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On viability: Climate change and the science of possible futures

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ABSTRACT

Growing attention to the impacts of climate change around the world has been accompanied by the profusion of discourses about the lives, livelihoods, and geographies that are "viable" and those that are not in the time of climate change. These discourses of viability often invoke concrete physical limits and tipping points suggesting a transcendent natural order. Conversely, I demonstrate how viability is co-produced through political economic structures that exercise power at multiple scales in shaping the environment and understandings of how it is changing. I describe three dialectics of this co-production: epistemic/material (between ideas about viability and their biophysical and political economic conditions), epistemic/normative (between how the world is understood to be and ideas about how we should live in it), and inter-scalar (between geographic scales, where action at one scale shapes both ecologies and understandings of possible action at another). Each of these dialectics shapes the knowledge regimes that govern the ambiguous social and biophysical process of disappearance and foreclosure of livelihood possibilities in the time of climate change. I examine these discourses of viability through narratives of unviable agrarian livelihoods in coastal Bangladesh, as a lens through which to examine the dialectics of viability more broadly. I situate these discourses concretely in relation to an analysis of interdisciplinary social and natural scientific research on ecological and agrarian viability in coastal Bangladesh now and in the future. Across a broad interdisciplinary spectrum, I find that scientific attention to political economy shapes the politics of possibility. Finally, I demonstrate how discourses of viability limit alternative possible economic and ecological futures. I do this through a concrete examination of the co-production of viable agrarian futures within communities in coastal Bangladesh. These alternative visions indicate that the viability of agriculture is shaped by historical and ongoing decisions in the present about cultivation, water management, and development intervention.

1. Introduction

What are the conditions under which a form of life—a landscape, community, livelihood, or socio-ecological system—may be considered unviable? Growing awareness of climate change has been accompanied by a great profusion of elegies for the forms of life that are projected to be no longer possible due to rising seas, extreme weather, and other climate threats. These elegies can be observed in popular, policy, and scientific narratives about climate futures, each informed by the others.

Yet, not all communities are said to be doomed, not all future livelihoods are said to be unviable. As Matthew Schneider-Mayerson has observed, "some islands will rise," reflecting on the apparently obviously viable future of Singapore in the face of climate change (Schneider-Mayerson, 2017). This capitalist haven of sustainable urbanism is growing upwards and outwards on land built with sand dredged and imported from its neighbors (Comaroff, 2014). In contrast, I consider Bangladesh, a low-lying deltaic state which is said to face an opposite fate: Bangladesh is sinking, its coastal communities are projected to be inundated by rising seas and subsequently depopulated. Unlike Singapore, narratives about Bangladesh's climate future are never triumphant. The future of life in coastal Bangladesh, it is often said, is not viable.

The discourse and science of viability are increasingly employed in the governance of life in the time of climate change. These claims about the communities and livelihoods that are viable and those that are not often becomes the source of significant contestation. After Hurricane Katrina, the threat that communities in New Orleans would need to prove their "viability" in order to be rebuilt galvanized citizen groups across the city to contest proposals for a radical restructuring around land use (Lamb, 2020). Similarly, viability has been used as a tool of urban triage in Detroit, where the designation has been employed in what Sarah Safransky calls "green dispossession" (Kirkpatrick, 2015; Safransky, 2014). In each case, these social scientists have found that rather than existing as an objectively knowable condition, viability is

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indexed by radically unequal political economies of development that shape who and what is considered worth saving in rapidly transforming economies and ecologies.

These diverse ways of thinking and knowing about viable futures are not only shaped by biophysical conditions, but also the social and political orders that frame these understandings of and intervene in the physical environment. These conditions co-produce one another (Jasanoff, 2004). Whether a community or way of life is viable or not is informed not only by the physical threats it faces, but also by whether it is thought to be viable in the first place. Some areas and livelihoods are considered worth the investments necessary to adapt to these threats, while others are not. While it is true that many coastal communities face similar climatic threats, it is also true that the diverse political economies of managing those threats reshape physical environments. Discourses of viability mediate and sometimes amplify these political economic conditions, thus operating not only linguistically but also resulting in and from concrete material dynamics. There is no transcendent condition of viability, rather it is an imposed designation that both reflects existing conditions of material power and has material effects. This means that who and what the designation of viability gets imposed on and how matters. When is it possible to say that an island will sink or rise, that a future is unviable? How do scientific practices play a role in this governance? How are these scientific practices informed by normative understandings of desirable futures?

In this article, I examine the discourse and production of viability through empirical attention to a claim that has become prevalent if not ubiquitous in development and adaptation planning communities in Bangladesh, popular media accounts, and some academic texts about climate threats to the region: that agriculture in Bangladesh's rural coastal area will soon be (or already is) unviable (e.g. Clarke et al., 2015; Didar-ul Islam and Bhuiyan, 2016; Haider and Hossain, 2013). Summarized briefly in the words of one sociologist, "rice farming is no longer viable, and farmers have to adapt" (Poncelet, 2010, p. 24).[1] These claims have serious implications for how the future of this coastal region is planned and the development interventions that are implemented in response (Paprocki, 2021). Yet, the basis of these claims is not always clear, and they are rarely questioned. I take up these claims, evaluating the physical conditions and natural scientific evidence associated with them, and also situate them in relation to the broader political economy of development in the region. This evaluation of the social life of a scientific claim surrounding unviable futures becomes a lens through which to investigate the broader questions of the politics of possibility in the time of climate change.

Examining this science of viability offers a window into the dynamics of co-production. Claims of viable or unviable futures in the time of climate change often suggest an absolute biophysical condition determined through scientific analysis of the material environment. In short, I find that while there is a great deal of diversity of methods, analyses and projections among these scientists, differences in attention to political economy shape their understandings of viability. Where scientists ignore political economy in their modelling and analysis, for example by disregarding the politics of changes in land use, they are more likely to find that agriculture and livelihoods are unviable in the coastal region. Researchers who assume the inevitability of the political economic status quo are largely unable to identify its ecological impacts, leading to claims of unviability. I situate these claims in relation to the historical political ecology of development in the region more broadly. In so doing, I find that this co-production of unviable futures is not the result simply of epistemic silos among diverse interdisciplinary researchers. Rather, the political economy of knowledge production itself shapes the environment, what is said to be known about it, and ideas about ideal interventions in the face of that knowledge.

In coastal Bangladesh, the implications of these knowledge politics are significant for millions of residents. While scientists and development practitioners debate the viability of these livelihoods and landscapes, residents rarely have a say in the interventions that are planned as a result. In the final section of the paper, I describe demands for canal excavation as one example of a physical intervention identified by local residents that calls into question many dominant claims about viability. This example suggests that changes in our systems of knowledge production could not only inform better understandings of ecological change, but could also offer new possibilities for viable futures in the face of a variety of present and future threats.

It is necessary to think outside of these existing political economic conditions to understand possible alternatives to them. Put bluntly, alternative political economies and alternative ecologies are linked. This disregard of political economy matters not only because of its implications to scholarship but also because it shapes understandings of possible alternatives, limits visions of alternative futures, and in turn shapes the ecologies on which those possibilities depend (Whitington, 2018).

In what follows, I briefly describe the methods used in carrying out this research and analysis, after which I outline the three dialectics of viability (epistemic/material, epistemic/normative, and inter-scalar). Next, I examine the empirical case of the co-production of viability in the Bengal delta, with attention to the political ecological history of the region and the two concrete biophysical processes of 1) land loss through sea level rise and erosion and 2) soil and water salinity, evaluating the available scientific evidence about each of these processes. Finally, I turn to a discussion of alternatives to unviability in the Bengal delta imagined and forged by local communities and social movements.

2. Methods

The foundations of this study are two years of ethnographic research conducted primarily in 2014 and 2015 on the political ecology of climate change and adaptation in Bangladesh. This research involved interviews and participant observation with policy makers, donors, development practitioners, farmers and day laborers, as well as with scientists and engineers studying the physical changes being experienced in this coastal region and modelling the potential for these changes in the future. This includes natural scientists (such as engineers, agricultural scientists, geophysicists, and physical geographers of socio-ecological systems) as well as social scientists with expertise in environmental modelling (such as economists) and survey methods (including some sociologists and human geographers).

I selected these scientists on the basis of their engagement with practitioner and policy communities working in the field of development and adaptation in Bangladesh. In some cases this means they were employed by Bangladeshi or foreign research agencies based in Dhaka (the Bangladeshi capital), and in some cases it means they were leading or participating in conferences, workshops, and other knowledge-sharing events focused on the use of research to inform policy-making for climate action. These actors also interact with each other, frequently through large interdisciplinary collaborations, as well as with other non-scientists, both through the formal methodologies of their research (e.g. by enlisting research assistants and local organizations that serve as interlocutors between researchers and communities) as well as through social systems that inform the assumptions that shape their research in less explicit ways (e.g. through popular reports in international media about Bangladesh's vulnerability to climate change that lead many to conduct research in the country in the first place). Often these forms of engagement were dictated by the terms of research funding, for example through US and UK government agencies with a specific grantmaking focus on research for "impact." My participant observation with these scientists through these knowledge sharing events, research field visits, and through interviews conducted in Bangladesh, India, the Netherlands, and the United Kingdom provided an extensive understanding of the work of this interdisciplinary group of scholars working at the science-policy interface.

[1] Translated from the original French. All translations are my own.

Subsequently, I expanded my understanding of this research through a thorough desk-based review of the scholarly literature produced by these scientists as well as others with whom they engage through citation and co-authorship. Finally, I identified some additional scholarly texts to review through their citation in popular media reports about climate and ecological change in Bangladesh, which incorporated a sample of scientists who do not conduct field-based research or engagement activities. Collectively, these texts provide a thorough sample of the scholarship focused on the science of current and future environmental change informing policy and action in Bangladesh.

Through this sampling process, key themes emerged about the social and environmental dynamics that are referenced in discourses of viability, specifically: 1) sea level rise and erosion, and 2) soil and water salinity. These themes are particularly significant because they are also commonly understood to be impacts of climate change. As my analytical focus narrowed onto scholarship focused on these dynamics, some adjacent fields of scholarship became less relevant and are therefore not represented here. For example, the work of some Bangladeshi and foreign agronomists focuses on adaptation measures associated with “climate smart agriculture” in the coastal region, such as index-based insurance and alternative agronomic practices. While this scholarship does not address questions of viability directly and is therefore outside the scope of my analysis here, it is worth noting that it often implicitly assumes the continued viability of agriculture in the region.

The ethnographic methods described above are also the basis of my analysis of alternative agrarian futures in the final section of the paper. My research with rural farmers and day laborers in three villages in Bangladesh’s coastal Khulna district builds on research I have been doing in these communities since 2012, initially through a participatory study of the agrarian political economy of shrimp aquaculture. My research in these communities alerted me to alternative understandings of ongoing change and the region’s possible ecological futures, and this in turn informed my interviews with scholars described above and analysis of their scholarship.

3. Three dialectics of viability

While my focus is on examining discourses and science of viability, I am interested more broadly in how these discourses are mediated by political economic forces that exercise power in shaping the environment (rather than exclusively on the causal powers of discourse). Scientific claims about viability are (co)produced within social systems made up of a variety of actors (Forsyth, 2003; Jasanoff, 2004). I engage deeply and critically with the discourses and practices of scientists studying environmental change in Bangladesh. I seek to understand the ways they draw on and produce representations of Bangladesh as a disappearing space of climate crisis where the viability of lives and livelihoods are threatened, but I also engage directly with their methods and data across a range of disciplines to understand the biophysical basis of their analyses. Similarly, anthropologist Jerome Whitington has used the term viability in the context of climate change “to call out thresholds of value that are not uniquely established by human observers, and terms of meaning not solely tied to linguistic signification” (Whitington, 2013, p. 324). In this sense, both Whitington’s study and my own are attentive to climate science not only as a set of discourses about the future but also a set of material relations that anticipate that future. My analysis thus draws on a tradition in political ecology that combines constructivist attention to the social construction of nature with realist attention to material features shaping environmental change (Blaikie, 1985; Forsyth, 2003; Lave et al., 2018; Watts and McCarthy, 1997).

3.1. Epistemic/Material dialectic

The first dialectic of the co-production of viability is that of the epistemic/material. That is, between on the one hand ideas about viability and on the other their biophysical and political economic conditions. Early work in political ecology engaged extensively with the politics of knowledge surrounding the idea of “adaptation,” particularly questioning organic analogies and also responding to the problem that the concept of adaptation spoke to the characteristics of an organism and not to the conditions under which an organism was made to adapt (for example, capitalism) (Watts, 1983, 2015). Discourses of viability reproduce these issues, introducing new organic analogies into understandings of threats to life and livelihoods in the time of climate change. To suggest that a livelihood or community is not viable is to infer a biological foundation for this determination, while leaving intact unstated assumptions about the social conditions that shape these ecological conditions. However, the referent of viability is rarely made explicit, so a way of life may be said to be unviable when in fact it is the conditions of the system in which it is embedded that make it so. Thus, discourses of viability carry with them a series of assumptions about the necessity of these existing material conditions. For example, a claim about the viability of agriculture may be embedded with assumptions about the viability of infrastructures, labor regimes, and foreign commodity exports, and more importantly with the assumption that there are no alternatives to the status quo of any of these.

Many contemporary discourses of viability suggest that there is a transcendent ecological order under climate change, ignoring that climate change is both part of and intervenes in an ecological system that is also characterized by the political economy of capitalism (Fraser, 2021). Whether it is possible to adapt to climate change is shaped not only by biophysical dynamics, but by the political economy within which adaptation transpires more broadly. In this case, the idea that adaptation is unviable itself shapes both the political and biophysical conditions that bring that unviability about. Discourses of viability shape the natural world and the material, biophysical conditions of viability within it. Discourses of unviable climate futures produce the very conditions of viability they anticipate (Koslov, 2019; Mathews and Barnes, 2016; Paprocki, 2019; Wakefield, 2021; Zeiderman, 2016), including by foreclosing alternative social and ecological paths (Asayama, 2021). Yet these discourses are also dialectically shaped by those same material conditions; they do not exercise agency independent of them. Discourses of viability mediate existing political economic dynamics that give rise to the conditions of viability in the first place. That is, biophysical processes also play an active role in shaping both human-environment interactions and the discourses surrounding them (Forsyth, 2003; Zimmerer and Bassett, 2003). For example, the unequal distribution of resources shapes ecologies in concrete material ways, and these material conditions are reflected in discourse about those ecologies. There is an ontological basis for the things we know about the environment, and we can attend to the scientific methods and practices that aim to understand this ontology even as we also are aware of the political conditions under which they do so.

3.2. Epistemic/Normative dialectic

Viability is also dialectically co-produced through epistemic understandings of how the world is and normative understandings of how it should be. While the framework of co-production has often been misunderstood as being limited to the proposition that scientific knowledge is socially constructed, scholars of science and technology studies have instead argued that neither the “social” nor the “natural” is ontologically prior to the other, rather they develop in parallel. (Jasanoff, 2004). The idiom of co-production directs us to the normative dynamics that shape these social and natural orders. Scientific understandings of the world are forged alongside these normative systems of knowledge and representation. As Jasanoff writes, “representations of the natural world attain stability and persuasive power, in my view, not through forcible detachment from context, but through constant, mutually sustaining interactions between our senses of the is and the ought: of how things are and how they should be” (Jasanoff, 2010, p. 236). This idiom of co-production draws our attention not only to ideas about viability as a social construct, but also to the ways in which these ideas are grounded concretely in natural orders. These socially constructed notions of viability have shaped, do shape, and will physically shape landscapes. Thus, the very viability of these natural orders is shaped by social orders. This relationship is manifested materially, not only conceptually. When it comes to climate change, this relationship between "is and ought" is particularly fraught, as multiple scales of both natural and social orders confront each other asymmetrically, such that, for example, planetary models of ecological change are forced to grapple with local and contextually specific moral economies and conceptions of how we should organise our societies (Elliott, 2021).

3.3. Inter-Scalar dialectic

Finally, viability is dialectically produced between geographic scales. Political ecologists have frequently interrogated the politics of scale in examining questions of adaptation and have identified a scalar mismatch between the social, natural, and normative. Rangan and Kull's examination of the politics of scale notes the common scalar contradictions between studies of biophysical and social dynamics, an attention that highlights the dialectical relationships between global and local processes (2009; see also Cohen, 2021; Riofrancos, 2017). Natural and social orders are co-produced, often at multiple scales that differ from one another (Sayre, 2015; Zimmerer and Bassett, 2003). Notions of viability are linked with particularly scaled understandings of possibilities for adaptation as well as responsibilities for action. So, for example, the authors of one paper on adaptive responses to coastal flooding write that "defence is an economically feasible option only in wealthier nations. Developing countries such as Bangladesh that have very high levels of vulnerability do not have the resources to defend and will have no choice but to retreat" (Dedekorkut-Howes et al., 2020, p. 2134). Here the idea that coastal livelihoods are unviable in Bangladesh due to the impossibility of coastal defense and protection from displacement is contingent on the assumption that the scale of responsibility and possible action for mitigating this displacement is limited to that of the Bangladeshi nation-state itself. Global funding for adaptation that might be an alternative source of financing for these defenses is excluded from the scenario in this assumption (see also Perry, 2021). Of course, sufficient global action to curb carbon emissions would also mitigate the need for such retreat. Thus, the viability of coastal livelihoods is understood only within a narrowly scaled frame of normative action.

While early critiques of the concept of adaptation in political ecology were concerned with teleologies of persistence (the persistence of a system is measured by its ability to adapt to perturbations) (Watts, 1983), these assumptions have in some ways been replicated in theories of "resilience" that have been popularized through research on Socio-Ecological Systems (SES). Resilience refers to the ability of a system to resist a "regime shift" or a transformation involving the fundamental reorganization of a system and its populations, to borrow terms used in the ecological sciences (Milkoreit et al., 2018). In the biophysical sciences, regime shift is a concept used to refer to a transformation of what is possible; this is measured through physical processes but is understood to be shaped by social processes as well. These concepts are used in several of the studies described in the following section. Viability is deployed as a metonym for these complex biophysical concepts, a term used in popular, policy, and some academic discourses to refer to a lack of resilience or a failure to prevent a transformation toward an alternative state inhabitable by a different set of populations and hospitable only to different production systems. If a way of life is said to be unviable, that is to suggest that a regime shift is immanent or has already occurred.

Cote and Nightingale have critiqued SES research for deploying these concepts in ways that overemphasize abstract structural conditions and physical shocks, while minimizing the importance of political economic factors (2012). They explain that SES research neglects normative questions about the political conditions that shape environmental management at multiple scales. The conditions that facilitate or resist a regime shift are often shaped at different scales from those at which they are experienced. Viability in Bangladesh's coastal region is similarly produced at multiple scales. For example, Sherin et al. describe a "regime shift" in salinization in the Bengal delta, with potential drivers at multiple scales including sea level rise, upstream freshwater discharge, and groundwater depletion (2020). Each of these drivers of change involves action that is taken at different scales; examples include carbon emissions leading to global climate change, transboundary water sharing agreements, and farm-level agricultural land use decisions. The implications to the viability of agriculture in Bangladesh's coastal region, however, are not necessarily experienced at each of those scales and sites of action. Thus, we see that if agriculture is not viable, it is necessary to interrogate the social relations and power dynamics at multiple scales that have made it so.

4. Viability in the Bengal delta

Questions of viability haunt much of the research conducted on the natural science of ecological change in the Bengal delta. Often claims about the viability of agriculture in the region are based on claims about these biophysical systems, collapsing conclusions about agricultural viability with those about ongoing environmental change. While climate change-induced sea level rise is a major concern in studies of ongoing and projected environmental change in this region, a variety of different ecological changes associated with sea level rise are said to threaten the viability of agriculture. Salinity intrusion and land erosion are the most widely cited examples of these changes, while out-migration from coastal Bangladesh is often cited as evidence of this deteriorating viability (Paprocki, 2021; e.g. Poncelet et al., 2010). I examine the available scientific evidence related to present and future biophysical conditions in the delta, claims about agricultural viability within it, as well as how scientific knowledge about these conditions has been constructed. This examination demonstrates that ecological change in the region is contingent on how the environment is managed in the past, present, and future; projections about the impacts of climate change cannot be separated from these ongoing decisions about how to manage the landscape and production within it. Determining the viability of any production system in the future is thus also inseparable from these deeply political decisions about how best to prepare for that future.

4.1. Historical political economy of development in the Bengal delta

A brief history of the recent political economy of development in the region sheds significant light on this ongoing environmental change. Two major and ongoing dynamics shaping the physical landscape independently of climate change are especially important: commercial shrimp aquaculture and the existence of large-scale physical infrastructures, particularly a massive network of embankments that have formed a network of "polders" across the coast. Both are increasingly described by development agencies and some scientists as measures to promote climate change adaptation. Yet, both also predate the observation of climate impacts in coastal Bangladesh and the adaptation efforts targeted at them. Understanding the history and political economy of each sheds light on these processes of co-production.

Bangladesh's coastal region is home to the delta of the Ganges, Meghna, and Brahmaputra (GBM) rivers, one of the most dynamic delta regions in the world. Efforts to manage and control these unruly rivers and their endless network of distributaries began prior to the colonial period, but the technologies characterizing the current water management regime can be dated to just after Partition, in the East Pakistan period. In 1961, the East Pakistan Water and Power Development Authority, with loans from USAID and driven by US and Dutch engineering expertise, initiated the Coastal Embankment Project (CEP), a program to build a large system of embankments across the coastal region of what is now Bangladesh. These embankments would create a network of Dutchstyle “polders” - areas of low-lying land surrounded by protective dikes (initial plans included 108 polders, and today there are a total of 123). Polder infrastructure is often used to reclaim low-lying land from the sea; in this case, coinciding with the incipient Green Revolution in South Asia, the goal was largely to expand agricultural cropping area in order to increase rice production (Adnan, 2009; International Bank for Reconstruction and Development, 1972a; Rahman and Salehin, 2013). The CEP was based on an engineering model of “hydraulic closure” (van Staveren et al., 2017), essentially intended to close off the active tidal estuary by creating larger land units and stopping the movement of water through smaller tidal streams within them (International Bank for Reconstruction and Development, 1972b).

Problems with this hydraulic closure model began to manifest almost immediately. The new embankments inhibited drainage in many parts of the polders, while impeding the necessary flow of water for agricultural irrigation to others (Advisory Group on Development of Deltaic Areas, 1966). Problems with the technical design of the polders, in particular the highly experimental transfer of hydraulic technologies from the Netherlands to Bangladesh, highlighted for some the failures of local consultation and the limited understanding of Bangladesh’s unique and highly complex physical geography among the foreign consultants hired to design them (Nandy, 1991; Thomas, 1972; van Staveren et al., 2017).

While the creation of the polders marked the beginning of a new era of hydraulic problems for the coastal zone, it also facilitated a major transformation in production regimes. The tidal ecology of the coast is particularly conducive to floodplain rice agriculture, which has been practiced in the region for hundreds of years. In the 1980s, major donors including USAID and the World Bank began to fund and promote the development of commercial shrimp aquaculture in this region under structural adjustment programs (Adnan, 2013). While artisanal aquaculture had been practiced locally during the rainy season in rotation with rice, these new programs involved the enclosure of large land masses previously used to cultivate rice, flooding tracts of land with brackish water required by shrimp. This enclosure was often carried out through illegal and frequently violent land grabbing by very large landholders and outside businessmen (Guhathakurta, 2008; Paprocki and Cons, 2014). The new embankments facilitated this expansion of shrimp aquaculture by keeping water inside the polders, instead of keeping it out. While water logging has often been an unintended impact of the embankment designs as described above, this water retention for shrimp cultivation has often been carried out deliberately by aquaculture enterprises, sometimes with pipes fitted through holes drilled in the embankments or even through private sluice gates constructed to control water egress and ingress.

Both these new physical infrastructures and the expansion of shrimp aquaculture have been instrumental in shaping the contemporary physical geography of the coastal region. In important ways they have each threatened the viability of agriculture in this region as well. Critically, they have also been implicated in many of the ongoing changes that are today discussed as impacts of climate change. I focus here on sea level rise and soil salinity as two concrete examples of this. Untangling these relationships sheds light on the processes of co-production of viability and the politics of knowledge about ongoing transformations.

4.2. Sea level rise and erosion

Land erosion is the subject of extensive research among scientists studying the physical geography of the coastal region, particularly due to the threats it poses to human settlements and agriculture. The viability of communities along the coast is often said to be threatened by this land erosion, which is attributed to a variety of causes. What is clear is that the land masses along the coast are constantly shifting, though the causes and direction of these shifts are less settled. Some geologists have attributed land erosion to the migration of major riverbeds in the delta owing to ongoing tectonic movement (Alam et al., 2003; Goodbred and Kuehl, 2000). This causes not only the shifting of waterways and coastlines, but also the appearance and disappearance of land masses, such as Bhola Island, a large and rapidly eroding island located at the mouth of the Meghna river (Allison, 1998; Brammer, 2009). While much attention has been paid to the process of secretion - the physical erosion and disappearance of coastal lands - the same processes also result in land accretion, likely resulting in net gains in land mass as opposed to losses (Akter et al., 2016; Allison, 1998; Bomer et al., 2020), although this varies spatially and temporally across the coast (Darby et al., 2018; Rahman et al., 2011). Other human-induced drivers of change contribute significantly to the ongoing transformations of these land masses, dynamics explored in further detail in this section.

The question of how much land mass Bangladesh will lose in the coming decades is the subject of great uncertainty, with the role of climate change in this process being especially uncertain. While claims of rapid sea level rise often lead to predictions of massive land loss in coastal Bangladesh, translation of these dynamics between science, policy, and popular narratives often conflates climate impacts with other drivers of environmental change. Specifically, many of these narratives often conflate eustatic or absolute sea level rise (ASLR) with relative sea level rise (RSLR), the causes of which are very different. ASLR refers to the increased volume of the oceans (either due to the expansion of water as oceans warm or the melting of water on land, including from glaciers and ice sheets). This form of SLR is tied to global patterns of environmental change and can be directly attributed to climate change. RSLR, however, refers to the height of the sea relative to land in a particular coastal landscape, often driven by the vertical movement of the land itself. This form of SLR can only be observed locally and must be understood through a variety of local drivers of change. In all deltas, including Bangladesh’s GBM delta, a major cause of change in RSLR is subsidence, the gradual downward sinking of land, which is caused by both physical and anthropogenic factors (Schmidt, 2015). The human-induced drivers of RSLR in particular places are often obscured by attention to sea-level rise as a global phenomenon in scientific as well as policy and popular work (Nicholls and Goodbred, 2004).

While the specter of sea level rise engulfing Bangladesh’s coastline draws quick associations with global climate change, absolute and relative sea level rise in the region are often conflated. The polder system in particular has been a major cause of RSLR across the coast. Prior to the construction of these embankments, periodic tidal flooding would deposit sediments on land across the coast, which would naturally build up land elevation to counteract the process of subsidence. After the embankments were constructed, this deposition of tidal sediments was cut off - as a result, the land has continued to sink, but has been deprived of the process by which it was historically built back up. Auerbach and colleagues estimate that the result has been a loss of 1.0–1.5 m of land elevation in these polders since the embankments were built in the 1960s, compared to the elevation of non-embanked neighboring areas which have remained relatively stable (2015). Sediments that would have otherwise been deposited on floodplains have instead built up on riverbeds, exacerbating problems of waterlogging within the polders (Rahman and Salehin, 2013). While a large range of measurements of subsidence and sea level rise have been reported across the coast, human-induced drivers of change at a regional and local level are more important than global climate change as drivers of sea level rise in the region (Brown and Nicholls, 2015). Thus, in the words of one team of physical scientists, Bangladesh’s coastal region is not “doomed to drown” (Rogers and Overeem, 2017) - at least not because of global climate change.

Nevertheless, major development agencies have continued to pursue the construction of embankments surrounding these polders as a primary means of investing in the environmental challenges that the region faces, focusing on sea level rise as a threat to the viability of communities currently inhabiting the polder region. The World Bank’s Coastal Embankment Improvement Project (CEIP) is a long-term program of investments targeted at raising the height of the embankments in anticipation of climate-induced sea level rise, while the physical and social dynamics described above that contribute to subsidence are left untouched. The World Bank itself estimates that the construction of just the first phase of these embankments will lead to the displacement and involuntary resettlement of 6203 households (which it refers to as "squatters") (2013). This new infrastructural development has come at the expense of recognition of the historic hydrological patterns in the region, the past failures of the hydraulic closure model, or an analysis of how different engineering models facilitate the viability of different populations and forms of habitation of the delta. Other water management models (such as a system known as Tidal River Management) may better facilitate the continuation of agriculture, based on the region's historic overflow irrigation agricultural regime (Adnan, 2009; Shampa, 2012; van Staveren et al., 2017). Thus, the hydrological regime shaping the viability of agriculture in these poldered environments is co-produced with dominant understandings particularly among development agencies about the threats to that viability and possibilities for addressing them.

4.3. Soil and water salinity

Like sea level rise, water and soil salinity are regularly referred to as impacts of climate change and are said to impact in turn the viability of agriculture in the coastal zone (e.g. Chen and Mueller, 2018; Islam et al., 2019). Several authors have noted the possibility of a regime shift in these agricultural systems due to an increase in soil salinity (Brown and Nicholls, 2015; Hossain et al., 2013; Hossain et al., 2016; Hossain et al., 2017; Islam, 2008; Prodhan and Nasreen, 2016). Dearing writes that "conversion of rice fields to shrimp farms is almost certainly a factor in increasing soil and surface water salinity, while water availability, shrimp farming and maintenance of biodiversity appear to have passed tipping points in the 1970s–1980s" (Dearing, 2018, p. 65). Even as they identify these regime shifts, many authors remain ambiguous about whether the regime shift has already occurred or is yet to come. This ambiguity is in part attributed to questions surrounding the possibilities of adaptation either to mitigate salinity or to facilitate agriculture despite it.

Both transformations in the landscape through major infrastructures as well as shrimp aquaculture have had a significant impact on growing salinity in the region. In addition to these, large dams upstream, including the Farakka Barrage and diversions of water from the rivers on both the Indian and Bangladeshi sides of the border, also increase salinization in the coastal region (Nicholls et al., 2016; Rahman et al., 2000; Thomas, 2017). The same problems with the polder system leading to subsidence have been linked with a rise in soil salinity. While the polders were initially designed to facilitate expanded agricultural seasons by keeping water out, the infrastructure was quickly co-opted to keep saline water in, often by piping this water in from the rivers in the dry season (Datta et al., 2010; Paprocki, 2021). Surreptitiously flooding agricultural areas with salt water has been a common tool used by elites and outsiders to force farmers to lease lands for shrimp aquaculture (Deb, 1998). Because of the subsidence described above, many poldered areas are now at a lower elevation than the surrounding rivers at high tide, impeding the drainage of saline water from shrimp ponds. Thus, many former agriculture fields are now submerged year-round; in the absence of regular flushing with fresh water for irrigation, the salinity of the soils increases (Afroz et al., 2017). Extended inundation with this saline water can lead to salinity percolating into the shallow groundwater (Hossain et al., 2013; Salehin et al., 2018). The extent of this in Bangladesh's coastal region is not fully understood by natural scientists, but it raises additional questions about the viability of agriculture given uncertainty about the process and timeframes associated with expelling salinity once it has seeped into shallow aquifers.

While these ecological impacts have been described by some natural scientists as regime shifts, for others whether tipping points have been passed is an open question, suggesting that solutions may be available to reverse course (Brammer, 2014; Sousa and Small, 2019). These natural scientists identify the viability of agriculture through their attention to the possibility of transformation of the social and political dimensions governing ecological change. For example, in considering whether a regime shift has occurred with respect to salinity and agriculture, Hossain and colleagues write "But is a turning point possible? Direct actions to reduce degradation could include greater control on water quality through stronger regulation on the extent and practice of shrimp farming" (Hossain et al., 2016, p. 440). In this sense, these authors recognize that the physical viability of agriculture in the region is contingent on the political management of salinity through land use governance.

This ambiguity surrounding the salinization of shallow aquifers plays an important role in the co-production of viability. Some researchers have described "positive feedback loops" between shrimp aquaculture and salinity (Hossain et al., 2017), suggesting that the cultivation of shrimp may be both consequence and cause of soil salinity. This ambiguity is reflected in the academic literature, in which many scholars claim that the transition to shrimp has been a response to soil salinity (Ahmed and Diana, 2015; Islam et al., 2019; Johnson et al., 2016), while others claim that it has been the cause of it (Afroz et al., 2017; Ali, 2006; Islam, 2008; Paul and Vogl, 2011). It is worth noting that in another recent study about farmers' perceptions of soil salinity in one coastal district, over 87% of surveyed farmers described shrimp aquaculture or shrimp combined with sedimentation of rivers as the primary cause of increased salinity (Islam et al., 2020). My own ethnographic research confirms that coastal residents largely attribute salinity to the rise of shrimp aquaculture. Arbitrating this question and assessing whether intervention in this cycle is possible is often a normative question of whether the cultivation of shrimp is desirable. The key question animating many of these studies is whether shrimp aquaculture is a positive "adaptation" to salinity and climate change. Ultimately the viability of agriculture is thus determined not by whether it is possible to sufficiently mitigate salinity, but by competing understandings of whether this salinity mitigation is in the interests of coastal producers. The point here is not that soil salinity may not be a serious threat to continued agricultural production in this region; rather, the point is that this threat is shaped by whether continued agricultural production is thought to be desirable in the first place.

Beyond these debates surrounding the drivers of salinity, there are also debates surrounding the implications of existing and projected salinity to the viability of agriculture. A recent disagreement concerning long-term salinization patterns between two groups of modelers offers a clear example of the methodological tensions surrounding the relevance of political economy to the assessment of agricultural viability (Sherin et al., 2020). In the first study, a team led by Susmita Dasgupta, an environmental economist at the World Bank, finds that soil salinization associated with climate change poses an existential threat to agriculture in coastal Bangladesh. Describing the threats of soil salinization to rice agriculture in the region, they write that "this inexorable process will continue as long as the sea continues to rise and salinity increases in coastal rivers. No prospect for near-term relief is apparent, since rising global greenhouse gas emissions continue to propel rapid climate change and melting of the polar ice caps" (Dasgupta et al., 2015, p. 825). In an interview with Dasgupta about this research in a feature story on the World Bank website, she explains that adaptation should involve moving people out of agriculture instead of adaptive responses within agrarian communities. The interviewer writes, "based on this new body of research, Dasgupta warned that more needs to be done. Many working-age adults have already been migrating out of threatened areas, and Dasgupta called for more efforts to provide vocational training and assistance to cope with the process of out-migration" (The World Bank, 2016). The obvious implication of this analysis is that agriculture is not viable and that agrarian disposession is inevitable. However, in a study led by Andrés Payo, a geomorphologist and coastal modeller at the British Geological survey, Payo's team projected significantly smaller soil salinity changes than Dasgupta's team, finding that agriculture will continue to be possible in the coastal region through 2050, the period investigated in both models (Payo et al., 2017). In describing their different approaches, Payo et al. explain that Dasgupta's model "assumes no changes on the land uses," (p. 496) and furthermore is based on simulations of annual median salinity without attention to inter-season variability, which has significant implications to what crops are grown when (and by whom). The implications of the differences in these two modelling approaches with respect to the political economy of agricultural production is significant in terms of policy and development interventions that might be pursued in response. As Dasgupta describes in the World Bank blog, their study indicates the need for support for out-migration from urban communities due to the unviability of agriculture in the coastal zone. Payo's study on the other hand indicates possibilities for continued agricultural production through attention to shifting land use patterns. The choices made by each team of researchers are political in the sense that the latter study questions assumptions about the inevitability of current and future production practices in the coastal region, opening up possibilities for alternatives to the agrarian dispossession projected by the former.

When I asked one agricultural scientist in Dhaka about whether a return to agriculture was possible in areas that had become heavily salinated due to shrimp cultivation, he prevaricated, responding that the answer to the "technical" question of whether it is literally possible is "maybe, but not without difficulty." The real question, he responded is "whether you can manage the power dynamics in that region… The politics of the region undermine this possibility." In this case, the scientist acknowledged directly that the viability of agriculture is less a function of ongoing or anticipated climate or ecological change than it is of the existing agrarian political economy of the region.

5. Alternatives

There are alternatives to this unviability. Some communities in Khulna are working to co-produce viable agricultural futures through the combined construction of social and biophysical orders. This work of co-production has involved social mobilization to disseminate ideas within communities about possible alternatives to shrimp combined with physical labor to facilitate those futures and to advocate for support to do so from the local government and NGOs. Their efforts indicate that the viability of agriculture is not transcendent but is rather shaped by historical and ongoing decisions in the present about cultivation, water management, and related infrastructures.

While shrimp aquaculture has turned much of the agricultural soil in Khulna saline as described above, some communities have mobilized to return to rice agriculture in areas that had earlier transitioned to shrimp. Clarke and colleagues find that up to a certain level of salinity, flushing salt out of soils with monsoon rains is sufficient to sustain salinity concentrations low enough for successful agricultural production, even when crops have been irrigated with slightly saline water (Clarke et al., 2015). This flushing is however contingent on adequate drainage and water management systems that allow the flow of water between fields and rivers, a process impeded by the faulty designs of the polder system as well as the obstruction of drainage by shrimp farmers.

The viability of agricultural livelihoods in this environment is also facilitated by strategies for expanding cropping area and agricultural seasons. Bangladesh has two principal rice growing seasons: *aman* or monsoon season rice harvested in November-December and *boro* or dry season rice harvested in May-June. While the *aman* crop is fed with rainwater, the *boro* crop generally requires irrigation with fresh water. The availability of this irrigation water is sparse in the coastal zone when it is needed during the winter due to increasing pressure on groundwater for irrigation and challenges accessing surface water, as river water is brackish during this season in most of the region. Thus, while *aman* rice is grown throughout much of the region with a high degree of success, the winter *boro* crop faces greater challenges (Lázár et al., 2015). Farmers find it difficult to survive on the profits from growing only a single crop in a year. For this reason, finding ways to grow *boro* rice or other winter crops is important to the viability of agriculture.

Thus, in many parts of the region, farmers have begun to devise or revive strategies for facilitating this dry season agriculture. One major strategy is the construction of canals within the polders which can be used as rainwater catchments during the monsoon and drawn on to irrigate crops later in the year. While these canals were a natural feature of the estuarine landscape prior to the CEP, the polder embankments cut off the flow of water between the rivers and internal canals, causing many of these water bodies to fill with silt and dry up. This sedimentation of the canals was exacerbated by the expansion of shrimp aquaculture, which hindered the regular flow of water through the canals for irrigation (Afroz et al., 2017). The technical designs for the polder infrastructure include many of the original canals; however, the buildup of silt around sluice gates managing the flow of water between rivers and canals has made many of the gates inoperable, compromising the hydraulic functioning of the canals.

Very little research has been conducted on the viability of agriculture through canal excavation, though some agronomists have identified the need for further research on surface water resources for irrigation (Qureshi et al., 2015). At one conference I attended in Dhaka in 2014, a Bangladeshi researcher from the International Water Management Institute presented an unpublished study that found that if properly excavated, these canals could store enough water to irrigate a full *boro* crop in the coastal zone, expanding the production area by as much as 40 percent. The researcher explained that this finding directly challenges common claims that a lack of sufficient fresh water in the dry season has made agriculture unviable in the region. Yet this potential for rainwater storage to expand the availability and use of fresh water during the dry season is obscured in most descriptions of the threats of coastal salinity. For example, development agencies such as The World Bank frequently use maps of salinity frontiers moving upward from the Bay of Bengal to depict the northward expansion of a region in which agriculture is unviable (e.g. Dasgupta, 2015), illustrated by ominous red lines cutting across the coastal zone. However, these maps depict projections contingent on the idea that irrigation water is only available from the rivers, which are brackish in the dry season, and not from canals or other catchment areas. They also illustrate the assumption that agricultural futures are contingent on *boro* rice, a crop which only recently grew in popularity in this region during the green revolution, despite the availability of other possible winter season crops less reliant on irrigation. Salinity frontier maps are thus used as a tool for the co-production of the unviability of agriculture.

In the absence of scientific data or support from development agencies, farmers in the coastal region have themselves identified canal excavation as a promising strategy for ensuring the viability of agriculture in their communities. During my fieldwork, I heard clear and persistent demands from coastal farmers throughout the region for such excavation. This excavation is possible either through the use of heavy machinery or more commonly by hiring laborers to carry out the work using small hand-held spades. In Polder 22, where farmers have historically resisted the shift toward shrimp aquaculture, a canal that cuts diagonally across the island demonstrates this viability. At the north end of the island, where the canal remains free of sediment, farmers produce for two or three seasons per year, including *aman* rice as well as a large crop of watermelon in the winter which is irrigated from the canal. At the southern end of the island where the canal has silted up and is therefore not presently able to store fresh water, most landholders are only able to farm the single *aman* crop, as the surrounding rivers are too saline during the winter months for irrigation, and farmers are otherwise unable to access fresh water to feed their crops. At this southern end of Polder 22, landless laborers are forced to migrate out of the area during the rest of the year to find work (Paprocki and Cons, 2014). Indeed, contained within this single island we find evidence that the viability of agriculture is contingent on decisions made in the present about the management of water and related infrastructures.

A variety of factors constrain the rehabilitation of these canals besides the polder infrastructure that has cut them off from the rivers. While many development agencies have replaced the functions of the state in managing water infrastructure and associated user groups in the region, a preference among these agencies for building new infrastructure or for market-based interventions as opposed to routine maintenance of existing infrastructure impedes possibilities for dredging work (Adnan, 2009), despite widespread demand among farmers. Moreover, the collective management of water resources at the local level has been obstructed by elite capture of water infrastructures, most commonly to facilitate shrimp aquaculture (Afroz et al., 2016; Paprocki, 2021). In this sense, the viability of agriculture is less contingent on the existing salinity of soils or the availability of fresh water at various times of the year than it is on the political economy of water management at multiple scales that governs access to water resources.

6. Conclusion

In coastal Bangladesh, the viability of agriculture is dialectically shaped by the political economy of development at multiple scales, the science of ecological change in the region, and popular imaginations of desirable climate futures. These knowledge regimes governing adaptation to climate and ecological change shape the politics of possibility for lives and livelihoods in the region and can limit understandings of alternative pathways and possibilities. Demands from local communities that resist contemporary political economies of development, such as for a return to agriculture where development agencies had abandoned it or maintenance of existing infrastructures that make this a possibility, suggest not only new ways of understanding what is possible but also new ways of understanding the science of viability.

While this critical political ecology of viability indicates the continued possibilities of agriculture and agrarian livelihoods in Bangladesh's coastal region, we also know that in the future climate change will impact this coastal region in ways that we do not yet understand, and these changes may pose new threats to this viability. To understand these threats and possibilities for the future, we need scientific research that is self-reflexive about its own politics and which examines these landscapes while centering both the political economic and material conditions shaping environmental change. Our knowledge regimes shape our landscapes as well as the politics of possibility for living within them. Embracing this knowledge that alternative economies and alternative ecologies are linked may offer new possibilities for shaping alternative futures for Bangladesh's coastal region.

However, even as more integrative scientific models may offer new insights into the dynamics of ecological change in the region, greater interdisciplinarity is not enough to address the concerns I have outlined here. In this paper, I have identified powerful narratives backed by dominant research, often supported by foreign donors and aid agencies, that conclude that large numbers of people should be displaced from their homes. These narratives often conflate local ecological dynamics with global change while also ignoring a range of political economic factors. What is most important in understanding how these narratives come to have power in the world is the political economy of knowledge production itself. Challenging this political economy would mean not only methodological shifts, but more substantively transferring power over knowledge production to local communities. The perspectives and priorities of people whose lives are defined as "unviable" should be prioritized in how the complex dynamics of social and environmental change are interpreted. It is critical not only to search for ways to make these priorities intelligible, but also to empower them in decisions about the lives and livelihoods that are viable now and in the future.

CRediT authorship contribution statement

Kasia Paprocki: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

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

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