# Towards a buoyant political ecology: Rethinking marginalization for coastal climate change adaptation in the tropics

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## Abstract

The land-water dichotomy plays a key role in the prevailing global climate change adaptation (CCA) policy discourse for tropical coastal areas. This dichotomy is implicitly informed by a land centered conception of property which regards areas that fluctuate between water and land, or 'aquaterras', as marginal and in need of development to make them economically profitable. By adopting this perspective, mainstream CCA policies ignore the diverse, vernacular systems of adaptation that communities that dwell in such tropical coastal aquaterras have developed through multigenerational and lived experiences to negotiate climatic and contingent uncertainties. The article calls on political ecologists to jettison land-centered, economic representations of marginality and marginalization in favor of a 'buoyant', critical CCA approach which recognizes and builds on the vernacular knowings and expertise of tropical coastal aquaterra communities.

**Keywords**: political ecology, marginalization, uncertainty, tropics, climate change adaptation

## Résumé

La dichotomie terre-eau joue un rôle clé dans le discours politique dominant sur l'adaptation au changement climatique (ACC) dans les zones côtières tropicales. Une conception de la propriété centrée sur la terre opère, qui considère les zones qui fluctuent entre l'eau et la terre, ou « aquaterras », comme marginales et nécessitant un développement pour les rendre économiquement rentables. En adoptant cette perspective, les politiques générales d'AAC ignorent les divers systèmes vernaculaires d'adaptation dans les aquaterras. Les communautés qui vivent dans ces environnements côtiers tropicaux ont des expériences vécues et multigénérationnelles qu'elles utilisent pour négocier les incertitudes climatiques et contingentes. L'article invite les écologistes politiques à abandonner les représentations économiques de la marginalité et de la marginalisation, centrées sur la terre, au profit d'une approche critique et « flottante » de l'AAC, qui reconnaît et s'appuie sur les connaissances et l'expertise vernaculaires des communautés de l'aquaterra côtière tropicale.

**Mots-clés:** écologie politique, marginalisation, incertitude, tropiques, adaptation au changement climatique

## Resumen

La dicotomía tierra-agua desempeña un papel clave en el discurso político mundial predominante sobre la adaptación al cambio climático (ACC) en las zonas costeras tropicales. Funciona una concepción de la propiedad centrada en la tierra, que considera las zonas que fluctúan entre el agua y la tierra, o «acuaterras»,

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como marginales y necesitadas de desarrollo para hacerlas económicamente rentables. Al adoptar esta perspectiva, las principales políticas de ACC ignoran los diversos sistemas vernáculos de adaptación de las acuaterras. Las comunidades que habitan estos entornos costeros tropicales tienen experiencias vividas y multigeneracionales que utilizan para negociar las incertidumbres climáticas y contingentes. El artículo hace un llamamiento a los ecologistas políticos para que abandonen las representaciones económicas y centradas en la tierra de la marginalidad y la marginación en favor de un enfoque crítico y «boyante» de la ACC que reconozca y aproveche los conocimientos y la experiencia vernáculos de las comunidades acuaterras costeras tropicales.
**Palabras clave**: ecología política, marginación, incertidumbre, trópicos, adaptación al cambio climático

## 1. Introduction

The land-water dichotomy plays a key role in contemporary narratives of climate change threats and adaptation in the tropics. The genealogy of this visioning extends back to the European colonial enterprise which, from its onset, relied on cartographic mapping of tropical territories by drawing a firm line starkly separating *terra* from *aqua* (Mathur & da Cunha, 2009). The global climate change adaptation (henceforth CCA) discourse is overwhelmingly preoccupied with water's unruliness (Amrith, 2018), be its excess or absence on land. Climate science projections of global warming and rising sea levels appear markedly menacing because they threaten to swallow tracts which maps have demarcated as not the realm of water. As Mathur and da Cunha observe, "here is a rush to defend land against a sea that refuses to keep its place beyond land's edge and outside landed entities such as cities and fields" (Mathur & da Cunha, 2009, p.186).

Communities in deltaic, estuarine and coastal zones in the tropics have multigenerational experiences of living with flooding (Mishra, 2001; Lahiri-Dutt, 2014, 2015; Morita, 2016; Camargo & Cortesi, 2019). Flooding is both part of and a disruption to the spatiotemporal relationship between *aqua* and *terra* which are embodied in the regionally, and locally, situated vernacular ways of knowing, interpreting and managing life and livelihoods within these fluctuations. Yet, the framing of the CCA policy discourse regarding such areas overlooks these vernacular understandings and practices of navigating the uncertainties of climate and water-land fluctuations. The discourse primarily relies on projections of global probabilities generated by climate science models despite their weak predictive efficacy for the tropics (Shepherd, 2019; Shepherd & Sobel, 2020). Multilateral agencies and national governments routinely invoke global predictions to present apocalyptic scenarios of flooding and destruction for coastal communities dwelling in 'marginal' *aquaterras* or domains which fluctuate between "water-becoming-land and land-becoming-water" (Harris, 1998, p. 71). A prime example of such global prophesying is the Bengal Delta where international development actors and national government policymakers have categorized coastally situated agrarian communities and their lifeways as marginal and vulnerable to extreme climate events, and advocated their removal from these areas to inland towns and slums in megacities (Paprocki 2021, 2022).

Uncertainty is the profound source of anxiety at the heart of the global CCA discourse. It invokes the specter of planetary warming to such an extent that large terrestrial ice masses – like those in Greenland and Antarctica – break apart, slip, and melt into the oceans, causing sea levels to rise and drown entire cities and populations located in coastal areas (IPCC, 2022). Climate change models predict the magnitude of change due to warming will be especially pronounced in the high latitudes of the polar regions and in the more populated tropics (Shepherd & Sobel, 2020). These planetary-level predictions are, however, beset by multiple uncertainties (Shepherd, 2019). Climate scientists Shepherd and Sobel (2020) point out that "the tropics are where the normative approach to climate prediction and uncertainty is most clearly found to be wanting" because of "scientific factors that make tropical precipitation inherently challenging to predict" (p. 13). They note that precipitation regimes in the tropics are already unpredictable in terms of their effects on the frequency and volatility of regional and local flooding events. Although melting glaciers are linked to increased risks of coastal inundation and cyclonic activity in the tropics, climate models cannot effectively quantify storm frequency and intensity because of "essential physical processes of deep convection [that] act on relatively small space and time scales" (Shepherd & Sobel, 2020, p. 13). Phenomena such as cloudbursts, cyclones, atmospheric

rivers, and storm surges intensify uncertainties of regional and local flooding in coastal zones even where large-scale engineering and infrastructure have been built to barricade land from incursions of the sea. Hence, by invoking model uncertainties to peddle old colonial solutions under the guise of climate adaptation (Paprocki, 2021), development experts and policymakers perpetuate what Shepherd and Sobel call "hermeneutic injustice" (2020, p. 13) on tropical coastal localities and regions.

In this article, we argue that the tropical coastal *aquaterras* where communities dwell (Ingold, 2011) between the fluctuating margins of sea and shore offer political ecologists a critical space to rethink concepts of marginal and marginalization for climate change adaptation. These areas and communities have long been the target of colonial and postcolonial schemes that have sought to 'reclaim' land from sea in the name of improvement, modernization, civilizational progress, property development, economic growth (Bhattacharya, 2018) and, today, climate change adaptation. Mainstream CCA narratives conjure visions of defenseless, impoverished millions living in tropical coastal margins of the global South without the capacity to survive the uncertainties of flooding and destruction from sea level rise and cyclones (Paprocki, 2020). What these narratives fail to acknowledge, though, are the vernacular knowings of diverse tropical *aquaterra* communities for sustaining life and livelihoods within the fluctuating fringes of sea and land. By vernacular knowings we mean the combination of multigenerational knowledges (Nunn, 2018), technologies, and ongoing learnings which enable these coastal communities to negotiate the uncertainties, volatilities, and vulnerabilities associated with changing climates, ecologies, and lifeways in their *aquaterras*. Simply put, our argument is that by imposing a land-based conceptualization of marginality and vulnerability on tropical *aquaterra* communities, the mainstream CCA discourse forecloses a more critical understanding of marginality in terms of the relative capabilities of such communities to mobilize and build on their vernacular knowings and resources for living with the contingent outcomes of climatic, fluvio-tidal, ecological, and socio-political processes in their localities and regions.

Instead of accepting mainstream CCA representations of tropical *aquaterra* communities as marginalized climate victims and potential climate refugees, a 'buoyant' political ecology can guide navigation towards a 'transformational discourse' (Ojeda *et al.*, 2022) and "transformative climate action" (Bassett & Fogelman, 2013, p. 51; Ribot, 2011; Nightingale *et al.*, 2020) that builds on their vernacular strategies and practices of adapting to and making resilient lifeways in watery margins. Such a buoyant approach can create new spaces of engagement for a critical CCA which brings together both vernacular and climate science interpretations of uncertainty through more equitable, respectful, 'situated' (Haraway, 1988) frameworks without fetishizing one or privileging the other. In doing so, political ecologists can overcome the hermeneutic injustice perpetrated by mainstream CCA policies which use climate uncertainty to justify development schemes that impose disadvantage and precarity on tropical *aquaterra* communities.

In the section that follows, we critically interrogate the concepts of marginal land and marginalization in political ecology to examine how these are deployed in the context of *aquaterras*. Focusing on regions we are familiar with, we proceed to examples of lifeways of communities dwelling in estuarine and deltaic zones of West Africa and the Indian subcontinent to understand how their vernacular systems adapt to living with the contingent outcomes of climatic, marine, fluvio-tidal, ecological and socio-political processes and extreme events. We show how mainstream CCA policies effectively reproduce colonial, postcolonial, neoliberal development approaches and schemes that sought to efface these vernacular systems of adaptation and transform coastal *aquaterras* into rent-yielding *terra firmas*. The final section proposes a buoyant political ecology approach which focuses on augmenting the vernacular capabilities of tropical coastal communities for making resilient lifeways and livelihoods on the new foreshores of climate uncertainty.

## 2. Marginal lands and watery margins

Political ecologists have for over four decades critically engaged with concepts of human vulnerability and adaptation to 'natural hazards' (Watts, 1983, 2015; Wescoat, 2015; Wisner *et al.*, 2004). When cultural and human ecologists drew on general systems theories and cybernetic models to explain adaptation to natural hazards such as floods, political ecologists argued that floods were not simply external biophysical threats but were in fact produced through a combination of ecological and political-economic factors (Hewitt, 1983). They

pointed out that the singular focus on human response to a 'natural' hazard overlooked the political-economic and structural/historical factors within countries and regions which rendered some social groups more at risk of exposure to environmental disaster events than other groups (Watts & Bohle, 1993). They noted that it was necessary to recognize how risk was differentially produced as 'spaces of vulnerability' emerging from the intersection of three causal factors: the dearth of entitlements (property and access rights to subsistence); disempowerment (lack of political and institutional rights); and class relations within a specific political economy (surplus appropriation) (Watts & Bohle, pp. 52-53). Although the contemporary CCA policy discourse has adopted concepts such as social-ecological systems and resilience in response to hazards (Wescoat, 2015), many political ecologists point out that neither of these concepts overcome the flawed analytical distinction between external/biophysical cause and human response (Head, 2010; Ribot, 2011; Bassett & Fogelman, 2013; Watts, 2015).

A central aspect of political ecology critiques of older human adaptation models and contemporary CCA policy discourse is the concept of marginality. Indeed, it forms the core of the 'degradation and marginalization' thesis, one of the key perspectives in political ecology (Robbins, 2020; Benjaminsen & Svarstad, 2021). The conceptualizations of marginal, marginality, and marginalization in political ecology stem from arguments challenging the apocalyptic narratives of environmental destruction based on Malthusian perspectives that were dominant through the 1970s and 1980s (Watts, 1983; Blaikie, 1985; Blaikie & Brookfield 1985; Hecht, 1985; Carney, 1988). Political ecologists drew attention to the political-economic patterns of access to and control over resources, changing social structures, and capital accumulation, which created "chains of interdependency linking farmers, households and communities to state and world markets which shaped and often undermined the capacity to manage land and soil resources" (Watts, 2015, p. 34). Their analyses demonstrated how "vulnerability and marginality (both ecological and socio-economic) were being produced by particular sorts of social and economic exposure rooted in the circuits of capital and in the operations of what passed as state policy" (Watts, 2015, p. 34).

However, despite being core to political ecology explanations of degradation, disasters, and vulnerability, not many scholars have critically questioned the hermeneutics of terms such as 'marginal', 'marginality', and 'marginalization'. Marginal is commonly interpreted as a signifier of an edge condition, a socio-economic and biophysical 'periphery' constituted in relation to a 'core' or center of privilege (Sturgeon, 2007; Edelman & Wolford, 2017; Sultana, 2021). Tania Li (1999) describes marginal as a hegemonic social construction where the margin and center are articulated in an asymmetrical and ongoing relationship of power. The characterizations of marginality may be positive or negative, sites of "nostalgia and fascination as well as derision"; whatever the representation, they underpin the "rhetoric and substance of interventions" in the form of policy design, decisions, and evaluations made by the center in these peripheries (Li, 1999, pp. 1-2). She notes that marginality signifies a relational situation of poverty and powerless existence, and marginalization as a political-economic process that impoverishes, disempowers, and pushes some individuals and groups to the socio-spatial peripheries of their societies. Marginalization occurs when the center (i.e., a state regime or governing elite) uses contrasting concepts of knowledge and power as part of the rationale for asserting greater territorial control and pursuing wealth accumulation in its peripheries.

Because political ecology emerged as a challenge to Malthusian and development theories that linked peasants with environmental degradation, much of the discussion of marginal, marginality, and marginalization in the literature relies on concepts developed within critical agrarian studies and Marxian political economy analyses of property (Wolf, 1972), core-periphery relations, and unequal exchange under European colonialism and globalization (Borras, 2009; Foster & Holleman, 2014; Edelman & Wolford, 2017). This legacy is most evident in Piers Blaikie and Harold Brookfield's foundational text, *Land Degradation and Society* (1987) which sets out the degradation and marginalization thesis within the analytical approach of regional political ecology. The authors devote considerable attention to how terms such as marginal, marginality, and marginalization have been theoretically conceptualized in economics, ecology, and political economy, and show how these can be brought together to understand state- or market-led interventions and processes which result in ecological and economic marginalization (land degradation) and political-economic marginalization (social disadvantage and

vulnerability) within regions, localities, and communities (Blaikie & Brookfield, 1987, pp 19-23). We summarize their explanations below.

Blaikie and Brookfield begin with classical political economic conceptions of margin and marginal by drawing on Ricardo's theory of land rent. Rent is the monetary benefit that is gained by the owner from putting their land into production. The *margin* represents an economic situation when the income derived from production is exactly equal to the cost of production, i.e., *marginal* land is that which, when brought into production, yields no rent (and perhaps even incurs monetary loss) for the landowner. The marginality of the land may be due to inadequate biophysical attributes for production or due to its geographic location in relation to markets (Blaikie & Brookfield, 1987, pp.19-20).

The authors then outline the ecological concept of marginal in terms of the variable stress caused by either human interference or environmental conditions. An *ecologically marginal* area or zone is one where an association of (non-human) organisms or biotic community can survive 'expected killing stress' (Blaikie & Brookfield, 1987, p. 20). In other words, ecologically marginal land is that which is severely stressed for extended time periods and contains a very sparse and impoverished biotic community. They note that the concept of marginality from economic and ecological perspectives are comparable because both relate to conditions of impoverishment and survival.

Turning to Marxian political economy, Blaikie and Brookfield (p. 21) highlight three ways in which marginality is conceptualized in terms of dependency, exclusion, and containment. The first draws on world-systems or dependency theories of core-periphery relationships and economic development (e.g., Rodney, 1972; Bernstein, 1973; Wallerstein, 1974; Amin, 1976; Stavenhagen, 1978; Nash, 1979; Taussig, 1980), which focus on the large-scale transfers of wealth (derived from land-based extraction and production) from Europe's colonies to its metropolitan centers. The extreme exploitation of producers and lack of investment in longer term productivity of land (*landesque capital*, p. 9) results in both economic and ecological impoverishment of regions and localities in the periphery and entrenches their dependency on the metropole. The second, marginality as exclusion, is linked to political-economic structures and processes within countries, regions, or localities that disenfranchise and exclude particular social groups from productive (waged) employment, thereby marginalizing them, i.e., forcing them to survive on meagre resources in slums or as refugees without political recognition or voice in their societies (e.g., Perlman, 1975; Agarwal, 1994; Harriss-White, 1996). The third, marginality as containment, relates to places that are categorized as ecologically and economically marginal where disadvantaged racial or ethnic groups have been confined by coercive state action (e.g., Wolpe, 1972; Watts, 1983; Comaroff & Comaroff, 1987; Mamdani, 1996; Scott, 2009) or displaced to promote capitalist development (e.g., Berry, 1993; Hart, 1996; Bernstein, 2010).

When Blaikie and Brookfield bring these different concepts of marginal together to explain the political ecological processes of land degradation and marginalization (pp. 21-24), the Ricardian concept of land in terms of its *potential to yield rent* becomes the underlying common denominator. Degradation essentially represents the inability of the biophysical attributes of the land to deliver rent from production, thereby rendering it ecologically and economically marginal for the tenant or landowner. Marginalization happens when, for example, tenant producers are unable to generate surplus to pay rent to the landowners, taxes to the state, or invest in landesque capital. In addition, political economic factors such as unequal exchange and exploitative agrarian relations may force them to intensify production on economically marginal lands and thereby reinforce the nexus of degradation and marginalization. By persisting with production, they put the land to further ecological stress for diminishing returns until they lose access to land altogether and become economically marginalized in their societies.

The point we wish to emphasize is that most political ecology explanations reproduce the classical economic conceptualization of marginal as the boundary marker of value and privilege. Drawing on Spivak's (1990) critique of marginality, we would argue that the Ricardian concept of marginal land is the invisible 'currency' which operates in both mainstream economic and political ecology approaches for 'value coding' territories, cultures, and peoples as marginal or marginalized (pp. 221-222). This value coding is implicit in the wide range of political ecology critiques which highlight how mainstream CCA policies and projects intensify marginalization of disadvantaged social groups, for example, by: producing maladaptive outcomes (Schipper,

2020); promoting neoliberal agendas of green capitalism (Swyngedouw, 2010; Sullivan, 2017); recreating a neocolonial, Eurocentric, global order by linking adaptation to mainstream international development discourses of economic growth (Taylor, 2013; Nightingale *et al.* 2020; Andreucci & Zografos, 2022; Sultana, 2022); failing to address generative causes of risk and vulnerability (Ribot, 2011, 2014; Forsyth, 2014); and enabling national governments to use IPCC targets as justification for appropriating lands where marginalized populations reside to benefit a powerful coterie of political-economic interests (Sultana, 2010; Nightingale, 2017; Sovacool, 2018; Mehtta, 2021). Despite making these valid criticisms, few have questioned the implicit land-water divide in mainstream CCA value codings of tropical coastal *aquaterras* as economically marginal lands. Nor have they challenged the value coding of communities that have long dwelt in these areas as marginalized because of their presumed inability to cope with the uncertain outcomes of climate change.

A constructive political ecology approach towards *critical* CCA requires rethinking how marginality is conceptualized within the fluctuating thresholds of land and sea. The implicit value coding of tropical watery margins as marginal lands effaces the vernacular knowings that diverse coastal *aquaterra* communities deploy for living within the fluctuating margins of water and land and negotiating the uncertainties of flooding due to storms, tidal surges, and other geological and climatic events. It ignores the capabilities they have developed and maintained through multigenerational, place-centered, time-authenticated, adaptive technologies, engineering, and ecological practices (Dove, 2021; Nakai, 2021), and instead portrays them as marginalized climate victims or potential climate refugees that will throng cities and invade the shores of rich countries (e.g., Rigaud *et al*., 2018).[2] Their vernacular knowings are usually categorized as indigenous, traditional, cultural, or grassroots knowledge, and represented "axiologically" (Cortesi, 2021, p. 884) in relation to the value systems of 'modern' economics and science. Even studies that advocate the need for incorporating local knowledges, multiple ontologies, plural epistemologies, and polyvalent histories to address climate change adaptation (e.g., O'Brien *et al.*, 2007; Mustafa & Halvorson, 2020; Nightingale *et al.*, 2020; Crowley *et al.*, 2022; Brink *et al.*, 2023) rarely discuss how local communities *analyze, interpret, and negotiate the uncertainties and contingent events* arising from the interactions of climatic, terrestrial, ecological and socio-political processes.

Instead of accepting mainstream CCA portrayals of tropical coastal *aquaterra* communities as vulnerable and marginalized climate change victims, political ecologists need to critically engage with their diverse, vernacular strategies and situated practices of making resilient lifeways in place. The following section explores some of these vernacular knowings and adaptive practices within the estuarine and deltaic *aquaterras* in West Africa and the Indian subcontinent.

## 3. Vernacular knowings of watery margins

Estuaries and deltas refer to distinct wetland ecologies where rivers meet the sea. Their geomorphological formations are key for understanding lifeways and vernacular knowings of peoples who have long histories of living with the environmental uncertainties of tropical *aquaterras*. A delta is a coastal landform where *land reaches into water* by deposition and accretion of sediments that rivers disgorge from their mouths into the sea. An estuary, in contrast, is a partially enclosed coastal body of water formed by marine tides flooding a coastline and injecting saltwater in lower river valleys (WHOI, 2024), i.e., where *water reaches into land*. Both are fluvio-tidal transition zones where the confluence of freshwater, saltwater, land, sediment, and biota are manifested in different ways.

These zones of confluence between sea and land experience the daily ebb and flow of marine tides and seasonal variance in the concentration of salts in the estuary. Coastal rivers, streams, and creeks meander through mudflats influenced by the mixing of fresh and saline water to which a diversity of plants and animals have adapted. In the evocative words of Rachel Carson (1955, p. 1), it is a watery world that is forever "changing with the swing of the tides, belonging now to the land, now to the sea." In tropical estuaries and deltas, this intertidal zone supports mangrove forests which as wave-breakers buffer coastlines from cyclones and tidal surges. They also provide vital habitats for a wide variety of marine mammals, fish, shellfish, and birds, and

[2] See Farbotko & Lazrus (2012); Bettini (2013); Verhoeven (2021), and Hayward *et al.* (2020) for critiques of the threat of climate refugee migrations from African and Pacific Island countries to the Global North.

are known as 'nurseries of the sea' for the many species that breed, spawn, and nest there. Human lifeways along with those of plants and animals in *aquaterras* depend on flexibility and adaptation to a liminal world of unceasing change.

*Lifeways in West African estuaries*

When Portuguese mariners reached the African coast south of the Gambia River in the mid-fifteenth century, they encountered for the first time mangrove forests and estuaries cultivated to rice (Carney, 2001). Communities in these estuarine zones grew an indigenous rice species (Oryza glaberrima), which their ancestors had domesticated some two millennia earlier. Over this long period, these communities had adapted rice cultivation to the ecologies of estuarine *aquaterras*. Adaptation involved building up a repository of knowings and practices of food production in coastal mudflats and mangrove swamplands influenced by anticipated patterns of seawater flow, rainfall, and tidal movements. Rice cultivation required understanding of marine tides, their lunar cycles of ebb and flow, seasonal changes in salinity, and the fluvial dynamics influencing the distribution of mud, silt, and sand in the estuarine ecosystem.

Figure 1. Estuary with embanked rice fields in Casamance, Senegal. Source: Pélissier 1966, Plate 47.

With the onset of the transatlantic slave trade, coastal rice culture transformed into what Scott (2009) has called 'escape' agriculture. Communities living along the littoral shifted their dwellings and crop cultivation to the interior of mangrove swamps to evade capture by slave traders (Hawthorne, 2003). These swamplands earned an early reputation among seventeenth-century European slavers as a 'white man's grave' (Lloyd, 1949,

p. 19; Curtin, 1964, pp. 73-74) largely due to their susceptibility to deadly falciparum malaria, whose epidemiology was not yet understood. The local population had, on the other hand, developed genetic resistance to this disease through the sickle cell hemoglobin mutation (Shah, 2010, pp. 47-48).

The notoriety of mangrove swamps as insalubrious continued to dominate the European imaginary during colonial rule well into the twentieth century (Cormier-Salem, 1999; Carney, 2017a). Mangrove swamplands and forests were deemed febrile wastelands on the continent's edge and, as such, consigned to the realm of the marginal along with their traditional occupants. Recent ethnographic research in estuaries of Senegal and Guinea-Bissau has begun to dispel this longstanding perception of mangrove communities as 'peripheral' (Cormier-Salem, 1999; Davidson, 2016; Sousa & Luz, 2018) by bringing attention to their knowledge and adaptive expertise at the frontline of climate change (Santos & Mourato, 2024, p. 151; Sandoval *et al.*, 2024).

The vernacular knowings of marine tidal flows, monsoons, and mudflat topography which guide some of the most productive indigenous mangrove rice-farming systems in the African continent are evident in two crucial *aquaterra* practices: the transformation of saline-influenced soils into fertile rice fields, and 'terraforming' tidal mudflats into polders.

Mangrove rice cultivation marshals a complex interplay of freshwater and marine hydraulic regimes (Pélissier, 1966). It typically takes place in estuaries that receive more than 1500 millimeters of rain annually (Sousa & Luz, 2018). Estuarine mudflats are made into 'polders' or cultivable terrains by manipulating seawater and rainwater during the wet and dry seasons. Polders that start out as nutrient-rich but saline soils must be desalinated before they can be planted. This requires the accumulated salts in the polder to be leached by rainfall over several consecutive wet seasons before it is ready for cultivation. The challenge thereafter is to ensure the polder's productivity beyond the dry season rice harvest and into the next cultivation cycle. During the dry months, farmers must keep these acidic-saline fields waterlogged to prevent their oxidation and the release of toxic sulfuric acids that can render the entire polder infertile (Varghese *et al.*, 2024). The danger of acid-sulphate soil formation is neutralized by admitting a layer of brackish water into the rice paddy to keep the soil hydrated (Figure 2a & b). Besides providing critical hydration, the introduced seawater carries sediments that renew soil fertility. With the arrival of the wet season, the first rains dilute the seawater, wash it away, and flush out residual salts in the polder soils.

Polders are created by building a large earthen embankment or protective dike which enables the landward side of mangrove mudflats to be transformed into rice fields. The design and layout of mangrove rice polders varies according to close observation of estuarine ecologies and hydrodynamics and the cumulative in situ experience of communities in terraforming swamps for agriculture. Rice cultivation requires flooding and drainage of seawater at critical stages of the growth and harvest cycle. The unwanted intrusion or flooding of rice paddies by saltwater during these stages can destroy the crop. The embankment is built as a barrier to protect the crop from marine tidal surges. Specialized knowledge of estuarine hydraulics and topography informs its location and orientation. The seaward side of the main protective embankment is typically left in mangroves to serve as a buffer against marine water intrusions (Figure 3). The area on the landward facing side of the dike is trenched to pool seawater overspills (Figures 2, 3). The incoming tides bring fish, crab, and shrimp into these spillover ponds between the embankment and rice fields. Since it is impossible to completely prevent the influx of seawater in the cultivated polder, mangrove farmers have, over generations, selected and developed salt-tolerant *glaberrima* rice landraces that confer some protection against saline toxicity.

Figure 2a: Rice polder with earthen dike in Guinea-Bissau.

Figure 2b: Estuarine brackish water channeled onto rice paddy to retain moisture and prevent acid-sulphate soil formation during dry season. The principal protective earthen dike or embankment is seen on the right.

Source: R.J. Oosterbaan, Guinea-Bissau, 2009. R.J.Oosterbaan@en.wikipedia, Public domain, via Wikimedia Commons

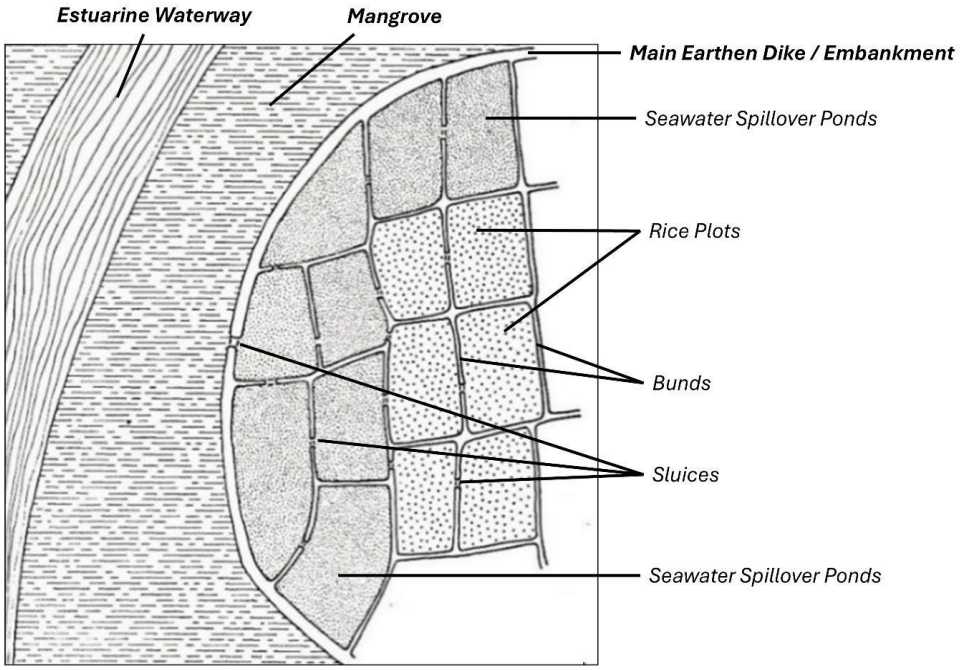


Figure 3: Example of a mangrove rice polder in Casamance, Senegal for controlling the flow of seawater into mangrove rice fields. Adapted from Pélissier, 1966, Figure 52, p.723a.

The dimensions of the main embankment are calibrated to known patterns of marine tides or the 'tidal clock' (Kamat, 2004), as well as cultural memory of historical, and less predictable, tidal surges. Farmers use mud of different textures and properties combined with sticks and rice straw to collectively build and seal the embankment. The length is determined by the area intended for cultivation at a height and breadth that can withstand the force and amplitude of both expected tidal patterns and known but exceptional tidal surges. The embankment is pierced by a sluice made of a palm trunk, which allows farmers to selectively control water flows into and out of the reclaimed area and between individual rice parcels.

Once the main embankment is in place, farmers begin subdividing the polder into rice plots by clearing the area of vegetation and forming mud bunds of lower height to enclose each parcel. These are also perforated by hollow palm trunks stuffed with their leaves, the latter serving as plugs to control the inflow and outflow of water throughout the cultivated area (Figure 4).

Depending upon the polder's topography, areas most at risk for saltwater spillover are left uncultivated or planted to salt-tolerant seedlings. Each year, the plots are readied for cultivation by lifting the nutrient-rich organic mud and turning it for aeration with a specialized shovel that mounds the ridges on which rice seedlings are transplanted and excavates the furrows that channel water flows. With the seasonal return of rains, rice is first sown on higher ground near villages after the first rainstorms rinse the polder of salts accumulated from dry season seawater flooding. Once the salts are sufficiently flushed from the polder by precipitation, seedlings are transplanted, and the rice cycle resumes.

Rice cultivation forms one component of a broader strategy by which West African coastal communities create lifeways in mangrove estuaries. During the dry season months, men fish in the estuary and shoreline waterways and harvest oil palm fruits from which women extract the kernels that are expressed into cooking oil and soap. Salt is harvested for household use and sale in markets. As the rainy season comes to an end and floodwaters recede, women plant vegetables on the bunds of the rice plots and turn to shellfish collection from the silty, muddy, and sandy substrates of the estuary. They travel the waterways with the tides in dugout canoes

to harvest oysters from mangrove prop roots, which they sun-dry, salt, or smoke to store for family consumption (Carney 2017b).

Figure 4. Left: Palm trunk set in main embankment as sluice for water control. Note the difference in water level between polder and waterway. Right: trunk sluice being replaced between individual rice parcels in the dry season. Casamance, Senegal, 1999. Source: Judith Carney

Today, these West African *aquaterra* communities are at the forefront of dealing with climate change in the tropics. Many community members are choosing to remain and adapt to changing conditions rather than migrate (Santos & Mourato, 2024). Independence struggles in Guinea-Bissau and ethnic conflict in Casamance, Senegal over past decades caused polders to be neglected or abandoned. But today, many of these are being rehabilitated, strengthened or rebuilt, guided by the expertise of elders with intergenerational knowledge of hydraulic regimes (Sousa & Luz, 2018; Temudo *et al.*, 2022; Sandoval *et al.*, 2024). For these communities, "staying put" (Santos & Mourato, 2024, p. 150) means implementing flexible vernacular strategies that continuously anticipate, improvise, and adapt infrastructure and cultivation practices to negotiate uncertainties of rainfall patterns, storm surges, sea flooding, and saltwater intrusion.

*Lifeways in coastal* aquaterras *of the Indian Subcontinent*

When the Portuguese established control over Goa in southwest India in 1510, they encountered traditional, community-managed *aquaterra* ecosystems in estuaries and mangrove-fringed swamps along the coast (Kamat, 2004; Sonak *et al.*, 2005). Called *khazan*, this agri-aqua cultivation system was similar to other *aquaterra* ecosystems engineered by early coastal communities in estuaries and deltas of the Indian subcontinent and, as the preceding section shows, by coastal communities in West Africa. These coastal agri-aquacultural systems in India (for example, *pokkali*, *kaippad*, and *kole* in Kerala (Chandramohanan & Mohanan, 2011); *gazani* in Karnataka, *gheri* in Odisha, and *bheri* in West Bengal (Sonak *et al.*, 2005)) activate their intergenerational and finely tuned vernacular knowings of the tidal clock, patterns of fluvio-tidal fluctuations, salinity regulation, and mangrove ecologies to cultivate rice, fruit trees, and vegetables and to catch or culture

fish and shellfish in the low-lying areas of estuaries and deltas. The technological complexes of embankments, sluices, bunds, water channels and ponds for managing the flows of seawater and freshwater in estuaries and deltas are designed and constructed in diverse ways by *aquaterra* communities.

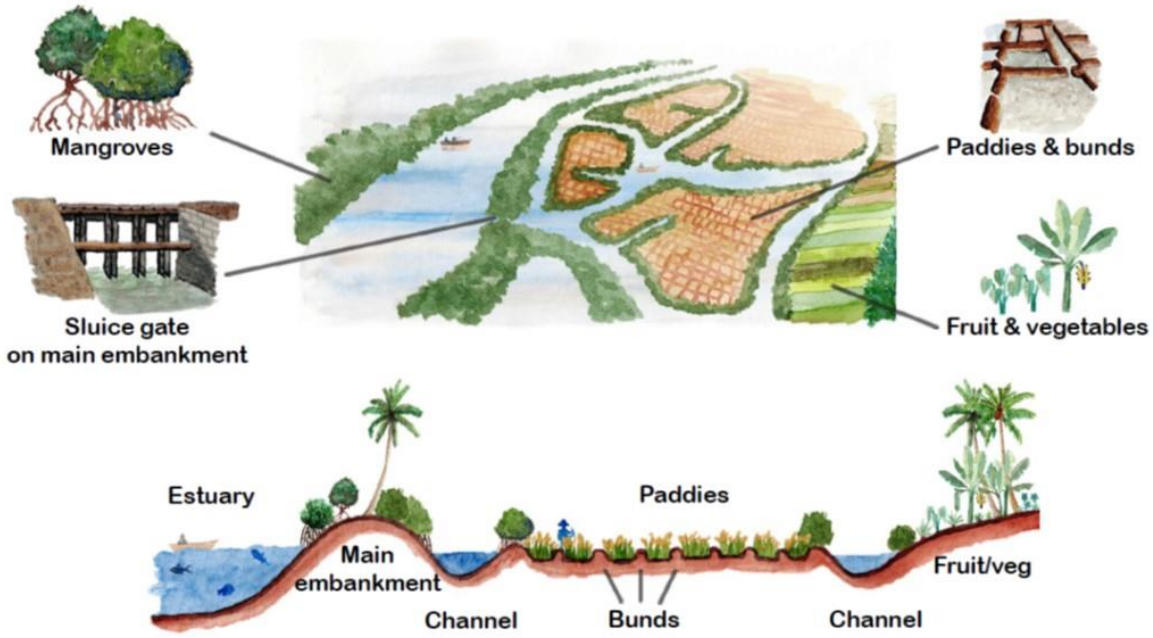


Figure 5: Schematic diagram of the Goan khazan system. Illustrator: Simon Connor

The *khazans* are engineered to control the balance between flows of freshwater from rainfall and aquifers and saltwater from tidal ingress in the estuary. As in the West African estuarine cultivation systems, the community that collectively owns and manages a *khazan* area determines the dimension and siting of the main embankment which protects it from saline water intrusion. The sluice gates are designed to only allow the volume of seawater that can be stored in the ponds, channels, and backwaters. At low tide, the sluice gates open to drain out the seawater. The main embankment is constructed using the different types of mud from the estuary, combined with rice straw, sticks and poles, and sluice gates made of hardy local tree species that can withstand the force of the high tides. Mangroves are maintained on the seaward side of the main embankment to absorb the erosive force of tidal surges. Behind the main embankment, the deep trenches adjoining the sluice gates and channeled backwaters are used for aquaculture. Areas close to the main embankment serve as spillover tracts or salt pans, while those further inland are cultivated to salt tolerant local rice varieties once the monsoon rains have leached out excess salinity from the soils. Coconut palms are planted along the main embankment for a variety of household uses and sale in local markets (Sonak, 2014).

During the annual monsoons (June to October), the backwater channels of *khazans* become rainwater reservoirs and wetlands that reduce the risk of flooding in coastal settlement areas and enable recharge of aquifers. After the monsoon season ends, higher elevation plots are used for cultivating vegetable, legumes, and fruit crops irrigated by water from adjacent rainwater ponds (Sonak, 2014).

While Goa's estuaries and *khazans* receive significant deposits of alluvium during the monsoons from rivers flowing down from the Western Ghats, these are dwarfed in comparison with the one gigaton (1 billion metric tons) of sediment annually transported by the Ganges, Brahmaputra and Meghna (GBM) rivers that flow

from the Himalayas and empty into the Bay of Bengal (Rahman *et al.* 2020). The GBM, or Bengal Delta, is one of the world's largest river deltas covering around 1.12 million hectares in which more than 140 million people live (Rogers & Overeem, 2017). The enormous sediment load that these Himalayan rivers transport to the delta is constantly being redistributed by the strong marine currents from the Bay of Bengal (Das, 2015). The process of delta formation also involves soil compaction and land subsidence from sediments deposited around the confluence of rivers and the advancing coastline.

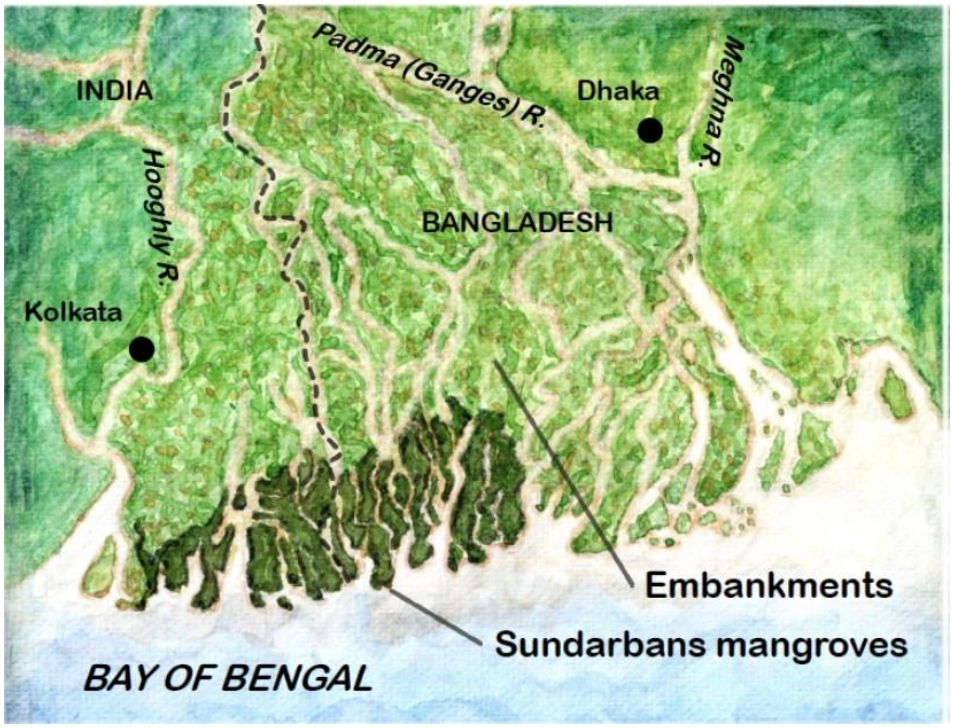


Figure 6: The Bengal Delta. Illustrator: Simon Connor

Over the past 6,500 years, fluvio-tidal sediment deposition and accretion has extended the shoreline of the delta into the sea by nearly 300 kilometers. This dynamic process also continues to be shaped by long-term tectonic and geological activity (Das, 2015, p. 16). The resulting coastal floodplain is a vast *aquaterra*, where river distributaries, tidal channels and flats, estuaries, mangrove swamps, saltmarshes, alluvial sandbars and islands (or *chars*) are constantly shifting and changing (Lahiri-Dutt & Samanta, 2013; Lahiri-Dutt, 2014; Das, 2015; Lafaye de Micheaux *et al.*, 2018; Paprocki, 2021). As Acharya (2023, p. 5) succinctly states, "In the Bengal Delta, land exists where water allows it."

It is in this huge, mobile, and shapeshifting *aquaterra* in which multitudes of Delta communities have developed their agri-aquacultural systems and social relations (Datta, 1998; Lahiri-Dutt & Samanta, 2013; Paprocki, 2021). As in the aforementioned West African and Goan estuaries, vernacular knowings have shaped specialized technologies and livelihood strategies that are responsive to the tidal clock, seasonal fluctuations in salinity, monsoonal flooding, cyclonic events, and the heterogenous floral and faunal ecological assemblages of the upper and lower deltaic floodplains. While the terraforming infrastructure is similar to the Goan *khazans* and West African estuarine systems, the deltaic communities build and manage it differently to address the enormity of sediment discharge and erosion.

Depending on proximity to the river channels and gradient levels, the annual agri-aquaculture system of the Bengal Delta permits cultivation of rice, vegetables, and legumes for household consumption and

commercial crops such as jute, fish, and shellfish. As in the estuarine systems, rice cultivation is attuned to the type and duration of freshwater availability. Seed types are selected for salt tolerance, early harvesting, or the period of freshwater availability. This allows for a continuous harvest of rice from different parts of the Delta between November and mid-January (Datta, 1998; Lahiri-Dutt & Samanta, 2013; Paprocki, 2021).

Following harvest of the first rice crop, the protective earthen embankments are cut open to allow water from river tides to enter the fields. This flooding delivers nutrient-rich organic materials that renew soil fertility. At the end of the monsoons, some of the elevated land is given over to grazing; vegetables, legumes, and other crops are planted near freshwater ponds close to settlements (Datta, 1998). Shellfish and fish culture takes place along the main embankments. Tidal flows aerate and regularly change the waters and allow the inflow of juvenile shrimps, fin fish fry, and the algal material that promotes their growth. With the agricultural cycle complete, bunds are repaired and fish and shrimp cultured for harvest prior to the onset of the next monsoon (Datta, 1998; Paprocki, 2021).

Despite increasing political economic pressures to replace the estuarine *khazans* of Goa with tourist resorts and residential development, many local communities have sought to maintain their vernacular agriculture and aquaculture systems (Sonak *et al.*, 2005; Sonak, 2014; Deepak, 2021; ICLEI South Asia, 2024). In the Bengal Delta, both national governmental and multilateral CCA policy categorization of agri-aquaculture practicing communities as marginal leads to their portrayal as desperate survivors and future climate refugees. These agencies have promoted 'blue economy' CCA development schemes in the Delta which force local communities to abandon their practices in favor of large-scale, year-round shrimp cultivation for export, or permanently migrate to cities in search of waged employment (Paprocki 2019, 2020, 2021, 2022). But some local communities have joined together to resist the economic pressures and saltwater intrusion caused by shrimp monoculture and have returned to their vernacular systems of agri-aquaculture (Paprocki, 2021).

*Resilience on land's edge*

The foregoing examples of coastal lifeways in West Africa and the Indian subcontinent bring us back to the key question: *what constitutes the basis for determining marginality within the fluctuating thresholds of land and sea*? The repeated warning that sea level rise threatens nearly forty percent of the global population living within 100 kilometers of the coast (Moser, 2014; UNEP, 2024) has focused on the tropics where much of it is concentrated. However, the CCA policy narratives rarely distinguish between residents of coastal cities and the *aquaterra* communities that have developed vernacular systems and adaptive strategies for negotiating the uncertainties of extreme flooding events. The implicit assumption is that non-urbanized *aquaterras* are marginal lands and that communities dwelling in them are ignorant about climate change risks and barely surviving on land's edge without the security of modern infrastructure. But, as the above examples show, this assumption might be more applicable for urban populations residing on lands reclaimed from the sea who, unlike *aquaterra* communities, may not be able to draw on collective repositories of situated knowledge and collective experiences of adapting to the uncertainties of flooding.

In many ways, the land reclamation projects pursued by colonial and postcolonial states that converted so-called marginal *aquaterras* into rent-yielding *terra firmas* by dredging, infilling, and concretizing the land-water divide are today acutely vulnerable to the uncertainties of sea level rise and flooding (Bhattacharya, 2018; Shepherd & Sobel, 2020; Sengupta *et al.* 2023). The financialization of climate risk (see Johnson, 2013; Stanley, 2013; Christiansen, 2021; Sullivan, 2021) through property insurance (e.g., Swiss Re, 2021) has not made reclaimed lands more secure or better adapted for living with flooding. Rather, it forces populations in these areas who cannot afford the costs of insurance into situations of greater vulnerability and precarity when extreme flooding events occur.

A critical political ecology move towards transformative climate action (Ribot, 2011; Bassett & Fogelman, 2013) in tropical coastal areas requires jettisoning the classical economic value coding of marginal land and marginalization. Instead, these concepts need to be reframed in terms of the situated knowings, relative capabilities, and infrastructure systems that communities and households in coastal areas can mobilize for living with and adapting to changing combinations of climatic, fluvio-tidal, and political ecological factors.

## 4. Towards a buoyant political ecology for *critical* CCA in tropical coastal areas

There is no doubt that global warming is influencing changes in climate for tropical coastal regions and localities in known and unknown ways. Nor are these changes restricted to the tropics. The unpredictable intensity of storms and flooding in the global North bear witness to the seemingly inexorable poleward expansion of tropical climate unruliness (Bowd & Clayton, 2019). As Cons (2017) observes, large and unprecedented flooding events in both the global North and South are indications that climate change has "fundamentally shifted our relationship to land, to water and to what we understand as 'habitable space'." (p. 49). Rather than approaching coastal CCA as defense of *terra firma*, the central concern for critical CCA should be *how* people can live in place by expanding their capabilities to negotiate new uncertainties of flooding from sea level rise, storms, and tidal surges.

The foregoing examples from West Africa and the Indian subcontinent illustrate how some estuarine and deltaic communities have developed effective, vernacular systems for doing so. The examples are not exclusive or unique to these regions; similar practices and systems can be found in tropical coastal areas around the world. Indeed, there is a significant body of work by geographers and anthropologists on tropical floodplains, estuaries, deltas and coastal zones. They have used concepts such as 'land-water hybridity' (Lahiri-Dutt, 2014), 'waterscape' (Acharya 2015), 'amphibious space' (Morita, 2016), 'aquatic space' (Oslender, 2016), 'water-land nexus' (Krause, 2022), and 'waterland' (Cortesi, 2022) to describe the diverse vernacular systems of adapting to the evolving uncertainties associated with dwelling between sea and land (also see Lamb, 2020; Ivars, 2021). Krause and Harris (eds., 2021) and their fellow contributors to *Delta Life* show how communities inhabiting these coastal environments understand volatility as an integral and existential feature of life in which anticipated movements of land, water, biota, and human activity can be suddenly or rapidly reconfigured and transformed alongside political-economic changes. Scholars have also demonstrated how large-scale infrastructure and development projects aimed at fixing the land-water boundary have exposed communities living in these areas to new risks (e.g., Pelling, 1999; Lahiri-Dutt & Samanta, 2013; Lahiri-Dutt, 2014; Nijbroek, 2014; Rogers & Overeem, 2017; Cons, 2018; Dewan, 2021; Paprocki, 2021; Santos & Mourato, 2024).

Freeing the concept of marginal in political ecology from its tethers to Ricardian *terra firma* opens up new ways of seeing diverse, place-based approaches of living with flooding. A buoyant political ecology approach allows us to think beyond *terra firma* to the myriad *aquaterras* across the world and examine the vernacular practices of communities that have long navigated lifeways along the liminal edges of land and sea. This visioning not only poses a powerful challenge to the apocalyptic scenarios of mainstream CCA policy narratives but can also offer pragmatic ways of working with climate uncertainties at regional and local scales. Reframing marginal and marginalization in terms of relative capabilities based on situated, vernacular knowings changes the way adaptation has been conceptualized in mainstream CCA discourse and in political ecology critiques of CCA. Rather than being a "process of adjustment to actual or expected climate and its effects" (IPCC, 2022: Annex II: Glossary, p.2898), adaptation can be seen as an active process of making resilient lifeways within a situated world of biophysical, climatic, and political economic uncertainties.

By rethinking adaptation in this way, a buoyant political ecology creates a new space for exploring the semiotic consonances and dissonances (*cf.* Cortesi, 2021) between vernacular knowings and climate science projections of uncertainty for tropical coastal regions. It redirects attention from antediluvian visionings of catastrophic sea level rise to questions of *how* tropical *aquaterra* communities accommodate and manage lifeways amid uncertainties of seawater incursion, sediment deposition, and storm surges. What factors enable or constrain local capabilities to recover from extreme flooding or other biophysical, climatic, and political-economic volatilities? Under what circumstances do their vernacular systems and *aquaterra* lifeways become subject to extreme precarity? By exploring answers to such questions, a buoyant political ecology brings vernacular knowings of coastal flooding to CCA. In doing so, it overcomes the hermeneutic injustice (Shepherd & Sobel, 2020) of mainstream policy discourse which invokes model uncertainties to repackage old colonial and postcolonial development schemes as new solutions for climate change adaptation in the tropics. Most importantly, a buoyant political ecology approach can create possibilities for transformative CCA in tropical coastal areas which respect and strengthen the capabilities of *aquaterra* communities to remain and thrive in

place. The examples from West Africa and the Indian subcontinent illustrate that alternative possibilities for coastal climate change adaptation are within our collective sights.

Bell Hooks (1989) once pointed out that margins were not just about deprivation but also spaces of radical openness. Adapting her thoughts to our changing climate present, we suggest that the coastal *aquaterras* of the tropical world (and the extra-tropics) may well be the realms where radical possibilities for our watery planet futures are already being cultivated.

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