023). The process of coastal land reclamation involves filling-in or enclosing and draining areas of shallow sea or intertidal zone. This is not a new practice, with examples in the Netherlands, UK and India dating back to the ninth century (Doody, 2004; Hoeksema, 2007; Riding, 2018).

However, "prestige reclamations" carried out in the last 25 years differ drastically from the industrial or agricultural developments of the past. Prestige or spectacle developments on land are considered to be aspirational, real-estate driven constructions encompassing large-scale urban development (Koch, 2018; Koch and Valiyev, 2015). In the context of the Anthropocene coast, we define a prestige reclamation as a high-end real estate development or resort constructed on reclaimed land with a cultural significance or social statement made through the reclamation planiform, and/or crenulate design to maximise waterfront

* Corresponding author. Plymouth Marine Laboratory, Prospect Place, Plymouth, PL1 3DH, UK
E-mail addresses: ds1e23@soton.ac.uk, dse@pml.ac.uk (D. Sengupta).

<https://doi.org/10.1016/j.ocecoaman.2025.107579>

Received 7 November 2024; Received in revised form 22 January 2025; Accepted 4 February 2025

Available online 13 February 2025

0964-5691/© 2025 Published by Elsevier Ltd.

length and therefore real estate potential. Furthermore we consider that the primary purpose of the prestige development is to generate wealth from real estate, tourism or recreation. Transport and shipping hubs, artificial wetlands, industrial, military, agricultural and dis-used land are not considered to fall in this development sphere although they may share some built environment characteristics.

3. Sending a message into space: cultural meaning and social statements

Many prestige reclamations take a symbolic form conveying meaning through abstract shapes or pictorial representation. The symbol for peace, the heart for love, skull and cross bones for danger are all universally recognisable. Symbols can also hold cultural or religious significance, for example, the interlinked Olympic rings which represent the inclusivity and sportspersonship of the five competing continents.



Fig. 1. Prestige reclamations from across the world. Top left: the Pearl, Doha Qatar (built to resemble a string of pearls after the historic pearl industry on these shores (NASA, 2018); top right: Ocean Flower Hainan, China. Middle row, left to right (all China): Ying Yang Island, Grape Island, Conch Island and Pisces Island. Bottom Left: the World, Dubai, UAE. Bottom right: Durrat al Bahrain, Bahrain. (Image credit-Google Earth, Maxar).

These simple shapes which convey meaning without words are now being incorporated into prestige reclamations, showcasing their extravagant designs to a digital and international audience, notably from aerial photographs and satellite images. Perhaps the oldest (completed 2003) and most renowned prestige reclamation is the Palm Jumeirah development in Dubai, UEA which depicts a palm tree with 16 fronds, surrounded by a circle. Palms not only have huge economic significance as the main cropping fruit in the region but also represent an ability to thrive in the desert. One more palm design constructions are also underway in Dubai. The Dubai coastline is also home to the notable 'The World Islands', an iconic construction consisting of over 300 islands grouped into the seven continents, resembling the globe (Fig. 1), (Alzaylaie and Abdelaziz, 2015). In contrast to the locally inspired palms, the world represents not only the power of globalisation but sets Dubai as the stage of an international hub welcoming wealthy internationalists to come and 'buy' their own country (Gupta, 2015).

Regional mythological and philosophical figures are also found amongst the newest prestige reclamations. For instance, a large planned reclamation in Jakarta, Indonesia has been inspired by the Garuda, a giant mythological bird which also features on the national emblem, tourism industry and national airline logos (Salim et al., 2019; Wade, 2019). Ancient Chinese philosophy has also found a home in the design plan of some of the major reclamation projects as part of a tourism led heritage regeneration in China; for instance, the Ying Yang construction offshore of Haikou in Hainan Island (Fig. 1).

4. High sinuosity and other ventures for maximising real estate profit

Prestige reclamations are astronomically expensive both to construct and maintain and so maximising profitability of the investment is essential. Costs can mount into the billions, for example the Dubai reclamation cost more than \$12 billion in 2008 while more recently the Ocean Flower was estimated to have cost \$13 billion (Higgins, 2013; Yu et al., 2022). To meet the high financial demands of these projects, revenue-generating opportunities such as luxury resorts, yacht and pleasure craft marinas, adventure parks, shopping centers and restaurants build the desirability of the destination. Nevertheless, Cai et al. (2020) showed that the majority of the revenue is created through real estate sales and investment, aiming at income generation such as through tourism for the rich or super rich.

So for investors the motivation towards the growing footprint and elaborate design of these reclamations is not only about showcasing their immense (and potentially growing) wealth and national pride, but also to generate as many waterfront properties as possible. The more intricate a prestige reclamation is, the higher perimeter (waterfront) to area (development) ratio, with better revenue weighted for those constructions with a heavier waterfront to development ratio, commodifying the 'bluescapes' around them (Speake and Kennedy, 2019). Analysis of real estate values have consistently valued blue or green spaces more highly than purely urban settings (Hansen and Benson, 2013; Sander and Zhao, 2015), a metric that is undoubtedly hard-coded into the DNA of prestige reclamations.

5. New shoreline shapes, new questions. Habitats, processes, people

Prestige reclamations are emerging as a distinctive type of highly anthropomorphised shoreline. Whilst they offer solutions to urban expansion and have been shown to draw significant wealth to regions (Koch and Valiyev, 2015), the collective impact of these developments has not been fully quantified. One of the most pressing concerns associated with this practice is the permanent destruction of marine habitat under the footprint of the developments, and unfavourable changes in the condition of surrounding coastal ecosystems. Furthermore, we do not yet fully understand the impact of these complex developments to

the wider economy, the fishing industry, carbon sequestration, on the natural transport of sediments along the coast, changes in water quality nor climate resilience. Here we outline a series of questions relating to the increase of prestige reclamations.

1. What is the extent and wider impact of disruption to marine ecosystems?

As cities reclaim land from the sea, they inadvertently disrupt delicate marine environments, leading to irreparable ecological damage, and prestige reclamations, although often packaged as 'green' developments are no exception. Irreplaceable habitat loss occurs underneath the immediate footprint of reclamations (Chee et al., 2023; Jones et al., 2007; Zainal et al., 2012) but also within the wider area in the wake of the construction activities, notably through reducing or degrading habitats which are important feeding grounds for other fauna. Prime examples of such damage are in Shanghai, China; Jakarta Bay, Indonesia; Penang Island, Malaysia, Le Havre, Baie de Seine, France; and Sheyang County, Jiangsu, China (Wang et al., 2014, 2021; Slamet et al., 2020; Chee et al., 2017; Dit Durell et al., 2005; Zhang et al., 2018, 2025). Coral reefs, often called the rainforests of the sea, are particularly vulnerable. These vibrant ecosystems, home to a myriad of marine life, have been buried under tons of sand and concrete, disrupting the natural balance and leading to the decline of numerous species (Zainal et al., 2012). The sourcing of sediments may also prove damaging to the environment, for instance, aggregate extraction from the South China Sea for controversial island reclamation was reported to have caused catastrophic damage to the natural environment (Asner et al., 2017; Madin, 2015; Mora et al., 2016). Consideration should also be given to the source of construction material as this may represent 'hidden' or indirect environmental impacts. For instance, illegal sandmining activities have been purported to lead to the erosion and collapse of river banks, leading to heightened flood risk in the wider area, as a result of increasing demand for sand (Hackney et al., 2021; UN Environment Programme, 2022; Yuen et al., 2024). Unlike other reclamations, the complex planiform of the prestige reclamations may not totally destroy the marine habitat on which it is constructed. Stressed, fragmented habitats may survive within a prestige development, however, currently there is a lack of quantitative research on this. Light, noise and introduction of pollutants from surface run-off are all areas which deserve more attention (Duan et al., 2016; Koh and Lin, 2006; Lee et al., 2014; Wang et al., 2014). Quantification of both the direct and indirect impacts of these prestige reclamations is warranted, as they are currently unknown.

2. How are coastal dynamics, circulation and water quality altered?

The complex shapes of prestige reclamations are profoundly different to natural shorelines as are the flows of water and sediment in and around them. By filling in natural bays and estuaries, reclamation projects obstruct the natural flow of both water and sediments, each of which have their own knock-on impacts with the potential to alter both tides and local wave fields (Li et al., 2018; van Bentum et al., 2012). Globally, the consequences of these altered shorelines on water quality and coastal geomorphology are unknown (Tu and Huang, 2023). In some areas, issues with water stagnation and flushing have already become a serious issue, for example, following the construction of Lotus and Conch island, the effect of toxic algal blooms have been exacerbated, reducing the rate of water exchange and thereby increasing the residence time by ~35% on average (Kuang et al., 2024).

Ironically, while coastal land reclamation often aims to protect against natural disasters such as flooding, it can increase vulnerability in some cases. Altering the natural topography and hydrology of coastal areas, reclamation may intensify the impact of storm events, putting both the reclaimed land and surrounding areas at higher risk during extreme weather events (Xu et al., 2021). Furthermore, many prestige

reclamations are located in regions with low tidal ranges (the Persian Gulf, Java Sea and South China Sea) which are especially sensitive to increases in sea level rise. Such transformation raises critical questions about future coastal adaptation, environmental sustainability, and the economic feasibility of maintaining such valuable land, especially in the face of the global sand crisis (Bendixen et al., 2019; Elliott et al., 2019; Lamb, 2023).

3. What is the impact of prestige development on humans and the local economy?

Prestige reclamations are built for the super-rich, the affluent and aspirational. There is no or little research on the current socio-economics or ethics of these new residential areas which are built out of the sea or the communities adjacent to them, i.e. the neighbourhoods which lost their coastline. Very little existing information is available on the service industry which maintains these islands, nor the construction teams which help build them. Further research could focus on how the prestige developments alter the occupations of the wider city. The loss of spawning grounds, essential to the fishing industry, can be an effect of reclamation (Jones et al., 2007; Wang et al., 2014). In Bahrain fish stocks declined as land reclamation of more than 21 km² per year between 1997 and 2007 reduced the size of the natural breeding grounds (Zainal et al., 2012). This disruption not only directly affected the livelihoods of local fishermen but also had far-reaching consequences on the local seafood industry (Syal, 2022).

It is likely that the impact of these prestige will lead to habitat loss that may prove to be irreversible, although efforts to 'green-the-grey' may mask any real negative impacts that the developments may be having (Firth et al., 2024). Further studies are needed to examine and quantify the ongoing changes to the habitats, processes and people along these increasingly artificial coasts. (Xiao and Zhao, 2017). Multiple questions surround the sustainability of such feats of engineering, which themselves are highly sensitive to fluctuations in the global markets. When the global financial crisis hit in 2008 construction on the World in Dubai stopped, only recommencing years later (Chang, 2012; Lewis, 2009). Since then, Sri Lanka effectively handed over ownership of its largest reclamation 'the Port of Columbo' after financial difficulties meant that it could no longer repay the Chinese loan which funded the construction of the project (Ethirajan, 2022), highlighting again the sensitivity of these developments to economic stability. Prestige reclamations have often been promoted by countries that have experienced rapid economic growth over recent decades, as a catalyst for further growth. However, with international crises looming, ongoing sand shortages and knock-on impacts already being felt on the coast, there are many hurdles yet to over-come and the future of these prestige reclamations is uncertain. With so few prestige reclamations completed (Fig. 1), it is a crucial time to study these new emerging coasts that are a topic of pride for the countries concerned.

CRedit authorship contribution statement

Dhritiraj Sengupta: Writing – review & editing, Writing – original draft, Conceptualization. **Dominique Townsend:** Writing – review & editing, Visualization. **Sally Brown:** Writing – review & editing. **Ivan D. Haigh:** Writing – review & editing. **Ian Townend:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

DS gratefully acknowledges the Strategic Development Time provided by the Plymouth Marine Laboratory, which supported the development of this short communication article. DS also extends sincere gratitude to Professor Matt Frost, Director of the PML International Office, for his invaluable guidance and support in shaping this article.

Data availability

No data was used for the research described in the article.

References

- Alzaylaie, M., Abdelaziz, A., 2015. Pearl Jumeira project: a case study of land reclamation in Dubai. UAE. 15th Asian Reg. Conf. Soil Mech. Geotech. Eng. ARC 2015 New Innov. Sustain 1778–1783. <https://doi.org/10.3208/jgssp.TC217-03>.
- Asner, G.P., Martin, R.E., Mascaro, J., 2017. Coral reef atoll assessment in the South China Sea using Planet Dove satellites. Remote Sens. Ecol. Conserv. 3, 57–65. <https://doi.org/10.1002/rse2.42>.
- Bendixen, M., Best, J., Hackney, C., Iversen, L.L., 2019. Time is running out for sand. Nature 571, 29–31. <https://doi.org/10.1038/d41586-019-02042-4>.
- Bentum, K.M. van, Hoyng, C.W., Van Ledden, M., Luijendijk, A.P., Stive, M.J.F., 2012. The Lagos coast – investigation of the long-term morphological impact of the Eko Atlantic City project. In: NCK-Days 2012 : Crossing Borders in Coastal research., 13 March 2012 - 16 March 2012. Enschede, the Netherlands.
- Cai, Z., Liu, Q., Cao, S., 2020. Real estate supports rapid development of China's urbanization. Land Use Policy 95, 104582. <https://doi.org/10.1016/j.landusepol.2020.104582>.
- Chang, W.W., 2012. Financial crisis of 2007–2010. SSRN Electron. J. <https://doi.org/10.2139/ssrn.1738486>.
- Chee, S.Y., Othman, A.G., Sim, Y.K., Mat Adam, A.N., Firth, L.B., 2017. Land reclamation and artificial islands: walking the tightrope between development and conservation. Glob. Ecol. Conserv. 12, 80–95. <https://doi.org/10.1016/j.gecco.2017.08.005>.
- Chee, S.Y., Tan, M.L., Tew, Y.L., Sim, Y.K., Yee, J.C., Chong, A.K.M., 2023. Between the devil and the deep blue sea: trends, drivers, and impacts of coastal reclamation in Malaysia and way forward. Sci. Total Environ. 858, 159889. <https://doi.org/10.1016/j.scitotenv.2022.159889>.
- Cosby, A.G., Lebakula, V., Smith, C.N., Wanik, D.W., Bergene, K., Rose, A.N., Swanson, D., Bloom, D.E., 2024. Accelerating growth of human coastal populations at the global and continent levels: 2000–2018. Sci. Rep. 14, 1–10. <https://doi.org/10.1038/s41598-024-73287-x>.
- Dit Durell, S.E.A.L.V., Stillman, R.A., Triplett, P., Aulert, C., Dit Biot, D.O., Bouchet, A., Duhamel, S., Mayot, S., Goss-Custard, J.D., 2005. Modelling the efficacy of proposed mitigation areas for shorebirds: a case study on the Seine estuary, France. Biol. Conserv. 123, 67–77. <https://doi.org/10.1016/j.biocon.2004.10.009>.
- Doody, J.P., 2004. "Coastal squeeze" - an historical perspective. J. Coast Conserv. 10, 129–138. [https://doi.org/10.1652/1400-0350\(2004\)010\[0129:CSAHPJ2.0.CO;2](https://doi.org/10.1652/1400-0350(2004)010[0129:CSAHPJ2.0.CO;2).
- Duan, H., Zhang, H., Huang, Q., Zhang, Y., Hu, M., Niu, Y., Zhu, J., 2016. Characterization and environmental impact analysis of sea land reclamation activities in China. Ocean Coast Manag. 130, 128–137. <https://doi.org/10.1016/j.ocecoaman.2016.06.006>.
- Elliott, M., Day, J.W., Ramachandran, R., Wolanski, E., Fang, Q., Sheehan, M.R., Seen, A. J., Ellison, J.C., 2019. A synthesis: what is the future for coasts, estuaries, deltas and other transitional habitats in 2050 and beyond? Coasts and Estuaries: the Future. Elsevier Inc. <https://doi.org/10.1016/B978-0-12-814003-1.00001-0>.
- Ethirajan, A., 2022. Colombo Port city: a new Dubai or a Chinese enclave? BBC News. <https://www.bbc.com/news/world-asia-59993386>.
- Firth, L.B., Bone, J., Bartholomew, A., Bishop, M.J., Bugnot, A., Bulleri, F., Chee, S.Y., Claessens, L., Dafforn, K.A., Fairchild, T.P., Hall, A.E., Hanley, M.E., Komyakova, V., Lemasson, A.J., Loke, L.H.L., Mayer-Pinto, M., Morris, R., Naylor, L., Perkins, M.J., Pioch, S., Porri, F., O'Shaughnessy, K.A., Schaefer, N., Strain, E.A., Toft, J.D., Waltham, N., Aguilera, M., Airolidi, L., Bauer, F., Brooks, P., Burt, J., Clubley, C., Cordell, J.R., Espinosa, F., Evans, A.J., Farrugia-Drakard, V., Froneman, W., Griffin, J.N., Hawkins, S.J., Heery, E., Herbert, R.J.H., Jones, E., Leung, K.M.Y., Moore, P., Sempere-Valverde, J., Sengupta, D., Sheaves, M., Swearer, S., Thompson, R.C., Todd, P., Knights, A.M., 2024. Coastal greening of grey infrastructure: an update on the state of the art. Proceedings of the Institution of Civil Engineers - Maritime Engineering 177 (2), 35–67. <https://doi.org/10.1680/jmaen.2023.003>, 2024.
- Gupta, P., 2015. Futures, fakes and discourses of the gigantic and miniature in 'The World' islands, Dubai. Isl. Stud. J. 10, 6. <https://doi.org/10.24043/isj.326>.
- Hackney, C.R., Vasilopoulos, G., Heng, S., Darbari, V., Walker, S., Parsons, D.R., 2021. Sand mining far outpaces natural supply in a large alluvial river. Earth Surf. Dyn. 9, 1323–1334. <https://doi.org/10.5194/esurf-9-1323-2021>.
- Hansen, J.L., Benson, E.D., 2013. The value of a water view: variability over 25 years in a coastal housing market. Coast. Bus. J. 12, 76–99. <https://digitalcommons.coastal.edu/cbj/vol12/iss1/5>.
- Higgins, K., 2013. Engineering challenges of dubai's palm Jumeirah. J. Undergrad. Eng. Res. Scholarsh. 1–8.
- Hoeksema, R.J., 2007. Three stages in the history of land reclamation in The Netherlands. Irrig. Drain. 56, 113–126. <https://doi.org/10.1002/ird.340>.

- Jones, D.A., Ealey, T., Baca, B., Livesey, S., Al-Jamali, F., 2007. Gulf desert developments encompassing a marine environment, a compensatory solution to the loss of coastal habitats by infill and reclamation: the case of the Pearl City Al-Khiran, Kuwait. *Aquat. Ecosyst. Health Manag.* 10, 268–276. <https://doi.org/10.1080/14634980701512814>.
- Koch, N., 2018. The geopolitics of spectacle: space, synecdoche, and the new capitals of asia. *Geopolit. Spect. Space, Synecdoche, New Capitals Asia* 61, 1–210. <https://doi.org/10.1080/15387216.2019.1689835>.
- Koch, N., Valiyev, A., 2015. Urban boosterism in closed contexts: spectacular urbanization and second-tier mega-events in three Caspian capitals. *Eurasian Geogr. Econ.* 56, 575–598. <https://doi.org/10.1080/15387216.2016.1146621>.
- Koh, T., Lin, J., 2006. The land reclamation case: thoughts and reflections. In: Singapore Year Book of International Law and Contributors, pp. 1–8. <https://heinonline.org/HOL/LandingPage?handle=hein.journals/singa10&div=5&id=&page=>.
- Kuang, C., Wang, D., Wang, G., Liu, J., Han, X., Li, Y., 2024. Impact of reclamation projects on water quality in Jinneng bay, China. *Estuar. Coast Shelf Sci.* 300, 108719. <https://doi.org/10.1016/j.ecss.2024.108719>.
- Lamb, V., 2023. Constructing the global sand crisis: four reasons to interrogate crisis and scarcity in narrating extraction. *Extr. Ind. Soc.* 15, 101282. <https://doi.org/10.1016/j.exis.2023.101282>.
- Lee, C.H., Lee, B.Y., Chang, W.K., Hong, S., Song, S.J., Park, J., Kwon, B.O., Khim, J.S., 2014. Environmental and ecological effects of Lake Shihwa reclamation project in South Korea: a review. *Ocean Coast Manag.* 102, 545–558. <https://doi.org/10.1016/j.ocecoaman.2013.12.018>.
- Lewis, P., 2009. Dubai's six-year building boom grinds to halt as financial crisis takes hold. *Guard.* <https://www.theguardian.com/world/2009/feb/13/dubai-boom-halt>.
- Li, L., Ye, T., Wang, X.H., He, Z., Shao, M., 2018. Changes in the hydrodynamics of hangzhou bay due to land reclamation in the past 60 years. *Sediment dyn. Chinese muddy coasts estuaries physics. Biol. their Interact* 77–93. <https://doi.org/10.1016/B978-0-12-811977-8.00005-4>.
- Madin, E.M.P., 2015. Land reclamation: halt reef destruction in South China sea. *Nature* 524, 291. <https://doi.org/10.1038/524291a>.
- Martínez, M.L., Intralawan, A., Vázquez, G., Pérez-Maqueo, O., Sutton, P., Landgrave, R., 2007. The coasts of our world: ecological, economic and social importance. *Ecol. Econ.* 63, 254–272. <https://doi.org/10.1016/j.ecolecon.2006.10.022>.
- Mora, C., Caldwell, I.R., Birkeland, C., McManus, J.W., 2016. Dredging in the spratly islands: gaining land but losing reefs. *PLoS Biol.* 14, 4–10. <https://doi.org/10.1371/journal.pbio.1002422>.
- NASA, 2018. The pearl-Qatar. *Earth Obs.* <https://earthobservatory.nasa.gov/images/91941/the-pearl-qatar>.
- Riding, T., 2018. 'Making Bombay Island': land reclamation and geographical conceptions of Bombay, 1661–1728. *J. Hist. Geogr.* 59, 27–39. <https://doi.org/10.1016/j.jhg.2017.08.005>.
- Salim, W., Bettinger, K., Fisher, M., 2019. Maladaptation on the waterfront: jakarta's growth coalition and the Great Garuda. *Environment and Urbanization ASIA* 10 (1), 63–80. <https://doi.org/10.1177/0975425318821809>.
- Sander, H.A., Zhao, C., 2015. Urban green and blue: who values what and where? *Land Use Policy* 42, 194–209. <https://doi.org/10.1016/j.landusepol.2014.07.021>.
- Sengupta, D., Lazarus, E.D., 2023. Rapid seaward expansion of seaport footprints worldwide. *Commun. Earth Environ.* 4, 1–8. <https://doi.org/10.1038/s43247-023-01110-y>.
- Sengupta, D., Choi, Y.R., Tian, B., Brown, S., Meadows, M., Hackney, C.R., Banerjee, A., Li, Y., Chen, R., Zhou, Y., 2023. Mapping 21st century global coastal land reclamation. *Earth's Futur* 11, 1–13. <https://doi.org/10.1029/2022EF002927>.
- Slamet, N.S., Dargusch, P., Aziz, A.A., Wadley, D., 2020. Mangrove vulnerability and potential carbon stock loss from land reclamation in Jakarta Bay, Indonesia. *Ocean Coast Manag.* 195, 105283. <https://doi.org/10.1016/j.ocecoaman.2020.105283>.
- Speake, J., Kennedy, V., 2019. 'Buying' into the waterfront dream? Trajectories of luxury property led developments in Malta. *Tour. Manag.* 71, 246–258. <https://doi.org/10.1016/j.tourman.2018.10.014>.
- Syal, R., 2022. Bahrain lacks land, so it's building more: lavish artificial islands. *Natl. Geogr. Mag.* <https://www.nationalgeographic.com/environment/article/bahrains-expansion-into-the-sea-threatens-fisheries>.
- Tu, M.-C., Huang, Y.-C., 2023. Impact of land reclamation on coastal water in a semi-enclosed bay. *Remote Sens.* 15 (2), 510. <https://doi.org/10.3390/rs15020510>.
- UN Environment Programme, 2022. Sand and sustainability: 10 strategic recommendations to avert a crisis, UN environment Programme. <https://www.unep.org/resources/report/sand-and-sustainability-10-strategic-recommendations-avert-crisis>.
- Virdin, J., Vegh, T., Jouffray, J.B., Blasiak, R., Mason, S., Österblom, H., Vermeer, D., Wachtmeister, H., Werner, N., 2021. The Ocean 100: transnational corporations in the ocean economy. *Sci. Adv.* 7, 1–10. <https://doi.org/10.1126/sciadv.abc8041>.
- Wade, M., 2019. Hyper-planning Jakarta: the Great Garuda and planning the global spectacle. *Singap. J. Trop. Geogr.* 40, 158–172. <https://doi.org/10.1111/sjtg.12262>.
- Wang, W., Liu, H., Li, Y., Su, J., 2014. Development and management of land reclamation in China. *Ocean Coast Manag.* 102, 415–425. <https://doi.org/10.1016/j.ocecoaman.2014.03.009>.
- Wang, X., Yan, F., Su, F., 2021. Changes in coastline and coastal reclamation in the three most developed areas of China, 1980–2018. *Ocean Coast Manag.* 204, 105542. <https://doi.org/10.1016/j.ocecoaman.2021.105542>.
- Woodcock, C.E., Allen, R., Anderson, M., Belward, A., Bindischadler, R., Cohen, W., Gao, F., Goward, S.N., Helder, D., Helmer, E., Nemani, R., Oreopoulos, L., Schott, J., Thenkabail, P.S., Vermote, E.F., Vogelmann, J., Wulder, M.A., Wynne, R., 2008. Free access to landsat imagery. *Science* 320, 1011. <https://doi.org/10.1126/science.320.5879.1011a>.
- Wulder, M.A., Masek, J.G., Cohen, W.B., Loveland, T.R., Woodcock, C.E., 2012. Opening the archive: how free data has enabled the science and monitoring promise of Landsat. *Remote Sens. Environ.* 122, 2–10. <https://doi.org/10.1016/j.rse.2012.01.010>.
- Xiao, L., Zhao, R., 2017. China's new era of ecological civilization. *Science* 358, 1008–1009. <https://doi.org/10.1126/science.aar3760>.
- Xu, L., Ding, S., Nitivattananon, V., Tang, J., 2021. Long-term dynamic of land reclamation and its impact on coastal flooding: a case study in xiamen, China. *Land* 10 (8), 866. <https://doi.org/10.3390/land10080866>.
- Yu, X., Zhu, J., Tian, L., Jim, C., 2022. Insight: dashed dreams for China Evergrande's showpiece resort island. *Reuters.* <https://www.reuters.com/markets/rates-bonds/dashed-dreams-china-evergrandes-showpiece-resort-island-2022-01-31/>.
- Yuen, K.W., Park, E., Tran, D.D., Loc, H.H., Feng, L., Wang, J., Gruel, C.R., Switzer, A.D., 2024. Extent of illegal sand mining in the Mekong Delta. *Commun. Earth Environ.* 5, 1–13. <https://doi.org/10.1038/s43247-023-01161-1>.
- Zainal, K., Al-Madany, I., Al-Sayed, H., Khamis, A., Al Shuhaby, S., Al Hisaby, A., Elhoussiny, W., Khalaf, E., 2012. The cumulative impacts of reclamation and dredging on the marine ecology and land-use in the Kingdom of Bahrain. *Mar. Pollut. Bull.* 64, 1452–1458. <https://doi.org/10.1016/j.marpolbul.2012.04.004>.
- Zhang, N., Thompson, C.E.L., Townend, I.H., Rankin, K.E., Paterson, D.M., Manning, A. J., 2018. Nondestructive 3D imaging and quantification of hydrated biofilm-sediment aggregates using X-ray microcomputed tomography. *Environ. Sci. Technol.* 52, 13306–13313. <https://doi.org/10.1021/acs.est.8b03997>.
- Zhang, G., Gu, J., Hu, H., Sun, M., Shao, J., Dong, W., Liang, L., Zeng, J., 2025. Impact of coastal squeeze induced by erosion and land reclamation on salt marsh wetlands. *J. Mar. Sci. Eng.* 13 (1), 17. <https://doi.org/10.3390/jmse13010017>.