

# Erosion by Design: Rethinking Innovation, Sea Defense, and Credibility in Guyana

SARAH E. VAUGHN

*Anthropology, University of California, Berkeley, CA, USA*

One late afternoon I was with state-sponsored engineers some forty minutes outside of Georgetown, Guyana's capital city which is located on the country's Northeastern Atlantic coast. It was low tide and they had taken a break from checking-in on the status of a refinished seawall. I listened to them exchange notes while gentle waves blanketed and receded from the tops of our shoes. Like clockwork, the sea drew all of its energy back and forth, as if to taunt us. Our footprints vanished with every wave, reminding us that we were not only standing in the sea but that we were in its embrace. They noted that the boulders they had installed a few weeks prior to heighten the seawall were now settling into its crevices.

All seemed well that day despite the low haze and suffocating humidity that made even this relatively open stretch of beach daunting to observe. I was intimidated by what caught my eye on the horizon. Pushing through the sky was a tall, cathedral-like structure that even at low tide appeared to float on top of the sea. It looked like some ancient gateway into an aquatic world, a gigantic compass of sorts that could help people find their way back to the shore. It was neither a lighthouse nor a buoy, but an out-of-use sluice that engineers believed could have been designed during the colonial Dutch or British era.

It was evidence that the shoreline had moved several times throughout the country's history. Engineers explained to me that the crumbling foundation around it might be remains of a groyne. Concrete or wooden walls built perpendicular to the shoreline, groynes are intended to reduce wave energy and trap sediment. Groynes dotting Guyana's 268-mile-long coast respond to a complex cycle of accretion and erosion that gives the country its distinctive

Acknowledgments: This essay would not have been possible without the patience, support, and interest of informants and colleagues who I have worked with over the years in Guyana.



IMAGE 1: Groyne at low tide. 2014. Author's photo.

“muddy waters” (see [image 1](#)). This cycle is supported by the Orinoco and Amazon rivers, which during the rainy season fill with copious amounts of sediment, some of which can transform into mile-long mudbanks. Every thirty years, mudbanks travel down river and migrate southeast by northwest along the coast, dampening waves and providing habitats for mangroves and other marine life (Augustinus 1978). The areas between mudbanks are prone to severe erosion which can cause mangroves to uproot. Over time, the rivers' silt counteracts this dynamic by contributing to the build-up of sandy beaches, and the cycle eventually repeats itself.

In recent decades, engineers have become committed to analyzing mudbanks' movements because climate-related storm surges have become more frequent and destructive (van Ledden et al. 2009). Retrofitting seawalls, as was under discussion in the vignette I offer above, help engineers classify areas of the shoreline that are highly erosive due to mudbanks. At these hotspots, engineers conduct field studies of the interactions between derelict and working groynes, which in turn guide their decisions about upgrades for the purposes of climate adaptation. In the most basic policy terms, climate adaptation has involved governments combating actual or expected climate change impacts. Integrated into United Nations-related climate-policy agendas in the late 1990s, climate adaptation is treated as an alternative to the steps nation-states take to reduce carbon emissions (Pelling 2011).<sup>1</sup> Within this emerging field of global climate governance, innovation, or improving the operations of sea defense, requires more than engineers' attention to the structural resiliency of

<sup>1</sup> See Schipper (2006) for a brief history of climate adaptation as a term and strategy, and its place in UN governmental protocol.

infrastructures. It also demands a desire to think and act in ways that do not seek to mimic past arrangements of capital-intensive and extractive sea defense.<sup>2</sup>

Experimenting with soft-pliable materials instead of concrete for groyne construction, engineers accept the premise that the boundaries of Guyana's shoreline are more fluid than static. With these materials they design with erosion rather than against it. Such efforts are related to engineering practices worldwide that harness nature as infrastructure (Carse 2014). But climate adaptation also involves engineers learning that their design innovations are mediated by different forms of erosion. I find it helpful, therefore, to situate climate adaptation within a broader understanding of the more-than-human timescales of innovation (Verbeek 2005). Erosion is a constant reminder that there have always been limits to sea defense. Yet, engineers still possess an incomplete conceptual vocabulary to describe the complex mediations between erosion and groynes. Erosion's capacity to take on various intensities shapes the way engineers mobilize responses to it. Looking to the shoreline for clues about how to move forward, they treat the climate adaptation of groynes as yet another effort within a longer history of converting water into land.

This essay explores the intersecting socio-material and ethical demands engineers confront adapting sea defense to climate change in Guyana. It builds on a diverse body of scholarship in the social sciences that extends debates in the field of environmental history about the conquest and capitalization of coastal-scapes, to consider erosion as an active principle of human history (see for example McLean 2011; King 2019). The new materialist approach I take in this essay, works to de-center social histories of agency, to emphasize the global and planetary effects of deep history on life forms (see also Chakrabarty 2021). From imperial China (Worster 2011), postcolonial urban Nigeria (Mendelsohn 2018), to post-Hurricane Sandy New York (Koslov 2016), erosion has been entangled with strategies of and for modernization. Less acknowledged is that erosion problematizes modernist divides between nature and culture. This is especially the case for the hydraulic engineering sciences, which are fundamentally concerned with the "place-making" erosion incites.<sup>3</sup> Engaging the social analytics of sea defense, this essay offers innovation as a conceptual

<sup>2</sup> I am highlighting innovation in an attempt to broaden discussions about climate change and adaptation that tend to narrowly focus on the discursive-ideological framework of resilience (e.g., Grove 2018). In many ways, the latter has circulated as an analytic that extends discussions about the forms of biopower and biopolitical practices that make climate change distinct from other contemporary problems of risk. Less noted is that climate adaptation does not only materialize around concerns about risk or, for that matter, questions about the management of human life. See Godin (2015) for a discussion of innovation as a term across sociohistorical contexts of technology, science, and engineering.

<sup>3</sup> Most engineers in Guyana who work on sea defense have degrees in either civil, hydraulic, or geotechnical engineering. Throughout this essay I focus on activities broadly understood as fundamental to the hydraulic engineering sciences.

framework for tracking engineers' place-making strategies alongside their appreciation for the materiality of erosion across time and infrastructural design.

Drawing on ethnographic fieldwork conducted in 2009–2010, 2014, and 2019, as well as oral histories and archival research, I show that the decision-making over whether to innovate new groyne designs is a fraught process. To cope, engineers produce what I call *innovation narratives* to describe how the combination of neocolonial empire, shape shifting ecologies, inconsistent maintenance programs, and fiscal debt creates obstacles for climate adaptation. Some engineers, for instance, talk about climate adaptation as an exercise in patience; they learn to respectfully inform foreign consultants about their local engineering context without being patronizing, while others stress that the core of what they do is stipulated by what they call “the ministry’s bank account.” Their dilemmas remind us that issues of credibility haunt even the most elite spaces of climate adaptation.

In what follows, I first outline the broader stakes of theorizing innovation in relation to the maintenance of infrastructures, to emphasize the temporalities that inform the political economy of the hydraulic engineering sciences. I then link the push for climate adaptation in Guyana to the national government’s efforts in 2010 to establish the Low Carbon Development Strategy (LCDS). So far, however, sea defense has received few funds from the LCDS relative to Guyana’s “development” industries such as sustainable logging and mining. I suggest that this marginalization is a partial effect of a colonial-era sea defense strategy called “holding the line,” which engineers now acknowledge has become ecologically detrimental over time. The paper’s final two sections explore engineers’ attempts to reimagine that strategy by innovating groyne design. Their innovation narratives detail how both working and derelict groynes alter patterns of erosion. These insights inform engineers’ efforts to stay relevant to the LCDS, by expanding their scientific study of erosion to include mangrove forests. In my concluding remarks, I reflect on why innovation narratives have the capacity to circulate beyond engineers’ technical concerns about design to inform their concerns about showing a so-called public face of credibility. Such concerns are most visible in engineers’ persistent but nonetheless ambivalent attachment to a nationalist vision of sea defense as they seek to enact more inclusive climate governance.

#### AFTERLIVES OF INNOVATION

This essay engages social science debates on infrastructural maintenance through an analysis of how engineers’ claims to innovation reconfigure the imaginary of sea defense (Bijker 2007). With a focus on innovation, I detail design activities invested in aspirational thinking about how infrastructures that have been adapted for climate change have the potential to make people and places better-off (Appadurai 2013; Hetherington 2019). At the same time, I stress

the often cautious but staggered pace at which the hydraulic engineering sciences are integrated into broader governance frameworks for climate change and adaptation.

Much of Guyana's territory is habitable only thanks to the continual maintenance of an intricate network of hydraulic infrastructures that keep the sea and rivers at bay. Guyana has a land area of roughly 83,000 square miles and a population of around 777,000. Between 85–90 percent of the population lives in its low-lying Atlantic coastal region. Portions of the coast sit from 19.7 inches to 39.4 inches below sea level, with 25 percent protected by seawalls, 60 percent by mangroves, and 15 percent by sandbanks or mudbanks (Lees, Wernerus, and Simpson 2009). African enslaved labor beginning in the seventeenth century, followed later by indentured laborers from India, Portugal, and China, dug the initial grid for canals and large-scale earthen dams, which to this day are still controlled by both gravity and pumped drainage. The seawalls also have sluice gates that allow drainage of floodwaters from heavy rains and waves that crest the seawall. Despite these arrangements, the persistent deposits of river silt and erosion of land make flooding from the sea a constant threat. Ambitious state planning in shore zone management has provided a rationale for policies regarding everything from housing to roads, commerce, energy, and wildlife protection.

Take, for instance, that with independence from British rule in 1966 the national government provided engineers with millions in foreign aid to construct seawalls. This focus reflected the belief that the nationalization of sugar with small-scale cooperative farms would offset state spending for irrigation and drainage. But in practice, during the socialist period (ca. 1974–1985), few canal and dam improvements were ever made. Farmers were left to devise flood prevention measures on their own. Meanwhile, the Ministry of Public Works enacted legislation for seawall constructions on land known as the “foreshore,” located on the direct shoreline adjacent to sea defenses and mangrove forests. But foreign aid for seawalls quickly dried up when the government extended its foreign relations with communist countries, including North Korea and neighboring Cuba. With the national debt mushrooming to US\$364 million by 1980, many Guyanese experienced these socialist-oriented policies as failures (Thomas 1984). Moreover, those with little success investing in state land and housing cooperatives tended to have no other option but to resettle on the foreshore. The migration contributed to an increase in squatting, subsistence fishing, accelerated erosion, and the deforestation of mangroves for fuel.

The combination of environmental ruin and economic plight deteriorated into a situation Mark Pelling (1999) has described as a “political ecology of flood hazards.” While scholars have begun to detail its racial-ideological logics (e.g., Vaughn 2022), less has been said about how a political ecology of flood hazards shaped engineers' commitments to various infrastructures. Consider that

engineers' daily activities primarily emphasized devising maintenance measures to prevent seawall breaches across the country's eight sea defense "districts." These constructions were expensive to complete, especially as the country embarked on a transition from socialism to market liberalization in 1985. By the early 1990s, the Ministry of Public Works attempted to offset costs with a jointly financed state-foreign grant of US\$100 million to rehabilitate seawalls (Government of Guyana 1996), but this partnership created more problems than solutions. The structural adjustment programs of the era cut resources for hiring government employees (Pelling 1999). Understaffed, the ministry was forced to limit the number of upgrades it could do so as to meet project deadlines. Many projects were stalled or never completed, leaving partial skeletons of seawalls as the cultural icons of maintenance in the early period of post-socialist Guyana.

Over time, this piecemeal approach to maintenance exposed the vulnerabilities of the country's sea defenses. The most telling episode was in 2005, when Guyana experienced a disastrous flood from what was believed to be a climate-related storm system. Over 60 inches of rainfall affected two-thirds of the country's population. Post-disaster engineering assessments revealed that the dam, canal, and drainage system would not withstand future storms unless it underwent a comprehensive overhaul in design (Kirby, Messen, and Ogink 2006). Likewise, the event raised concerns that extreme flooding originating from the Atlantic Ocean could compromise seawalls in the future if engineers could not gain a better understanding of how sea level rise affects erosion cycles (Dalrymple 2006). And yet, these threats did not lead to elaborate plans for coastal retreat. Instead, the national government doubled down on a future invested in climate adaptation projects that they hoped would "correct" its decades of sea defense neglect.

The best-known national-level climate adaptation plan to date has revolved around the LCDS. This ambitious report outlines the threats of climate change to the country's socioeconomic stability, and a key component is strategies for financing climate adaptation. As a partially sponsored UN REDD+ Investment Fund project, the LCDS envisions the country's interior forests as resources for carbon sequestration and carbon markets with Norway (Government of Guyana 2010). But with its inauguration in 2010, the government was relatively silent as to whether the LCDS payments would finance the climate adaptation of sea defense. The silence was striking given that the LCDS symbolically encourages engineers to invest research in more ecologically sound engineering techniques such as mangrove replanting (*ibid.*: 11).

Against the backdrop of this LCDS funding vacuum, engineers have taken climate adaptation into their own hands in both symbolic and organizational terms. They have changed the name of the Ministry of Public Works to the Ministry of Public Infrastructure (ca. 2014). The renaming exposes what historian of engineering Henry Petroski (2016) describes as engineers' growing self-consciousness about the pork barrel image of government

spending associated with large-scale projects that are promised to be transformative. At the same time, the ministry has taken its post-disaster assessments into account by investing in more cost-effective groyne design projects, sponsored by the Caribbean Development Bank.

Through the groyne design projects, erosion has become the key object of intervention in Guyanese sea defense that links human and more-than-human concerns about the shoreline's climatological future.<sup>4</sup> In short, engineers' commitment to groyne construction has the capacity to contribute to the flourishing of so-called "emergent ecologies" that are more responsive to erosion (e.g., Kirskey 2015). Take, for instance, that new groynes may radically alter processes of erosion in ways that make some seawalls difficult to maintain, or in some instances obsolete, as mangroves overtake neighboring mudflats. Or, reinvestments in groynes could advance land reclamation projects by creating new shoreline. Throughout this essay I will track how this epistemic turn to erosion shapes engineers' engagements across sea defense structures, while challenging their assumptions about the value maintenance practices have toward technological advances in their field.

Maintenance has been theorized in the anthropology of hydraulic infrastructures and related scholarship as a form of skilled labor central to broader processes of world-making (De Laet and Mol 2000; Howe et al. 2015). From land use practices that make infrastructure development tenable to refining the appearance and design of grids, maintenance often involves learning by doing (Mattern 2018; Star 1999). Consider Timothy Mitchell's (2002) colonial historiography of Egypt that details how engineers, landowners, and peasants possess competing visions of canal maintenance and water (re)allocation. Such disputes over scarce resources remind us that improvisation is a vital dimension of maintenance practices (Anand 2017; Barnes 2016). Practical decisions about, say, fixing a pipe or digging a borehole often inform people's understandings of their past, current, and future quality of life (Redfield 2016). What Steven Jackson (2014) calls "broken world thinking" defines the range of both the imaginative and material possibilities of maintenance. However, not all maintenance practices are equal nor are they intended to be performed by every rank of engineer with credentials in hydraulic engineering (Wesselink et al. 2007). Indeed, maintenance is a claim to professionalism within engineering circles at the same time that it undergirds debates about the ontological stability of infrastructures (Houston 2017).

While this literature has generated helpful insights on the political economy and materiality of maintenance, it still tends to reduce hydraulic infrastructures to

<sup>4</sup> The urgency of engineers' groyne initiative is only further highlighted by joint state and corporate planning for offshore oil exploration, whose revenue is projected to replace foreign aid for sea defense by 2040.

the timeframe of human life. This implies that the goal of maintenance as both activity and craft is simply to “better” or make more equitable social institutions dedicated to managing hydraulic infrastructures. Within this timeframe, scholars have depicted engineers as social figures who become critical of lofty discourses about “improvement” and related statist models of development (e.g., Ley 2021). Yet, the groyne initiative in Guyana reveals something different about the work of engineers in climate adaptation. Their work is predicated less on the diagnosis of “improvement” as a discrete event than on an appreciation for the processual nature of infrastructural design. Take for instance that the groyne initiative extends engineers’ maintenance programs in ways that model and plan for unavoidable inequalities, hazards, and even catastrophes. Engineers have refenced existing wave models and bathymetric surveys to devise a “soft” groyne design that they believe is more responsive to erosion than the “hard” groyne design devised during the colonial period. Still, engineers move forward without a firm grasp of the distinct maintenance practices (if any) that the new soft groynes will require. Groynes are like barnacles of innovations past in that engineers recognize them as integral to the contemporary “nature” of erosion even as their existence may compromise the integrity of the shoreline into the future.<sup>5</sup>

Building on this insight, I use the phrase *afterlives of innovation* to analyze human and more-than-human responses to groyne operations. Sea defense focused on erosion requires engineers to attend to complex reconfigurations of the shoreline over time as well as ambiguities around the temporariness and permanence of groynes. These material processes are mutually constitutive in that they reveal engineers’ attitudes about working for a state apparatus that has historically been inconsistent in terms of concern for erosion and funding to combat it. But rather than treat afterlives of innovation as simply an analytic invested in tracing the specters of maintenance, I place it in dialogue with what philosopher of science Isabelle Stengers (2018) calls “slow science.” Critical of modern science, she argues that the experimental method has run its course in the face of mounting global risks (e.g., climate change) that show no sign of dissipating anytime soon. She looks to slow science as a way to foster methods that actively draw on multiple traditions of scientific research programs to challenge the vested interests of the status quo. “Slow science,” she writes, is fundamentally about “wasting time ... or breaking with the symbiotic relation that binds ‘true progress’ to industrial innovation” (ibid.: 124). In Guyana, engineers’ investment in “soft” groyne design *with* field studies of erosion is an instance of slow science. Their position, on the relative fringe of the LCDS, signals the competing institutional timescales of slow science that shape engineers’ desires for innovation in climate adaptation.

<sup>5</sup> I thank a *CSSH* reviewer for this helpful phrasing.



The fate of groynes in Guyana provides site specificity for the “innovationist thinking” that both academic (Braun 2014) and popular literature (Kolbert 2021) often treat as a taken-for-granted stance toward climate adaptation. The groyne design projects create space for engineers to exchange innovation narratives: stories that reference past or ongoing challenges that stand in the way of transforming climate adaptation into an effective state intervention. Ideas about innovation are being constantly revised in these narratives as engineers struggle to confront erosion while seeking transnational networks of funding, data, and consultants to address climate adaptation.

This is not to say that innovation narratives are attributed solely to engineers’ technological know-how. Similar to Stengers, many scholars have argued that by the mid-twentieth century innovation had become synonymous with the economic theory of developmentalism and integral to both the right’s and the New Left’s visions of postwar abundance (Girvan 1979; Russell and Vinsel 2016). A central problem with developmentalism is now well-known: governments’ steadfast commitments to developmentalism at any and all costs eventually contributed to rampant environmental ruin and the demise of publicly engaged science. Further, developmentalism has undergirded ideologically inflected doubt about science, notably in climate denialism (Oreskes and Conway 2010). Thus, innovation never was or will be a politically neutral term in climate adaptation policy arenas.

This is particularly the case for engineers in the global South, where the credit given for innovation has historically been tethered to scientific diplomacy or technical collaborations with foreigners (Mavhunga 2017). As in Guyana, concerns about who (or what) gets credit for innovation have appeared within engineering circles, across state agencies and local firms as well as in collaborations with foreign consultants. Moreover, such concerns cut across divides in training, political allegiance, generation, and professional status, and in some instances, they have shaped the way engineers perceive and experience erosion.

#### FROM RETREAT TO HOLDING THE LINE

Much of the story of Guyana’s shoreline can be told in terms of its steady reengineering in response to human observations of its erosion. Before colonial contact, Amerindians including the Warao inhabited the coast only seasonally, dependent on boats, and migrated into the interior during rainy season (Williams 2003). When Christopher Columbus arrived in 1498, he was unable to dock his fleet of ships because of “inhospitable mudbanks and marshes” (Lakhan 1994: 172). Subsequent Spanish, Dutch, and British explorers followed suit by staying off the coast, and ultimately failed to find the gold they sought in the interior riverine areas. Only after the Dutch West

Indies Company authorized coastal settlements in 1621 did settlers confront the riches and violence brought about by their efforts to halt the erosion of land. Building on approaches early of British planters from Barbados and Antigua had used to battle erosion, the Dutch embarked on land reclamation (Klooster 2016). With little to no government regulation of polders (drained land), settlers ordered slaves to dig canals and build seawalls to suit the individual needs of each estate.<sup>6</sup> Coastlands were empoldered much faster than in neighboring French Guiana, where settlers had the “miserable reputation” of being gentlemen-adventurers and rum drinkers instead of efficient cultivators of the lowlands (Lowenthal 1952: 22; Redfield 2000).

This individualized approach to empoldering was complicated by erosion. Planters responded to it by moving their line of seawalls further inland. Even when the colony changed hands to the British in 1814, planters made no significant changes to this “retreat-oriented” approach to sea defense. As historian Walter Rodney (1981) described, planters’ fears of sea and waves eroding their land verged on paranoia and erosion deeply informed the colony’s system of land tenure.

A dramatic increase in sea defense construction was initiated with slave emancipation (ca. 1834–1838), albeit mostly for the benefit of the plantocracy. The majority of freedmen had few options for resettlement and so collectively purchased front lands, or abandoned estates that were difficult to maintain because they were located on the direct shoreline (Rodney 1981). In turn, labor shortages on plantations led wealthy planters to import indentured laborers. By re-indentureship in 1873, indentured laborers, too, successfully purchased and cultivated coastal areas. Yet they resided near “back dams,” flood-prone land on the outskirts of plantations with little infrastructure. Land ownership across race and class, thus, was tied to living with not only the sea but “*putta-putta*,” the Creolese term for “the worst kind of mud: wet, sticky, stinky, and one mini step up from feces itself” (Edwards 2017: 4).

By 1883 the governor had hired a Royal Engineer to run the Public Works, the first agency in the colony that required landowners to build sea defenses along specific guidelines. Given that these constructions were costly, most landowners opted to suffer losses rather than abandon their property when seawalls were breached (Government of Guyana 1996). This protocol of “holding the line” was institutionalized by the Public Works in 1916 through systematic field investigations of erosion headed by the foreign consulting engineer Gerald O. Case. With extensive experience researching deltas in South Asia, Europe, and New Jersey in the United States, Case surmised that the coast’s erosion was caused by not only waves but also the water that flowed

<sup>6</sup> Land reclamation in Guiana was in stark contrast to the historical practice of empoldering in the Netherlands. Dutch land polders, at least in theory, involved community-based water boards (see Metz and van den Heuvel 2012).

out of sluices and sea dams. He was unsure under what conditions “sea dam caused-erosion” could be mitigated, though he suspected that planting mangroves could help (1920). The problem, though, was that the coast had few sand dunes and beaches, and he ordered Public Works to counteract erosion by building concrete groynes similar in design to those he had observed on research trips to the Netherlands.

Engineers in Guyana adhered to Case’s design approach for decades, even after independence in 1966. But unlike Case, their perspective on erosion was not oriented only toward what the sea was doing. They surmised that erosion was related to “sling mud,” the Creolese term for the highly-fluid, thick, muddy silt that breaks off from mudbanks. The majority of their observations of sling mud was based on their time dredging ports and a study with Delft Hydraulics Laboratory of channel bars. By the early-1970s, in collaboration with the Dutch engineering firm Netherlands Engineering Consultants, or NEDECO, they expanded their observations. Fieldwork involved bathymetric surveys along with borehole samples of the coast’s clay soils and sediments from rivers. The surveys revealed that the shoreline was not uniform even though the “coast showed a pattern of cyclic erosion and accretion in close relation with travelling mud shoals [mudbanks] offshore” (NEDECO 1972: 1). They determined that this cycle occurs every thirty years, which suggested that the lack of a uniform coast could mean that groynes were not behaving solely like “sediment traps” but were also disrupting how sling mud broke off from mudbanks. The research team tentatively concluded that, contra to Case’s findings, groynes were unreliable infrastructures in Guyana’s fight against erosion (*ibid.*: 6).

The NEDECO study was perhaps the first instance in Guyana’s history wherein the afterlives of innovation unfolded: engineers changed their groyne activities in response to erosion. In a final report, the NEDECO team recommended that the ministry should focus on building seawalls rather than groynes and collect more data about erosion for future surveys. As retired engineer Philip Allsopp, who worked for the ministry during the NEDECO study, explained to me in an interview: “We were of the mind that we could no longer just build and build to keep the shore under control. We had to slow down and consider what was happening to each sea defense.”<sup>7</sup> This is an outspoken statement given that collecting erosion data did not require engineers to use unfamiliar methods. Allsopp, for instance, was trained by the “grandfather of soil mechanics,” Alec Skempton, at Imperial College London, doing borehole drillings and analyzing how soils can “slip and rotate” under structures. NEDECO’s seeming passion for data collection was not lost on engineers in Guyana. The collaboration imparted a new design norm:

<sup>7</sup> Author’s interview, Georgetown, Guyana, 6 Mar. 2010.

innovations of sea defense were based on engineers' observations of infrastructures contributing to environmental ruin.

Engineers recognized that this modern design norm had broader implications for the ways they negotiated the national government's fiscal (dis)investments in long-term research programs for sea defense. Take another engineer's description of his professional commitment to design during Guyana's socialist period: "You can't divide the issue of design from the realities of the day that knock you to the ground. When we were working on a project funding was there but as we came down to the end the government terminated the contract ... it wasn't available to pay outside [foreign] consultants. They left and we were working in an inadequate environment. *So we had to innovate*. We did river defense near the shore and we were using timber sheet piling. There's no way anybody was gonna do that then or now."<sup>8</sup> This engineer lost faith that the national government would provide resources for a long-term research program that could build on the NEDECO study. With the metaphor "inadequate environment," he explains that it is difficult for the national government to galvanize political support from engineers when they are forced to design without data.

With foreign consultants gone, engineers began to treat Dutch and British sea defense design styles as more than simple legacies of colonialism, and their attitudes toward them also displayed a shift in attitude away from the naïve appreciation for modernization they had once shared with former colonizers. From the perspective of engineers working and trained in Guyana, the colonial-era groyne designs were *contributing* to environmental ruin. They believed that, if Guyanese sea defenses were to survive, they needed to continue North-South collaborations so as to learn more about groynes and stop their destructive impacts.<sup>9</sup> Consequently, engineers in Guyana began to treat national differences in sea defense design as a framework for critically assessing the global relations of credibility that inform long-term research programs.

Still today, as engineers embark on climate adaptation, there is no consensus about what to do with groynes. Some believe that those built by Case should be retired (Government of Guyana 1996), while others insist they were simply built at the wrong angle and could effectively manage erosion if reinforced with other materials. Innovation in an "inadequate environment" is accompanied by engineers questioning institutional culture as much as how to standardize design practices.

Senior Engineer Jermaine Braithwaite explained to me this lack of consensus. "We constantly repair," he noted, "but then one day even when you monitor you get a mudbank or some land erosion happens—messes with

<sup>8</sup> Confidential source, author's interview, Georgetown, Guyana 1 Apr. 2010.

<sup>9</sup> The NEDECO collaboration exemplified the Dutch turn in hydraulic engineering during the 1970s that catered to developing ecologically sound design practices (Disco 2002).

your plans, washes a structure away, and you are back to square one or you think of *something new*. They [foreign consultants] don't want to hear that because they are on a deadline. Eventually we are the ones who have to do something about it."<sup>10</sup> He describes erosion monitoring as an activity that is integral to cultivating an expert persona of credibility among a nationally diverse group of engineering experts. He has a national pride in long-term field studies of groynes and treats erosion as a key resource for supporting other possible climate adaptation activities into the future. Yet, he also expresses a sense of uncertainty about the outcome of the ministry's efforts. Any ecological force, from mudbanks to waves, has the capacity to "mess with plans" and disrupt the ministry's timeline for construction or observations across sites.

Engineers, then, have a twofold interest in innovating groyne design: they hope to respond to erosion before it creates too much disturbance, while also forging a scientific research program that keeps them engaged with foreign consultants. Such investments have not neatly translated into support from all voting constituencies/citizens in Guyana who have become familiar with the term "climate adaptation" solely through the LCDS. Many of them, during the early years of LCDS's inauguration (circa 2009–2015) were skeptical of the LCDS and its tendency to privilege the development needs of the interior region in sustainable logging and mining over the coastal region's long-standing dependency on agriculture.

Take for instance, that the LCDS was initially proposed by members of the People's Progressive Party (PPP), which has a majority Indo-Guyanese base of supporters. The party was in power and held the Presidency for over two decades (1992–2014, and 2020), and has governed a country politically divided across the majority Indo-Guyanese, Afro-Guyanese, and Amerindian populations. On the one hand, social activists expressed concern with how the LCDS encroached on Amerindian titled lands to further extend the land grabs of foreign extractive industries. On the other, coastal farmers—who are predominately Indo-Guyanese—dreaded the LCDS because it brought state interest in a flood insurance scheme they could not afford to participate in. The scheme failed to gain traction beyond a pilot survey because concerned farmers questioned how the LCDS monies would be distributed fairly across state agencies. Moreover, questions about the transparency of the LCDS's audits led critics to argue that it re-entrenches practices of state patronage and political racialization (Bulkan 2014). The People's Progressive Party administration responded by creating new bureaucracies, including the Office of Climate Change, to manage, among other things, public outreach related to climate adaptation.<sup>11</sup>

<sup>10</sup> Author's interview, Georgetown, Guyana, 13 July 2019.

<sup>11</sup> These bureaucracies have been crucial to establishing the state's legitimacy with external donor agencies that are interested in supporting the climate data products and services of the LCDS. The information gathered by these bureaucracies, for example, has framed Guyana's National Communications to the United Nations Framework Convention on Climate Change.

Even so, less central to critical debates about the LCDS' transparency and the *organization* of natures have been engineers' attitudes toward innovation. The lack of consensus about groynes, for instance, refers to more than the technical matters Braithwaite describes. The ministry employs a multiracial and intergenerational group of engineers who have witnessed the shortcomings of maintenance projects across both socialist and post-socialist presidential administrations. As Braithwaite suggests, engineers' understandings of what counts as realistic groyne innovations are informed by not only their professional experiences of state/economic planning but also their personal experiences and the sentiments they felt while designing them, which ranged from frustration, to boredom, to joy. In short, engineers in Guyana work to protect a scientific profession, and a shoreline, from being destroyed. They make the time for "intelligent relationships not just with scientific outcomes, but with [other engineers] and scientists themselves" (Stengers 2018: 4). They attempt to reclaim climate adaptation from the narrow logics of economic progress, to envision a future that fosters an appreciation of the scientific-political missteps of the past.

Engineers, in other words, treat innovations as having afterlives. Groyne operations inform engineers' professional roles as more than technocrats. They are also participants in an inequitable global system of knowledge exchange, on which national climate policies such as the LCDS are predicated. Even so, it is one thing for engineers to aspire to erosion and groyne research, and quite another to sustain an interest in such research programs when, in their past experiences, there have been few continuous blocks of resources and aid to maintain projects.<sup>12</sup> This tension between letting go of the past, and the possible, sustains the circulation of innovation narratives across climate adaptation activities. I now turn to this tension in order to trace how innovation narratives have come to delimit the social worlds of erosion in Guyana.

#### DESIGN PRACTICES

As with engineers, my initial introduction to groynes was not seamless. After roughly two months of observing and interviewing engineers, they still met me with apprehension. I was repeatedly reminded that they were most comfortable working with foreign consultants and, more recently, academic engineers collecting data and modeling for sea defense designs. As an anthropologist I had no expertise to offer along these lines, so I was of little immediate use to

<sup>12</sup> The ministry has tried to implement such a program, but contingencies of external donor projects have presented logistical difficulties for buying needed technologies and paying staff beyond a project's lifespan. These projects do not necessarily create the sorts of partnerships with the national university that would help support such long-term knowledge infrastructures.

them. One engineer greeted me with the cunning request: “When you are done you can tell us what society, people out there, think about what we do.” The epistemic boundary he drew between his expertise and mine exposed his fear that lay people think innovation is always already a social, technical, and political good. He wanted to change this misconception yet recognized that his cause was not helped by the LCDS report, which by 2010 had been widely circulated online and in social media.

Groynes make visible the competing innovation narratives that inform engineers’ understandings of climate adaptation. Between 2010–2016, engineers at the ministry experimented with the design of soft groynes. Constructed of geotextiles—a woven, thick plastic material—they are not only cheaper than concrete groynes but are believed to build up beach quicker. Engineers hoped that the designs would eventually convince the national government to help fund a project to map and archive the country’s working and derelict groynes.

“We haven’t been focused much on what groynes do—their *ambience* and what they do to the coast—and we haven’t learned to appreciate them.” A group of four engineers shook their heads in unison as one of their colleagues made this evocative statement during an interview I conducted at the Ministry of Public Infrastructure.<sup>13</sup> His insight summarizes, albeit in a modest tone, engineers’ difficult relationships and past missed opportunities with groynes. But the relationship is not as straightforward as simply building infrastructures. They split their workdays between sea defense sites and large conference rooms similar to the IT and digital tech spaces of Silicon Valley, where the image of the autonomous, creative genius is disciplined into collegial interactions and exchange (Messeri 2016). This office organization and architecture contrast starkly with the sling mud and slow-moving mudbanks they work alongside in the field. For instance, the room’s perimeter is boarded with tall metal filing cabinets overflowing with paper copies of field reports. Across three floors are offices where senior staff and their assistants hold meetings, budget, and plan for projects. The daily patter across these spaces is filled with conversations about the minutiae of scheduling and observations made during visits to sea defense sites.

When engineers do bathymetric surveys by boat, measuring the depth of water and its features, they often encounter submerged derelict groynes that they believe are centuries old. As one detailed:

The derelict groynes we see were probably built two centuries ago and made of grouted boulders ... and we are currently looking at that design and similar technologies because it has worked for so long, and we [would now] just use rocks

<sup>13</sup> Confidential, author’s interview, Georgetown, Guyana, 18 Mar. 2010.

[granite] as our main material for groynes because it is locally available and is cheaper [than concrete]. There are other options such as gabions even concrete sheet piles. We basically go by visual inspection. We don't have satellite data of [derelict groynes] ... you can just see them above the water at low tide.<sup>14</sup>

This engineer suggests that groynes have been in use much longer than Case ever intended, and so he resists the narrative that they are only associated with one national style of design or material for construction. He implies that because of the various materials that make up these derelict groynes, the most pragmatic approach for engineers is to simply categorize all hard materials as "effective." Engineers make the general assessment that hard materials can trap the longshore flow of sand that builds up on one side of derelict groynes, but they may alter other features of the shoreline in ways that engineers are unaware of.

An extended field observation in 2009 and early 2010 at the Fort Kingston groyne reaffirmed their insights. Over 680 feet long and constructed of boulders, this groyne is a known spot for intense sedimentation because it is located at the outfalls of the largest coastal river, the Demerara. But the field team also found that erosion processes can vary from point to point because nearby derelict groynes were stealing sediment from the Fort Kingston groyne. Their observations veered from standard textbook cases, which tend to focus on the length of groyne structures, to also describe breaking waves and littoral drift (waves transporting sand).

Here, field observations of erosion are a fundamental step by which engineers trace the afterlives of innovation. The field team treated the Fort Kingston groyne as an "ideal case" of erosion. Give that working and derelict groynes operate together in ways that alter and intensify erosion cycles, engineers could use them to guide data collection about the life expectancy of other sea defenses such as seawalls vulnerable to intense storm surges. This fieldwork contributed to changing engineers' basic appreciation for the concept of "design life" in sea defense.

Design life refers to the relative period of time it is believed that an infrastructure will work before it fails, breaks, or becomes a liability. The design life of concrete sea defenses in Guyana is forty to fifty years. Engineers do routine maintenance activities, walking the shore to discern if seawalls are deteriorating faster than expected. I accompanied them on shore walks looking for cracks in the seawalls that might lead to breaches. Balance and patience are some of the skills that engineers, and I, needed to identify their life stage. Seawalls are elevated no more than 6 or 7 feet from the ground, and walking

<sup>14</sup> Confidential, author's interview, Georgetown, Guyana, 18 Mar. 2010.



atop or alongside them is much like navigating an underground cave, contouring one's body to the demands of slopes. Pockets of mud, heaps of sand, and the unwieldy roots and branches of mangrove trees impede one's path, a further reminder that erosion blurs the boundaries between sea and shoreline. Shore walks are activities that, in Stefan Helmreich's phrasing, "draw waves into relation with human enterprise" (n.d.: 36–37, cited with author's permission). One might think of Guyana's labyrinth of sea defense as another kind of slow wave that gathers strength over time as its structures change and engineers work on them. From this view of the amorphous slow wave, the afterlives of innovation cannot be reduced to the operations of groynes, or even shore walks—they must be understood in terms of engineers learning to work with erosion.

After the Fort Kingston observations, for instance, engineers began to build soft groynes as an initial attempt to innovate by redefining their adversarial stance toward erosion (image 2). They constructed them by filling long geotextile tubes with sand. One of the pilot sites for soft groynes in 2010 was south of Fort Kingston, on beach downdrift believed to have its sand stolen from the working groynes at Fort Kingston. Soft groynes are intended to have little environmental impact because, as the geotextile wears away over time, the remaining sand consolidates as beach. Because they are built relatively low to the ground, they lose the recreational purposes the hard groynes had as boardwalks for pedestrians and temporary docks for fishermen. And while their shape is long and tubular, they are susceptible to submersion at high tide or taking on new forms as sand build-up increases around them. In short, their dual technological and aesthetic appeal is in their capacity to mimic and become shapeshifts of the shoreline's boundaries.

Innovation in climate adaptation depends on engineers treating natures not as mere resources for infrastructural design but as collaborators in creative planning and action. Soft groynes are part of a global school of design that



IMAGE 2: A geotextile structure or "soft" groyne, 2014. Author's photo.

treats earthworks as technological agents that help people plan for the future. Another such earthwork is American artist Robert Smithson's 1970 "Spiral Jetty." His coiled sculpture is composed of mud, salt crystals, and basalt rock and was built in the waters of Utah's Great Salt Lake. In recent decades, intense drought has lowered the lake's water level and has made the sculpture visible. As Smithson argued, earthwork sculptors take on the "persona of a geologic agent ... rather than overcoming the natural process of challenging the situation" (quoted in Rubio 2012: 148). This reference to the changing image of a sea defense over its design life is also what engineers in Guyana mean when they speak of groynes creating an "ambience" for sea defense even as they recognize that the shore is eroding beyond their control.

Yet, the recent inclusion of soft groynes has not liberated the ministry from its ongoing difficulties of doing basic maintenance activities and record-keeping. At the Fort Kingston field site, engineers discovered that the geotextile tubes were vandalized before the end of the observation period. Those engineers initially skeptical of geotextiles' durability perceived the vandalism as an opportunity to turn their attentions back to retrofitting concrete groynes. Moreover, because geotextile, unlike concrete and rock, is sourced from other countries, engineers feared that repeated vandalism and geotextile replacement would make their construction less cost-effective than they hoped. Others insisted that the beach nourishment already accumulated near the groynes should not be disrupted and that concrete boulders could be placed around the torn strips of geotextile. In the end, the ministry decided that soft groynes were not worth the long-term investment and ended the program.

The experimentation with soft groynes demonstrated that innovation narratives in climate adaptation gain traction within engineering circles when engineers treat them as fluid performances. That is, the operations of working and derelict groynes are not static but dynamic, as engineers distinguish between their data collection for the maintenance of infrastructures and that for long-term research. What is more, choices about data collection and its oversight unfold as ethical-aesthetic problems that impose a shared sense of professional ethos among engineers, even as infrastructures breakdown or fail them. This professional ethos translates into other sea defense design and research activities. The ministry, for instance, has a division that is in charge of hydrographic studies. The "in-house" team of engineers coordinates bathymetric surveys with no support from foreign consultants, and this was also the case with the Fort Kingston observations. But engineers have failed to implement a consistent erosion monitoring program. They still lack the funds and staff needed to keep all the ministry's tide gauges up to code. The plastic and metal membranes of unmonitored tide gauges have been corroded by salt water, or never recalibrated. Some engineers' judgments have been affected by these malfunctions to the point that they fret about not trusting their eyes when they see waves breaking near groynes and seawalls.

Given these struggles with instrumentation, many engineers believe it is easier to simply build anew than figure out why a seawall is breaching or how a previous repair changed the integrity of a structure. This prioritization and hierarchical valuing of design activities creates rifts in expert ideas about what are “optimal” conditions for scientific inquiry in a national context, whether into erosion or climate change, where data is scarce. Engineers are aware of this dynamic and so tentatively describe climate adaptation as activities related to “maintenance” as much as “innovating” sea defense. As I have described regarding shore walks, this distinction can at times become blurred in practice.<sup>15</sup> Nonetheless, engineers do recognize that their continued efforts at data collection could be harnessed by the national government in ways that exceed the direct aims of infrastructural design.

#### SPOKESPERSONS FOR EROSION

Despite the impacts that working and derelict groynes have on erosion cycles, engineers still treat them as a “public good” that not only contributes to data collection but furthers scientific research into climate adaptation. For instance, engineers have a choice as to which aspects of groyne design they share with lay publics. During the initial years of the geotextile design project, they detailed the specific mechanic features and construction activities related to geotextiles on the ministry website, in local newspapers, and at engineering conferences. Given their long-standing disagreements about groynes, hiding these details would have compromised professional solidarity at the ministry as well as the public face of credibility. At the same time, these details have transformed them into “spokespersons” regarding erosion, and so accountable for explaining to lay publics, as well as to each other, why they are competent and should be trusted with regards to all matters of climate adaptation.

Speaking about erosion is a strategic political act that allows engineers to experiment with design without appearing naïve or blind to the challenges of doing climate adaptation in an under-resourced place. It is important to recognize, however, that engineers speaking about erosion are not informed only by data from risk assessments. They also detail the material-ecological features of sea defense that reinforce the idea that there is a political economy to innovation narratives that circulates well beyond the demands of state/economic planning. One engineer explained this to me at length:

Just to be clear, to determine the height of sea defenses, there is the hydrologic consideration but really what we do, we look at the waves, we also look at the tides, we do have some

<sup>15</sup> See Denis, Mongili, and Pontille 2016, for a longer discussion about the indistinction between maintenance and innovation that can often emerge in scientific-engineering practice as well as the conceptual frameworks scholars have offered to take into account this phenomenon.

historical data, don't get me wrong.... For quite a while [since the 1990s] we have had documentation of sea level rise and this foreign consultant who worked with us, who helped us run this DHV [an acronym for a sea level rise scenario model], all that is incorporated into building for a fifty-year design life. But we have to bear in mind that when we build a groyne in an area we can't always just build it. Beach nourishment has to be going on in that area; what I mean is that we might need to pump sand, to get the construction going.... We had these Greek consultants come telling us to build a seawall near a groyne, with a "stone column" structure. And the first thing—well we laughed—and then we said, "We need the sand, beach nourishment." They thought it [sand] would just be there and when they looked at the site, they were scared until we explained.<sup>16</sup>

Innovation figures into this engineer's analysis of climate adaptation in two ways. First, there is his reminder that the activity of beach nourishment involves engineers using earthmovers and barges to transport the physical components—sand and rock—from one area of the shore to another. This expensive and resource-consuming activity requires experiential knowledge of the shore, not just modeling its characteristics. This engineer suggests that a focus on model outputs—particularly wave height—would likely contribute to resources being wasted and accelerate the shore's vulnerability to sea level rise. A fifty-year design life, moreover, provides engineers with a timeframe for when the groyne will become derelict because of wave damage, but does not indicate how its structural foundation might affect the movement of sediment. The second way innovation figures into his analysis is that his experience reveals that sea level rise is an event that comes into conflict with "scientific institutions and expertise [as] constructed in the crucible of national imagined communities" (Jasanoff 2010: 240). Similar to struggles over expertise in other postcolonial settings, from health (Fullwiley 2011; Tousignant 2018) to field biology (Geissler 2015), his story emphasizes a horizontal rather than vertical North-South exchange of knowledge for climate adaptation.

Engineers' aspirations for climate adaptation are defined by those competing forms of nature (e.g., waves and sand) that provide them with more data about how to innovate in groyne design. For instance, as engineers have come to appreciate sea level rise as a threat, they have turned to other types of sea defense to which engineers in Guyana have historically given less attention. They have centered on an ambitious mangrove replanting and mapping program,

<sup>16</sup> Confidential author's interview, Georgetown, Guyana, 18 Mar. 2010.

inaugurated in 2009. The multi-million Guyanese dollar Mangrove Restoration Project was initially sponsored by the European Union's Global Climate Change Alliance and Guyana's Ministry of Agriculture (GMRP).<sup>17</sup> The latter has brought together engineers with state-sponsored botanists and forestry officials, private citizens working as apiarists in coastal mangrove forests, and French academic geoscientists. Relying on a third-generation wave model (SWAN) patented by Delft Laboratory, the geoscientists have provided engineers with detailed analyses of how mudbank-caused erosion affects the regeneration of mangroves. Their collaborations provide another perspective on the afterlives of innovation, since they show how important the global circuits of "local" knowledge are to climate adaptation. With the aid of satellites at the international space station, launched from the Space Centre in neighboring French Guiana," they began building an archive of mudbank images that spans the regional mudbank migration route from the shores of northern Brazil to southern Venezuela.

The GMRP's modeling underscores a number of the initial findings by the NEDECO study in the 1970s. When mudbanks migrate to the outfalls of the coast they become habitats for mangroves, creating fertile pockets for their seedlings to take root. At the same time, the SWAN model indicates that many existing mangrove forests in the path of these migrations may become uprooted by the sheer force of subsequent migrations (Anthony and Gratiot 2012). The model shows that no form of sea defense is immune from erosion but that some forms of erosion are *not* predicted by the thirty-year mudbank migration cycle. In turn, engineers and geoscientists have drawn on local apiarists' expertise about pollination regimes to improve the life expectancy of mangroves that the SWAN model cannot represent.

But as GMRP participants have planted more trees, new boundary disputes have arisen among Guyanese engineers. Their credibility is now attached as much to wave modeling for the purposes of knowing mangrove ecology as to their willingness to collaborate with non-engineering experts to respond to erosion. Some engineers speak about the turn to systematic mangrove planting as "common sense" and long overdue. The deferral reminds us that innovation can take on multiple meanings and may appear self-evident only after repeated failures of other designs or time wasted. In this respect, some engineers have been frank about their ambivalence as to whether mangroves are a reliable form of sea defense.

In interviews with me, retired engineers and senior staff at the ministry articulated their critiques through autobiography: detailing stories about when they were children encountering "courida bush" (black mangrove; *Avicennia germinans*) one day near a groyne, trapping sediment, and a year later the courida

<sup>17</sup> In 2009, US\$5 equaled roughly GYD\$1,000.

bush was gone. Others recounted the ministry's failed 1970s efforts to plant mangroves to manage deforestation. By the inauguration of the GMRP, retired engineers formalized such "mangrove autobiographies" in editorials to local newspapers to "warn" people about the GMRP. Mangroves crept into innovation narratives as natural forms that buttressed engineers' roles as spokespersons regarding erosion. As a potential threat to engineering expertise, mangrove management falls into a different sphere of knowledge that could make groynes less significant to the ministry's future sea defense priorities. Far from proving a model of nature as infrastructure, engineers' indoctrination into mangrove restoration further revealed the uneven uptake of innovation as an organizing theme of engineering finance, professional ethos, and sociality.

Given the SWAN model's limited capacity to predict mangrove-related erosion, the Guyanese climate adaptation of sea defense is not reliant on a "vanguard vision" of innovation (see Hilgartner 2015). It is no surprise, then, that the GMRP's agenda turned to awareness campaigns to solicit public support for the further promotion of mangroves as a sea defense. A senior engineer at the ministry in the early years of the GMRP (ca. 2010) gave interviews on local television news. She delivered ample information about the ministry's past initiatives to engage public backing for mangrove protection, including campaigns against squatters and mangrove cutting. She defended these initiatives as for the public good, against portrayals of them as encroachments on individual rights.

She reiterated that engineers are not single-minded, rule-enforcing technocrats but rather environmental stewards. The ministry's reliance on the GMRP to convince ordinary citizens of engineers' credibility in regards to sea defense was premised on the idea that the "frontier" is a viable political trope in climate adaptation (Mahony 2014). On the one hand, the idea of the frontier flattens existing socio-material conditions, such as fiscal debt, lack of data, political fatigue, and staff shortages, which can hamper state-sponsored research programs into climate adaptation. On the other, the frontier image expands the scope of engineers' design expertise to include the lay public as having the civic vision and pride to counter the shortcomings of an ill-prepared but climate-conscious Guyanese state.

At the experiential level of engineering practice, mangroves are a very different means of intervention than are groynes because the approach makes it easier to draw in participants across lay/expert divides. And since climate adaptation is also a struggle about "the 'visiting' investigator and her hosts [being] capable" of producing knowledge in equitable ways and with mutual approval issues of participation become central to innovation (Stengers 2018: 129). One way in which the GMRP has taken on such issues is by establishing an ecotourism venture (Vaughn 2021). The tour, in operation since 2014, was planned around some of the GMRP's original experimental planting sites. On

the mangrove heritage trail, tourists can visit mangroves, learn about their environmental-cultural value to Guyana, and during some seasons, participate in replanting them.

A few tour guides have also been trained as rangers authorized to monitor forests and stop people from cutting trees and dumping garbage. Guides also check on faulty sea defenses. One time, guides found a derelict soft groyne near a replanting site, but both they and engineers surmised that this time waves and not vandalism had shredded its geotextile fabric. For the guides, this derelict groyne now serves as a tour attraction, a technical artifact that broadens the appeal of the mangrove heritage trail for educating tourists in the hydraulic engineering sciences. For engineers, this groyne further underscored that guides, along with other GMRP participants, are important allies that help keep engineers relevant spokespersons on erosion in climate adaptation policy arenas. In turn, engineers' shore monitoring exercises have come to depend on an ever-widening array of interdisciplinary data collection networks whose futures depend on support from the LCDS. The frontier has become a political trope in the conflicting forms of expertise, labor, data, natures, and capital that incite innovation narratives in climate adaptation.

#### CONCLUSION: "GLOBE-TROTTING SALESMEN"

When it comes to matters of sea defense, it can be difficult for engineers, let alone a nation-state, to shift from a developmentalist to a climate adaptation mindset. Conversations, policies, marketing, and projects around climate adaptation often turn on engineers explaining why sea defenses will inevitably fail. Importantly, their explanations go beyond analyses of breakdown to ask how past innovations have shaped, but in many cases challenged, modernist divides between nature and culture. Central to these explanations are evaluations of the competing ways in which *techné* and institutional capacity signal credibility within engineering circles. And yet, engineers cannot assume that desires for innovation will gain traction across all sectors of their daily work or domains of expertise. Innovation, then, is not a guaranteed outcome of climate adaptation, no matter how hard engineers may try to make it so.

Engineers cope with such doubts by telling stories or innovation narratives that detail the circumstances behind why some sea defenses work and others become derelict. Innovation narratives shape engineers' commitments to collecting data that will sustain long-term scientific research on erosion alongside consistent programs to maintain sea defenses. Yet, they also recognize that these commitments might not always align as they respond to emerging or unexpected transformations of the shoreline. This makes their commitments starkly different from those in other scientific fields, such as biotechnologies, whose influence "crashes" when the difference between what they are expected to do and what they actually do becomes too great (Brown

2003: 17). In climate adaptation, engineers acknowledge the persistent gap between the real and the imaginary because both generate demands for market-driven research from inside and outside of engineering circles, including from states, international NGOs, and lay publics. These demands are especially palpable in postcolonial contexts such as Guyana, where engineering craft and professionalism are often overdetermined by concerns about technological underdevelopment and fiscal debt.

Even so, popular accounts of innovation in climate adaptation are often associated with tropes about some silver bullet design or national style of engineering that will save humanity from its climate crisis. A glance at scientific journalism reveals how it has informed public attitudes about the planet's rising seas. This trope is exemplified by a 2017 *New York Times* article, "The Dutch Have Solutions to Rising Seas: The World Is Watching." The reporter is curt in his assessment: coastal communities from Jakarta, Ho Chi Minh City, New York, to New Orleans need Dutch engineers. Described as "globe-trotting salesmen," Dutch engineers "dominate the global market in high-tech engineering and water management" (Kimmelman 2017). Dutch thinking about sea defense changed in the 1990s after floods forced thousands to evacuate Rotterdam. Along with heightening seawalls and building wave-responding levees, Dutch engineers have since then incorporated early warning systems into their planning. "It's in our genes.... Water managers were the first rulers of the land," a Rotterdam city bureaucrat explained. The reporter hypothesizes that climate adaptation will become some kind of folk tradition that is midwived into existence around the world because Dutch engineers are entrepreneurial but not risk-averse in their design measures.

The assumption that Dutch engineering expertise should continue to circulate as the gold standard arises in part from the technical language that serves as a primary window into climate change. Some Dutch believe they possess a sort of "inherited" knowledge of water and that only through close collaboration can non-Dutch engineers become as fluent as they are. This worldview of innovation assumes a coevalness of space-time and that engineers worldwide are committed to making their shorelines replicate those of the Netherlands. I am not implying here that engineers in other parts of the world cannot learn to implement Dutch measures; they have, sometimes with ease and in other cases, like that of the eroding Guyanese shorelines, with great difficulty. My point is that trying to replicate the Dutch system comes with a cost because it creates expectations that a nation can single-handedly harness natures to manage climate change. The problem though, is that natures do not inhabit national boundaries until engineers identify some natures and not others as "native" to a given national territory or space. This identification, moreover, is part of a broad range of performances caught up in historical experiences of disaster, empire, fiscal debt, and nation-formation that exceed the technical language of climate change. In short, climate adaptation projects thus far have



provided engineers with no overarching political framework or liberal institution that recognizes plurality in innovation.

This erasure of the variety and complexities of approaches to climate adaptation is chilling, and it is urgent that it be countered. It can slip easily into populism of the type that Bruno Latour (2018) describes as people believing that climate change inspires them to violently defend the territorial claims of their own nation-state. Alternatively, this erasure can contribute to forms of racism and nativism by treating non-Dutch engineers, particularly those from the global South, as always already lacking expertise. But as the Guyana case suggests, this desire for inclusion might be short-sighted, or present only a partial version of climate adaptation's story.

Engineers in Guyana also adhere to a complex practice of North-South knowledge exchange that is fluid and not reducible to technology transfers inaugurated by the state or external donor agencies. They perceive what I have analyzed here as the "afterlives of innovation," or the ongoing material effects of past sea defense innovations on coastal strategies of climate adaptation. These material effects have generated shifting geopolitical arrangements of epistemic labor that inform ideas about credibility. Innovation in climate adaptation is dependent on engineers crafting a professional ethos of credibility that takes seriously thinking with erosion in real time. Engineers draw on episodes of erosion to demonstrate their credibility within the competitive funding arenas of green markets that now appear taken-for-granted in the organization of global climate governance. Thus, even as engineers admit to not finding permanent solutions for sea defense, innovation provides a language for both critique and, perhaps more importantly, efforts at creating more secure climatic futures.

#### REFERENCES

- Anand, Nikhil. 2017. *Hydraulic City: Water and the Infrastructures of Citizenship in Mumbai*. Durham: Duke University Press.
- Anthony, Edward J. and Nicolas Gratiot. 2012. Coastal Engineering and Large-Scale Mangrove Destruction in Guyana South America: Averting an Environmental Catastrophe in the Making. *Ecological Engineering* 47: 268–73.
- Appadurai, Arjun. 2013. *The Future as Cultural Fact: Essays on the Global Condition*. New York: Verso Press.
- Augustinus, PGEF. 1978. The Changing Shoreline of Suriname (South America). PhD diss., University of Utrecht.
- Barnes, Jessica. 2016. States of Maintenance: Power, Politics, and Egypt's Irrigation Infrastructure. *Environment and Planning D: Society and Space* 35, 1: 146–64.
- Bijker, Wiebe E. 2007. American and Dutch Coastal Engineering: Difference in Risk Concept and Difference in Technological Culture. *Social Studies of Science* 37, 1: 143–52.
- Braun, Bruce. 2014. A New Urban Dispositif? Governing Life in the Age of Climate Change. *Environment and Planning D: Society and Space* 32, 1: 49–64.

- Brown, Nik. 2003. Hope against Hype—Accountability in Biopasts, Presents, and Futures. *Science Studies* 16, 2: 3–21.
- Bulkan, Janette. 2014. REDD Letter Days: Entrenching Political Racialization and State Patronage through the Norway-Guyana REDD-Plus Agreement. *Social and Economic Studies* 63, 3 & 4: 249–79.
- Carse, Ashley. 2014. *Beyond the Big Ditch: Politics, Ecology, and Infrastructure at the Panama Canal*. Cambridge: MIT Press.
- Case, Gerald O. 1920. *Coast Erosion Protection Works on the Case System in British Guiana*. New York: Tidal Engineering Corporation.
- Chakrabarty, Dipesh. 2021. *The Climate of History in a Planetary Age*. Chicago: University of Chicago Press.
- Dalrymple, Omatoyo K. 2006. Sea-Level Rise Implications for the Coast of Guyana: Seawalls and Muddy Coasts. Paper presented at the Fourth Latin American and Caribbean Conference for Engineering and Technology, Mayagüez, Puerto Rico, 21–23 June.
- De Laet, Marianne and Annemarie Mol. 2000. The Zimbabwe Bush Pump: Mechanics of a Fluid Technology. *Social Studies of Science* 30, 2: 225–63.
- Denis, Jérôme, Alessandro Mongili, and David Pontille. 2016. Maintenance & Repair in Science and Technology Studies. *Technoscienza: Italian Journal of Science & Technology Studies* 6, 2: 5–15.
- Disco, Cornelis. 2002. Remaking “Nature”: The Ecological Turn in Dutch Water Management. *Science, Technology & Human Values* 27, 2: 206–35.
- Edwards, Michelle A. 2017. *They Taught Me to Think: A Memoir*. Bloomington: WestBow Press.
- Fullwiley, Duana. 2011. *The Enculturated Gene: Sickle Cell Health Politics and Biological Difference in West Africa*. Princeton: Princeton University Press.
- Geissler, Paul, ed. 2015. *Para-States and Medical Science: Making African Global Health*. Durham: Duke University Press.
- Girvan, Norman. 1979. The Approach to Technology Policy Studies. *Social and Economic Studies* 28, 1: 1–53.
- Godin, Benoît. 2015. *Innovation Contested: The Idea of Innovation over the Centuries*. London: Routledge.
- Government of Guyana. 1996. *National Development Strategy, Chapter 40: Water Management and Flood Control Policies*. At: <http://www.guyana.org/NDS/chap40.htm> (accessed 16 Apr. 2020).
- Government of Guyana. 2010. *Transforming Guyana’s Economy while Combating Climate Change: A Low Carbon Development Strategy*. Georgetown: Office of the President.
- Grove, Kevin. 2018. *Resilience*. London: Routledge.
- Helmreich, Stefan. n.d. From the Waterwolf to the Sand Machine: Domesticating Waves in the Netherlands. In his “The Book of Waves,” manuscript, 30–85.
- Hetherington, Kregg. 2019. Keywords of the Anthropocene. In Kregg Hetherington, ed., *Infrastructure, Environment, and Life in the Anthropocene*. Durham: Duke University Press, 1–16.
- Hilgartner, Stephen. 2015. Capturing the Imaginary: Vanguard, Visions, and the Synthetic Biology Revolution. In Stephen Hilgartner, Clark Miller, and Rob

- Hagendijk, eds., *Science and Democracy: Knowledge as Wealth and Power in the Biosciences and Beyond*. New York: Routledge, 33–56.
- Houston, Lara. 2017. The Timeliness of Repair. *Continent* 6, 1: 51–55.
- Howe, Cymene *et al.* 2015. Paradoxical Infrastructures: Ruins, Retrofit, and Risk. *Science, Technology, & Human Values* 41, 3: 547–65.
- Jackson, Steven. 2014. Rethinking Repair. In Tarleton Gillespie, Pablo J. Boczkowski, and Kirstin A. Foot, eds., *Media Technologies: Essays on Communication, Materiality, and Society*. Cambridge: MIT Press, 221–39.
- Jasanoff, Sheila. 2010. A New Climate for Society. *Theory, Culture & Society* 27, 203: 233–53.
- Kimmelman, Michael. 2017. The Dutch Have Solutions to Rising Seas: The World Is Watching. *New York Times*, 15 June. At: <https://www.nytimes.com/interactive/2017/06/15/world/europe/climatechangerotterdam.html> (accessed 16 Apr. 2020).
- King, Tiffany L. 2019. *The Black Shoals: Offshore Formations of Black and Native Studies*. Durham: Duke University Press.
- Kirby, Andrew, Peter Meesen, and Henk Ogink. 2006. *Engineering Assessment of 2006 Floods. Report for the Government of Guyana*. Georgetown: United Nations Development Program.
- Kirksey, Eben. 2015. *Emergent Ecologies*. Durham: Duke University Press.
- Klooster, Wim. 2016. *The Dutch Moment: War, Trade, and Settlement in the Seventeenth-Century Atlantic World*. Ithaca: Cornell University Press.
- Kolbert, Elizabeth. 2021. *Under a White Sky: The Nature of the Future*. New York: Crown.
- Koslov, Liz. 2016. The Case for Retreat. *Public Culture* 28, 2: 359–87.
- Lakhan, V. Chris. 1994. Planning and Development Experiences in the Coastal Zone of Guyana. *Ocean & Coastal Management* 22: 169–86.
- Latour, Bruno. 2018. *Down to Earth: Politics in the New Climatic Regime*. Cambridge: Polity Press.
- Lees, David, François Marie Joseph Wernerus, and Murray Charles Simpson. 2009. *Strategic Environmental Assessment of the Sea Defences Sector Policy in Guyana*. Georgetown: European Union.
- Ley, Lukas. 2021. *Building on Borrowed Time: Rising Seas and Failing Infrastructure in Semarang*. Minneapolis: University of Minnesota Press.
- Lowenthal, David. 1952. Colonial Experiments in French Guiana, 1760–1800. *Hispanic American Historical Review* 32, 1: 22–43.
- Mahony, Martin. 2014. The Predictive State: Science, Territory and the Future of the Indian Climate. *Social Studies of Science* 44, 1: 109–33.
- Mattern, Shannon. 2018. Maintenance and Care. *Places*. At: <https://placesjournal.org/article/maintenance-and-care/?cn-reloaded=1> (accessed 19 Apr. 2020).
- Mavhunga, Clapperton C. 2017. *What Do Science, Technology, and Innovation Mean from Africa?* Cambridge: MIT Press.
- McLean, Stuart. 2011. Black Goo: Forceful Encounters with Matter in Europe's Muddy Margins. *Cultural Anthropology* 26, 4: 589–619.
- Mendelsohn, Ben. 2018. Making the Urban Coast: A Geosocial Reading of Land, Sand, and Water in Lagos, Nigeria. *Comparative Studies of South Asia, Africa, and the Middle East* 38, 3: 455–72.

- Messeri, Lisa. 2016. *Placing Outer Space: An Earthly Ethnography of Other Worlds*. Durham: Duke University Press.
- Metz, Tracy and Maartje van den Heuvel. 2012. *Sweet & Salt: Water and the Dutch*. Rotterdam: Nai010 publishers.
- Mitchell, Timothy. 2002. *The Rule of Experts: Egypt, Techno-Politics, Modernity*. Berkeley: University of California Press.
- Netherlands Engineering Consultants (NEDECO). 1972. *Report on Sea Defence Studies. Volume I*. Georgetown: Ministry of Works, Hydraulics and Supply.
- Oreskes, Naomi and Erik M. Conway. 2010. *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming*. New York: Bloomsbury Publishing.
- Pelling, Mark. 1999. The Political Ecology of Flood Hazards in Urban Guyana. *Geoforum* 30, 3: 249–61.
- Pelling, Mark. 2011. *Adaptation to Climate Change: From Resilience to Transformation*. New York: Routledge.
- Petroski, Henry. 2016. *The Road Taken: The History and Future of America's Infrastructure*. London: Bloomsbury Press.
- Redfield, Peter. 2016. Fluid Technologies: The Bush Pump, the LifeStraw and Microworlds of Humanitarian Design. *Social Studies of Science* 46, 2: 159–83.
- Redfield, Peter. 2000. *Space in the Tropics: From Convicts to Rockets in French Guiana*. Berkeley: University of California Press.
- Rodney, Walter. 1981. *A History of the Guyanese Working People, 1881–1905*. Baltimore: Johns Hopkins University Press.
- Rubio, Fernando D. 2012. The Material Production of the Spiral Jetty: A Study of Culture in the Making. *Cultural Sociology* 6, 2: 143–61.
- Russell, Andrew and Lee Vinsel. 2016. Hail the Maintainers. *Aeon*, 7 Apr. At: <https://aeon.co/essays/innovation-is-overvalued-maintenance-often-matters-more> (accessed 20 Apr. 2020).
- Schipper, E. Lisa F. 2006. Conceptual History of Adaptation in the UNFCCC Process. *RECIEL: Review of European, Comparative & International Environmental Law* 15, 1: 82–92.
- Star, Sisan Leigh. 1999. The Ethnography of Infrastructure. *American Behavioral Scientists* 43, 3: 377–91.
- Stengers, Isabelle. 2018. *Another Science Is Possible: A Manifesto for Slow Science*. Stephen Murche, trans. Cambridge: Polity Press.
- Thomas, Clive Y. 1984. *The Rise of the Authoritarian State in Peripheral Societies*. New York: Monthly Review Press.
- Tousignant, Noémi. 2018. *Edges of Exposure: Toxicology and the Problem of Capacity in Postcolonial Senegal*. Durham: Duke University Press.
- van Ledden, Mathijs *et al.* 2009. Extreme Wave Event along the Guyana Coastline in October 2005. *Continental Shelf Research* 29, 1: 352–61.
- Vaughn, Sarah E. 2021. Ecotourism's Ethics: Self-Organization and Care in Urban Guyana. *Environment and Planning E: Nature and Space*. At: <https://doi.org/10.1177/25148486211018566> (last accessed 5 Dec. 2021).
- Vaughn, Sarah E. 2022. *Engineering Vulnerability: In Pursuit of Climate Adaptation*. Durham: Duke University Press.

- Verbeek, Peter. 2005. Artifacts and Attachments: A Post-Script Philosophy of Mediation. In Hans Habers, ed., *Inside the Politics of Technology: Agency and Normativity in the Co-Production of Technology and Society*. Amsterdam: Amsterdam University Press, 125–46.
- Wesselink, Anna J. et al. 2007. Dutch Dealings with the Delta. *Nature and Culture* 2, 2: 188–209.
- Williams, Dennis. 2003. *Prehistoric Guiana*. Kingston: Ian Randle.
- Worster, Donald. 2011. The Flow of Empire: Comparing Water Control in China and the United States. *RCC Perspectives: Transformations in Environment and Society* 5: 1–23.

---

**Abstract:** This essay explores the intersecting socio-material and ethical demands that engineers confront in adapting sea defenses to climate change in Guyana. It focuses on the tensions in climate adaptation that create the possibilities for theorizing innovation as a key theme of counter-modernities in the Anthropocene. Drawing on ethnographic fieldwork, oral histories, and archival research, I show that engineers' decision-making regarding whether or not to innovate sea defenses is a fraught process dependent upon processes of erosion and the ontological (in)stability of specific infrastructures known as groynes. To cope, engineers produce what I call "innovation narratives" to describe how obstacles to climate adaptation are created by combinations of neocolonial empire, shapeshifting ecologies, inconsistent maintenance programs, and fiscal debt. At the same time, their efforts signal an emerging global politics of credibility that is reinforced by desires for more inclusive forms of governance rather than brute power or capitalization.

**Key words:** innovation, historical time, climate adaptation, knowledge economies, cultures of engineering, Guyana, soil erosion