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Coastal Adaptation – for Whom and to What?

Zooming in on Eroding Sands and the Livelihoods of Artisanal Fishers in India

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Summary

Climate change adaptation is a key pillar in climate policy. The Paris Agreement's Global Goal on Adaptation (GGA) provides a unifying framework to accelerate action towards strengthening resilience and reducing vulnerability to climate change. However, the implementation of adaptation projects is constrained by complex political processes, and while the GGA targets all levels from local to global, adaptation efforts that are not linked to the vulnerability context are a major cause of maladaptation. This complexity is particularly relevant to the management of coastal sand resources and their role in climate change adaptation. With the global increase in coastal development and urbanisation, sand resources that protect the coast are critical for the well-being of communities but also for concrete production for the construction sector. This often leads to trade-offs between development and adaptation, resulting in maladaptive outcomes such as coastal erosion and loss of livelihood of fisheries communities. Within this context, this policy brief exemplifies how the use and distribution of coastal sand resources determine whether adaptation outcomes are successful or maladaptive, taking a case study from India.

Policy recommendations for strengthening coastal adaptation governance in India and beyond

- **Integrate sand governance in existing coastal management:** Sand should be institutionally recognised as a protected resource essential for fishing communities with a legal framework for sand rights and coastal zone mapping.
- **Avoid maladaptation through transboundary governance:** Adaptation to shifting shoreline boundaries necessitates governance of sand as a vital political entity across state boundaries, creating opportunities to restore sand movement by reducing or removing obstructive infrastructure.
- **Address trade-offs between development and adaptation:** Development interventions like harbours can exacerbate coastal hazards, necessitating policymakers to balance economic growth, transformative adaptation strategies and the interests of the construction sector, coastal communities and tourism.
- **Untangle what needs to be adapted to:** Considering sand is crucial for identifying adaptation needs, which requires a holistic approach to address both climate and non-climate related risks.
- **Co-production for locally adapted solutions:** Adaptation planning must involve at-risk communities with deep knowledge of coastal processes, implementing beach nourishment not just for tourism, but also to secure fishing livelihoods.

Introduction

Globally, adaptation to ever-increasing coastal hazards is a major challenge for policymakers and coastal communities alike, not least because of the complex governance challenges posed by highly dynamic land-sea interfaces characterised by ocean currents and sand movement. On the one hand, the complexity of coastal adaptation arises from climate change, which is leading to ocean warming and continued sea-level rise. This makes coastal hazards, such as more frequent cyclones, and, for example, the salinisation of freshwater resources, more unpredictable and uncertain than before and directly affects human settlements and activities along the coast (IPCC, 2019). The livelihoods of small-scale fishers are especially affected by dwindling fish catches in warmer seas and increasingly uncertain climatic conditions. On the other hand, non-climate drivers affecting the coastal environment, ranging from the construction of harbours to hard protective infrastructure (e.g., seawalls) and tourist resorts, add to this complexity (Barnett & O'Neill, 2010; Masalu, 2002). This is because both climate and non-climate drivers contribute to coastal risk by disrupting the coastal dynamics, thus obscuring the root causes of what makes coastal communities vulnerable or adaptation strategies unsuccessful (Eriksen et al., 2021).

Hard coastal protection measures are common adaptations that shift vulnerabilities from one area to another, for example, through groins or seawalls that block the movement of sand and cause erosion and the loss of protective beaches in other coastal areas (Sovacool et al., 2015). While such measures, increasingly framed as climate change adaptation, may protect some areas in the short term, eroded beaches directly affect the livelihoods of fishing communities that depend on access to sandy beaches to launch their boats (Schüpf et al., 2024). Although often overlooked in coastal adaptation strategies, sand resources supplied by rivers and tidal currents sustain and help build coastal areas where more than one billion people live worldwide (IPCC, 2019). Sand has multiple uses and functions in marine ecosystems but also in urban development for construction. In coastal areas, sand exists where different stakeholders are competing to access it (Jouffray et al., 2023; Torres et al., 2017). Sand acts as a natural buffer at the land-sea interface between the terrestrial and marine ecosystems and increases their resilience to the above-mentioned hazards.

The current predominance of infrastructural and technical adaptation interventions risks overlooking pre-existing power relations between these actors that determine, for example, how sand is distributed and who is to be protected. It is necessary, therefore, to critically examine the embedded trade-offs between adaptation and development that need to be understood in order to reduce the risk of maladaptation to changing coastal environments. This policy brief addresses this question by taking the case study of artisanal fishers affected by massive sand erosion with the aim to inform policymakers and development practitioners working on coastal governance.

Sand resources and coastal (mal)adaptation

The link between sand and climate change is significant but complex. On the *mitigation* side, the extraction of marine sand (directly) releases the greenhouse gases sequestered in the sediments (Sun et al., 2023), while the production of concrete (indirectly) releases huge quantities of CO_2 (UNEP, 2022). On the *adaptation* side, sand not only sustains livelihoods and the marine ecosystem, but also protects coastlines and is used for land reclamation or beach nourishment (Pilkey et al., 2022).

The proper use, conservation and distribution of coastal sand resources are at the heart of successful coastal adaptation strategies aimed at protecting coastal communities. Used as livelihoods spaces, the formation of beaches is crucial for fishers. Coastal adaptation measures, such as seawalls, often (re)distribute sand by blocking or redirecting its movement. Despite the central role

of sand in these measures, most adaptation strategies disregard it. The governance of sand resources, therefore, needs to move much more into focus in order to reduce the risk of *maladaptation* – a concept that refers to "actions or inactions that may lead to increased risk of adverse climate-related outcomes, increased vulnerability to climate change, or diminished welfare, now or in the future" (IPCC, 2014, p. 857). This analysis is based on fieldwork done in Pondicherry, southern India, where the construction of a harbour has disrupted sand movement, resulting in the loss of living spaces and livelihoods for thousands of artisanal fishers who depend on sandy beaches for boat parking and storage.

Maintaining sand resources as a coastal barrier may be a cost-effective adaptation strategy. For example, the costs of rebuilding infrastructure after coastal hazards (e.g., cyclones, flooding) due to the loss of protective beaches often do not outweigh the profits generated from extracted sand resources (Pilkey et al., 2022). However, contrary to the common perception that sand is abundant, sand resources are declining globally and are the second most consumed resource after water, with the main uses being the construction sector and coastal development (UNEP, 2019). In contrast with the rounded sand grains found in deserts, sand found in coastal and marine environments is angular with the right characteristics to be suitable for concrete. The unprecedented demand for sand is fuelled by the expansion of ports and coastal cities through land reclamation or beach nourishment, leading to a "looming tragedy of the sand commons" as sand extraction by far exceeds supply from rivers, coastal dunes and beaches (Torres et al., 2017).

Coastal adaptation is situated within technical, economic as well as financial barriers and social conflicts that may constrain their effectiveness (Nicholls, 2007). Current coastal adaptation strategies often fail because coastal communities are highly dependent on access to a range of resources, including sand, but also technology, information and finance (see Table 1). Moreover, a coastline is never static and fixed on a map but dynamic and in constant interaction through erosion and accretion. To overcome these challenges, societies will need to resolve distributional conflicts over finance related to spending public funds on, for example, coastal protection, which may lead to the loss of tourism due to less attractive beaches (Hinkel et al., 2018). In addition, this can lead to conflicts due to underlying social vulnerability factors, such as gender, class and ethnicity. Challenges to coastal adaptation, therefore, stem not only from the climate crisis, but also from the rootedness of vulnerability in societies where communities are marginalised (Garcia et al., 2022).

Table 1: Categories of coastal adaptation strategies

Coastal adaptation approaches	Activities	Challenges
Governance	Management and planning processes (e.g., improving Integrated Coastal Zone Management (ICZM), Marine Protected Areas (MPAs), Marine Spatial Planning)	Complexity rooted in unequal power relations and competing/conflicting interests of stakeholders (e.g., tourism, fisheries), less clear boundaries than on land
Social and knowledge	Social and community-based adaptation responses (e.g., risk awareness, public and local participation, improving scientific communication)	Diverging worldviews and forms of understanding and living in coastal environments (e.g., indigenous knowledge)
Physical and ecological	Technical, engineering or ecosystem-based adaptations (e.g., hard engineering (seawall), soft engineering (beach nourishment), ecosystem restoration)	Equity and social vulnerability (who is protected?), spatial scale and temporal uncertainty (e.g., reducing erosion in one place but increasing it somewhere else)
Economic	Adaptation responses involving monetary features (e.g., land acquisition, public funding, payment for ecosystem services, private investments)	Social conflicts over access to resources, displacement of communities for conservation or capital accumulation

Source: Authors, adapted from Cabana et al. (2023)

Case study: Fishing communities in Pondicherry, India

The maladaptation cycle

The coastal region of Pondicherry and the state of Tamil Nadu are among the most vulnerable areas in India to coastal hazards, particularly due to more frequent cyclones and storm surges caused by climate change. The natural movement of sand (littoral drift) shapes the entire coast of India. However, in Pondicherry, a commercial harbour built in 1989 within the littoral zone caused massive erosion as its breakwaters blocked the natural movement of sand and deposition of sediment (see Figure 1). As the erosion shifted northwards, hard coastal defences, including seawalls and groins, were constructed, resulting in the armouring of the coastline and the loss of more than 80 hectares of beach (Bautés et al., 2023). As a result, affected fishers demanded the construction of groins and were absorbed into this vicious cycle of maladaptation (see Figure 2). The latter is conditioned by different interests and levels of influence, such as a growing tourism industry, the associated caste of coastal communities, and the religious importance of spiritual leaders who own coastal property. For instance, fishers from Tamil Nadu are not allowed to use the Pondicherry harbour, which originally caused the erosion and sand loss, exemplifying vested interests and unequal power relations over the distribution of coastal sand.

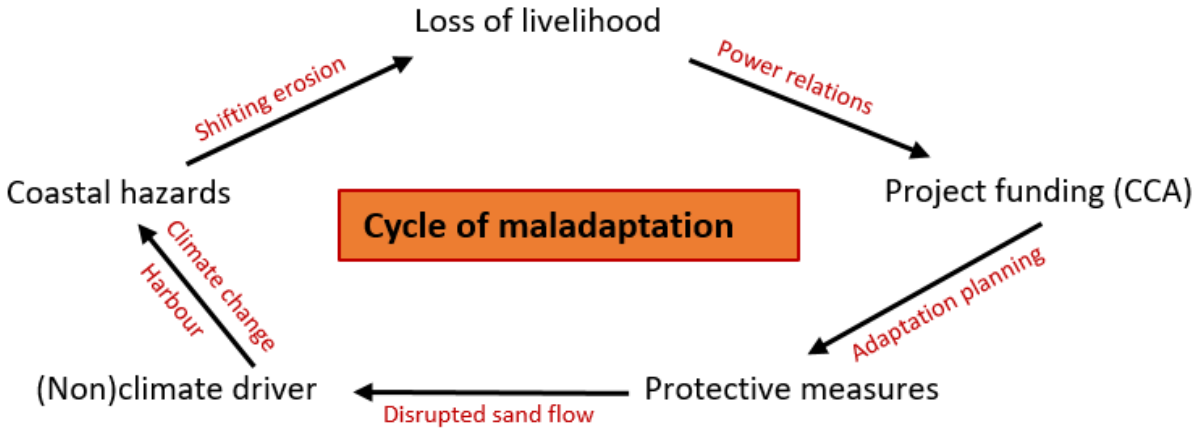
To date, more than 7,000 fishers have lost their livelihoods and at least a dozen fishing hamlets have been wiped out (Bautés et al., 2023). Fishing communities are still affected by the increasing loss of working space due to the loss of beaches. As beaches are lost and extended seawalls impede access to the sea, many are forced to launch their boats from distant beaches outside their village or find new employment in urban areas. In addition, the shoals of fish that come close to the shore have diminished, making artisanal fishers more vulnerable as they are pushed further out to the sea where storms are reportedly becoming more unpredictable as the Bay of Bengal heats up.

> Beach and sea are inseparable. The rock beach in Pondicherry town, on which the government is focusing on for development, is for entertainment purpose. But for us, it's about livelihood.
>
> (Fisher interview, 2023)

Figure 1: Case study area

Source: Authors, using OpenStreetMaps

Figure 2: The maladaptation cycle



Source: Authors

Protective measures are not implemented as a long-term anticipation of risks, but as an *ad hoc* emergency measure after a severe weather event, such as a cyclone, has occurred:

> Suppose you have a stomach-ache, what do you need? You need a medicine to eat, because you don't know. You don't have time to think about your pain, why it's happening. What is the cause? So, exactly the same. These groins and everything. I think it is a temporary measure without understanding the dynamics of the sea.
>
> (Coastal scientist interview, 2023)

As a result, hard infrastructure that shifts the erosion is passed without environmental impact assessments as demanded by NGOs or without obtaining Coastal Regulation Zone (CRZ) clearance. Moreover, groin fields (see Figure 1) block the sand that would normally reach the coast further north, ultimately creating new barriers and accelerating erosion in neighbouring fishing communities. Although considered an emergency measure for reclaiming eroded beaches, the construction of groins is often delayed and can take more than a year. In addition, fishing communities, adapt to the loss of sandy beaches caused by coastal hazards, development and failed protection measures by moving their boats and gear to other stretches of coast where sand accumulates (see Figure 3). While this can lead to conflicts with neighbouring fishing communities that have sufficient beach, it also (re)negotiates new rules on how coastal space is used, allocated and shared. For example, fees are charged for additional boats that require space or catches must be shared.

When it comes to the design and construction of groins, **fishing communities are not participating in planning processes** and consequently protest so that the government will at least approve groins to be built to reclaim their lost beaches. When asked about participation, a fisher stated:

> We fishermen know how the sea works. If both fishermen and farmers are left with a boat in the middle of the sea, do the farmers know how to get back to the shore? But the decisions for the fishing community are made by the people from the plain region who don't know about the sea and shore.
>
> (Group interview with fishers, 2023)

Figure 3: Fishers relocate their gear to coastal space with wider beaches

Source: © Dennis Schüpf

Lessons for strengthening governance mechanisms

Sand moves and accumulates across politically determined boundaries and jurisdictions. Particularly in the case of shifting sands and eroding coastlines, transboundary coastal governance is a challenge as erosion crosses jurisdictional boundaries and thus solutions need to be worked out between trans-state coastal authorities to assess projects like the one proposed by the Public Works Department. While as per the CRZ Notification 2019, the area where groins are being constructed falls under CRZ IV (water body) and CRZ IB (intertidal zone) where any construction is prohibited ("no development zone"), an agreement for future adaptation to coastal risks is required between the respective coastal zone management authorities.

> The coastal zone is almost like a no man's land. It is not under the Ministry of Agriculture, and it is not under the Ocean. It is a part of land, which is actually not managed by anyone.
>
> (Civil society organisation interview, 2023)

Beach space and the perception and value of sand resources need to be addressed in policies that deal with and adapt to coastal risks. While the loss of a beach for an adjacent fishing community has a major impact on its economic cycle, including its cultural belonging and identity, other coastal actors perceive the importance of sandy beaches differently:

> Of building groins, you just see the land area, how much of beach we have lost. You can see that the beach has no value. Because it not really public property nor is it private, so it has no value.
>
> (NGO interview, 2024)

Even though the sheer value of sand grains may elude economic reasoning and utilisation, incentivising the retention of sand on the coast may be the most cost-effective adaptation strategy, as argued above. This means creating public awareness of sand movement in its role as a naturally occurring protector of the coastline.

Access to beach space is critical to the livelihoods of fishers to enter the sea and to prevent spatial conflicts between neighbouring communities over resources. Traditional artisanal fishing techniques have evolved over centuries around a sandy beach ecosystem that provides a variety of functions, from maintaining nearshore fish habitats to providing space for boat parking, catch drying or net mending. Houses are built close to the shore to ensure visibility of the sea to locate shoals of fish (e.g., changes in sea colour or wind direction). Usually, the fishing communities rely on strong self-governance through traditional institutions to maintain social control and access to the use of fish resources and community management (Bavinck, 2001). When the construction of a 6-km-long seawall further shifted the erosion from Pondicherry to Tamil Nadu state, conflicts over shrinking beach space arose between self-governing fishing communities.

> With the help of a tractor, we moved our boats near the burial site and moved further to the roads. But if we don't have a place to park our boats, it will be very difficult. The land near the temple used to belong to the fishing community. But people sold it and now we don't have enough space. The land next to the burial ground is being bought by a spiritual leader who claims that the land belongs to the temple.
>
> (Fisher interview, 2024)

Fishing communities need to be recognised and involved as knowledgeable actors, rather than being overheard by experts and planners who often make decisions far away from the affected coastal area. The livelihoods of artisanal fishers have evolved with, not against, the dynamics of sand and the sea. Importantly, women in the fishing sector suffer disproportionately from the loss of beach space and are forced into the streets to dry and sell fish, as beach space is predominantly used by men. This not only adds to their economic burden as prices are negotiated and auctioned at the beach, but also affects women's capacity to gather collectively in public spaces. The relocation of their livelihoods due to lack of access to the beach is itself an adaptation to climate and environmental change and critically linked to the social vulnerability of fishing communities. As a whole, the *Pattinavar* fishing caste also faces discrimination in the social hierarchy of Indian society. This makes it difficult to find employment outside of fishing, leading to seasonal out-migration to international trading ports that attract cheap labour.

Policy recommendations

This policy brief underscores that often-overlooked coastal sand resources are integral to the livelihoods of fishing communities. Sand, in its various functions and uses, is at the very heart of coastal adaptation processes as well as development interventions. The ability to access, use and redistribute sand resources is critical to adaptation strategies, overlapping climate and human-induced environmental risks. Protective measures, such as groins and seawalls, redistribute coastal sand and can worsen local conflicts over shrinking beach space. This raises issues of environmental justice in future adaptation efforts: to whom will coastal sand be distributed and from whom will it be taken?

This case study has important policy implications for strengthening coastal governance in India and beyond as well as for development practitioners:

- **Integrate sand governance in existing coastal management**: Sand needs greater institutional recognition as a secured good on which the protection of fishing communities depends. A legal framework towards sand rights for traditional sand-based livelihoods is needed to recognise sand beyond a mere commodity for construction purposes. Sand

commons should be recognised not just as tourism spaces but also as labour sites, marked accordingly in coastal zone mapping.

- **Avoid maladaptation through transboundary governance**: Due to the shifting shoreline boundaries at the coast, adaptation is accompanied by less clear legal frameworks than on land. Adapting to such dynamics requires the governance of sand as a vital political entity that operates across state boundaries. This creates opportunities for coastal strategies that restore sand movement by reducing or removing obstructive infrastructure.
- **Address trade-offs between development and adaptation**: Development interventions, including harbours, are not isolated from adaptation and can exacerbate coastal hazards. Policymakers need to be aware of the trade-offs and explore synergies between prioritising economic growth over transformative adaptation strategies. This also requires balancing the economic interests of the construction sector involved (sand mining) and those of coastal communities or tourism.
- **Untangle what needs to be adapted to**: Looking at sand is a key starting point for identifying adaptation needs. This may not always be climate change. It is necessary to untangle whether there is an overlap between climate- and non-climate related risks. Adaptation efforts should then take a holistic approach, addressing different symptoms of what has collectively created the risk to which adaptation is being sought.
- **Co-production for locally adapted solutions**: Adaptation must be co-produced with at-risk communities, which carry deep knowledge of coastal processes. Adaptation planning needs to involve affected communities in its design solutions. Beach nourishment as a strategy could be implemented not only for tourism, but also to secure fishing livelihoods that depend on beaches.

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