

# A Clear Past and A Murky Future: Life in the Anthropocene on the Pampana River, Sierra Leone

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**Abstract:** The impacts of human activities on ecosystems are significantly increasing the rate of environmental change in the earth system, reshaping the global landscape. The rapid rate of environmental change is disrupting the ability of millions of people around the globe to live their everyday lives and maintain their human niche. Evidence suggests that we have entered (or created) a new epoch, the Anthropocene, which is defined as the period in which humans and human activities are the primary drivers of planetary change. The Anthropocene denotes a global shift, but it is the collective of local processes. This is our frame for investigating local accounts of human-caused disruptive environmental change in the Pampana River in Tonkolili District, Northern Province, Sierra Leone. Since the end of the Sierra Leonean civil war in 2002, the country has experienced a rapid increase in extractive industries, namely mining. We explored the effects of this development by working with communities along the Pampana River in Tonkolili, with a specific focus given to engaging local fishermen through ethnographic interviews (N = 21 fishermen and 33 non-fishermen), focus group discussions (N = 21 fishermen), and participant observation. We deployed theoretical and methodological frameworks from human niche construction theory, complex adaptive systems, and ethnography to track disruptive environmental change in and on the Pampana from upstream activities and the concomitant shifts in the local human niche. We highlight the value of integrating ethnographic methods with human evolutionary theory, produce important insights about local human coping processes with disruptive environmental change, and help to further account for and understand the ongoing global process of human modification of the earth system in the Anthropocene.

**Keywords:** niche construction; mining; environmental change; perceptions; land use; Sierra Leone; Anthropocene

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## 1. Introduction

The impacts of human activities on ecosystems are significantly increasing the rate of environmental change in the earth system, reshaping the global landscape [1–4]. The rapid rate of environmental change is disrupting the ability of millions of people around the globe to live their everyday lives and maintain their human niche—the ecological and cultural contexts humans live in and construct [5–7]. People already living in impoverished conditions are the most exposed and vulnerable to human-caused environmental disruptions [8,9]. Exemplifying this pattern, the riparian communities in Tonkolili District, Sierra Leone are recovering from a bloody 11-year civil war, and a deadly Ebola outbreak that killed 4000 people. Intersecting with and upending this process are the daily effects of living downstream of mining operations that are believed to be actively poisoning

their river. Collectively, each disruptive ecological change experienced by communities causes an effect that is greater than the sum of each individual disruption [10–14].

Environmental change and resultant disruptions in ecosystem functioning have always been a part of human development and adaptation [15,16]. Ecosystems are complex adaptive systems that are in a constant state of change and restructuring—a property termed dynamism [12,13,17,18]. However, due to human activities, the rate and primary source of change now differs in intensity and scale than it did even in the recent past [2,6,19–21]. Accumulated research suggests that we have entered (or created) a new epoch, the Anthropocene, which is defined as the period in which humans and human activities are the primary drivers of planetary change [3,22–26]. The Anthropocene denotes a global shift, but it is the collective of local processes. This is our frame for investigating local accounts of human-caused disruptive environmental change in Tonkolili District, Northern Province, Sierra Leone.

A major impediment to tracking human-caused disruptive environmental change is the lack of local or microscale data [1,27]. This issue is exacerbated in infrastructurally developing countries [28,29]: Sierra Leone is one of these countries. To understand local ecosystem changes and disruptions, then, we must rely on living memory and perceptions of the past from people who have lived it to develop an account of the shifting local ecological and cultural inheritances, i.e. the ongoing process of human niche construction [30–33]. By exploring perceptions of changes in the Pampana River due to upstream mining and their effects on the everyday life and the landscape of riparian communities in Tonkolili, we see how multiple lines of evidence can be drawn together to understand how people are responding to a specific form of environmental change and how this shapes their expectations and perceptions of the future.

The question being explored here is not what pollutants are disrupting the local ecosystem or the extent of their contamination in the landscape measured in parts per million. Rather, we investigate people's perceptions of change in the Pampana River and how these changes are affecting local human niche construction processes and practice primarily through the lens of village fishermen. Although knowing the quantity and extent of pollutants pervading this ecosystem is important, this knowledge is not currently available to the fishermen and other villagers; thus, such measurements, while important, are not the sole way of knowing an ecosystem and understanding how people are co-constructing it through interactive human–natural processes.

What changes have villagers along the Pampana experienced in the local ecosystem? How have villagers—particularly fishermen—actively pushed against or responded to these changes? Additionally, looking forward, what is their expectation of future change? To address these questions and answer the call put out by Fuentes [34] to pursue meaningful and useful integrations of human niche construction theory (HNCT) and ethnographic methods, this assessment relies on ethnographic data—including semi-structured interviews, focus group discussions, and participant observation notes—collected in 2017 working with villagers along the Pampana River. The goal was to deploy theoretical and methodological frameworks from HNCT, complex adaptive systems, and ethnography to track disruptive environmental change in and on the Pampana from upstream activities and the concomitant shifts in the local human niche.

### 1.1. Context

Sierra Leone is a post-conflict country rebuilding from a disastrous civil war that ended in 2002 [35–37]. In the process of rebuilding, it was again thrown into turmoil by the 2014 Ebola outbreak [38]. Entangled with these events has been Sierra Leone's struggle with mining that many people in the country believe has been more of a curse than a blessing [39–41]. The mining industry in Sierra Leone—which primarily includes gold, diamond, and iron ore mining—is fraught with human rights abuses ranging from hazardous working conditions to physical violence against workers [42,43].

The Sierra Leone Environmental Protection Agency has regulations intended to restrict the polluting effects of mining and other extractive industry [44]; however, they are often incapable or unwilling to enforce those regulations, leading to unsafe drinking water, rapid rates of erosion, and a range of other environmental impacts [45,46]. The effects of mining and changes in intensity of land

use are exacerbating the already impoverished conditions of rural populations [43,45,47]. For example, only 26% of rural dwellers have access to improved, such as a borehole or a well as opposed to a natural unprotected surface water body, water resources [48], which are now also threatened by degradation and the portending effects of climate change [49]. In all of Sierra Leone, only 49% of the population has access to improved water resources (AMCOW 2011). Climate-driven disasters that degrade water resources, such as flashfloods that wash trash and human waste into surface water resources, are projected to increase [1,50,51]. The United Nations Human Development Report ranks Sierra Leone 179th of 188 countries in the Human Development Index, which includes assessments of health outcomes, poverty, human security, gender inequality, educational achievements, and other important development variables [52]. The ND-GAIN Vulnerability Index ranks Sierra Leone 149th out of 181, first being the least vulnerable and 181st the most vulnerable, countries based on vulnerability to climatic change and readiness to respond to climate-driven events [53]. While these measures alone cannot tell the story of a nation of diverse peoples, they clearly indicate the relative vulnerability of Sierra Leoneans relative to most other countries in the world [45].

In Tonkolili District, river fish have historically been a primary source of protein and other essential nutrients [54]. If fish stocks are decreasing as a function of degradation of the river, which riparian villagers believe is the case, then food insecurity may drastically increase. Food insecurity is already a pervasive issue in Tonkolili District, where more than 40% of children under the age of 5 are stunted due to malnutrition [54]. Persistent reductions in fish stocks will significantly exacerbate this tragedy.

Sierra Leone's geographic location along the West African coast and just north of the equator between 7- and 10-degrees N latitude results in it having a semi-tropical ecosystem with a mix of lowland grass plains, rainforests, forest-savannah mix, and coastal and riverine wetlands (World Bank 2016). The average temperature is 78.8 degrees Fahrenheit. Sierra Leone has two major seasons: The wet season, which is from mid-May to November; and the dry season from December to mid-May. During the wet season, areas of Sierra Leone see upwards of 3200mm of rain, resulting in widespread flood events and erosion, and more recently increased rates of landslides in areas denuded of trees (IAid 2015). The stark differences in the wet and dry seasons significantly affect the Pampana River watershed. Dry season conditions facilitate mining along the river by reducing water flow and increasing access to alluvial soils, as well as increased mobility of equipment and personnel. The wet season and its high volume of rainfall results in significantly increased flow in the river. The significant difference between seasons shapes people's perceptions of the river and is a key influencer of the local human niche.

The Pampana River flows approximately 150 km from Lake Sonfon in the northeastern corner of Northern Province near Kabala to the southeastern corner of Northern Province, where it converges with and becomes the Jong River. The Jong River flows another 100 km to its delta in the Atlantic Ocean. The communities included in this study are located approximately 7 km north of the Pampana–Jong confluence.

### 1.2. Theoretical Framing

Niche construction theory was developed within ecology as a framework for understanding how organisms adapt to and actively change their environment, co-evolving over space and time [55]. The co-evolutionary process of niche construction is argued to have greater explanatory power of species evolution than the standard evolutionary synthesis, which focuses on natural selection as the sole driver of evolution, and is included as part of the extended evolutionary synthesis [56]. This process of interactive co-evolution holds particularly strong for humans due to our immense creativity and capacity for adapting our environment as we respond to the ecological contexts and processes we engage with at local to global scales [6,23,57]. HNCT specifically, then, is the process by which humans proactively modify and reactively respond to the selection pressures we face in everyday life [6,23,30].

Through the process of niche construction, genetic, cultural, ecological, and material inheritances are developed and transmitted over time, and are always in a state of dynamism [19,33].

Dynamism is one of the characteristics that make ecosystems complex adaptive systems [12,58]. Other properties of complex adaptive systems that ecosystems have are non-linearity—meaning a change in one aspect of the system may result in significantly larger or smaller changes in other aspects of the system rather than a one-to-one ratio; self-organization—meaning parts of the system can form organic, complex relationships with varying flows between them; and holism—meaning that the totality of the system is greater than the sum of the individual parts because of the relationships established between the different parts [13,14,18].

To explain these terms in the context of our study area, Figure 1 is a heuristic model of the complex adaptive system—the human niche—for communities along the Pampana River. Upfront we acknowledge that any heuristic diagram such as this is innately reductive and static. That is, it does not display all of the many and complex relationships and constituent components of the local human niche, and it does not depict the dynamism of the local human niche. With that said, the model does help to conceptualize the complexity of the relationships between different components of the human–river co-development and shifting over time.



**Figure 1.** Heuristic model of the local complex adaptive system—the human niche—of communities living along the Pampana River, Sierra Leone.

Environmental quality data that tracks the extent of elemental change in the ecosystem of people living along the Pampana does not exist. However, by engaging residents of riparian communities in conversation and participating in everyday life activities, we can piece together an understanding of the dynamism, interconnections, and feedback intensities of the local human niche [34], i.e., an account of ecological and cultural change as it has been experienced and perceived by people in an active relationship with the Pampana.

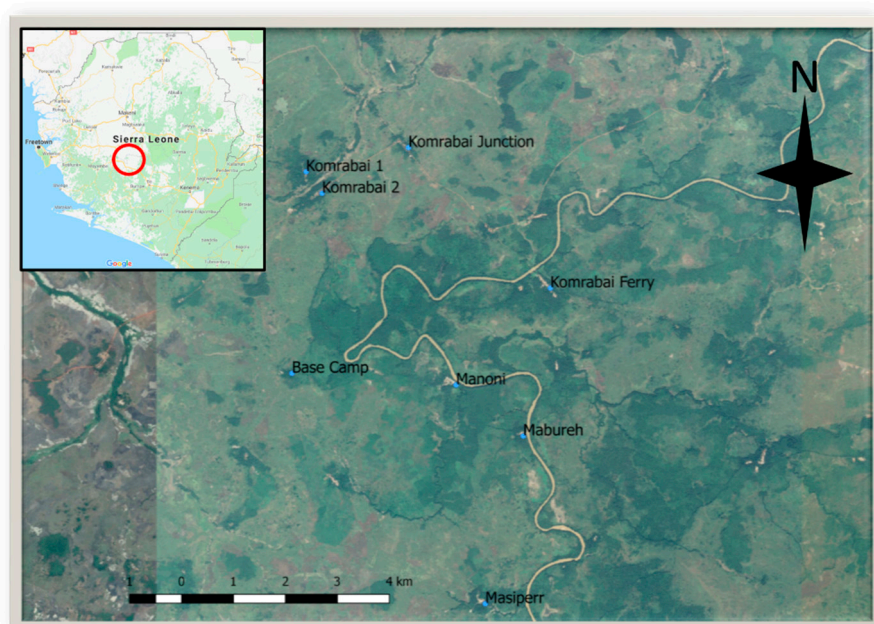
Ethnographic work, paired with a thorough understanding of the local ecological contexts, can in tandem integrate the complexity of everyday life with evolutionary frameworks, such as HNCT, to better understand both the proximate and potential ultimate outcomes of human-caused disruptive environmental change [6,19,23,34]. We draw on this strength by using multiple lines of evidence including participant observation, interviews conducted by one of the co-authors (RAM), and focus group discussions to understand how the Pampana has changed, how this has affected the human niche of communities that live along the Pampana, and what this may signal about broader trends in human engagement with disruptive environmental change. It is because of the potential evolutionary impacts of disruptive environmental change that we must employ an HNCT framework, accounting for the proximate, and estimating the long-term effects of these changes where other anthropological frameworks often stop short (in an evolutionary or *longue durée* sense). This is especially necessary as we look to connect this local process to the ongoing global process of disruptive environmental change and the potential changes they have on bodies, behaviors, and ecologies across time.

## 2. Materials and Methods

The interviews, focus group discussions, and participant observation data are the result of a two-month period spent in Tonkolili in the wet season (May–July) of 2017 at the start of an ongoing multi-year project being conducted in partnership with the Conservation Society of Sierra Leone, a Sierra Leonean Non-Governmental Organization that focuses on social–environmental interactions and sustainability. Other data collection methods were employed as part of the multi-year project but are not included here, such as fish, water, and soil samples collected ( $N = 70$  each) for lab analysis to measure the silt and heavy metal toxin concentrations present. To date, as part of the multi-year project, fish, water, and soil samples ( $N = \sim 200$  each) as well as further ethnographic work has been conducted in Tonkolili and at the top of the Pampana River watershed at Lake Sonfon. While that data is not utilized here, it significantly informs our understanding of the area and people, as well as the ecological context of the Pampana. This data is intentionally excluded because it is information not available to, or part of the perceptions of, the people we engaged with. Conversations with people in Tonkolili suggest that in place of a measure of total suspended solids in the river (for example), people here think of the change in referential terms with past perceptions of the river clarity and silt content developed through their everyday interactions with the water. Since it is their standpoint and experience that are the primary focus, we limited our description and measurements to the same metrics and concepts that they employ while navigating their niche. Each of the ethnographic modes of inquiry were employed in six different communities along the Pampana River, with population sizes ranging from approximately 85 people to 350 people who are permanent residents and many more people that come and go from surrounding and more distant urban areas (see Figure 2). In total, 71 people were engaged in direct face-to-face interviews that lasted between 45 min and 2.5 hours long, and many more through participant observation and the everyday encounters that occur when you live in or between villages, such as talking with people as you walk past each other on the trails linking villages or when fetching water to bathe with from the village well. Almost all the engagements were conducted in Temne, the primary language used by people locally, and were facilitated by a research partner, Papanie, a native Temne and English speaker. Hand-written notes were taken during each interview to record questions and responses, and then a discussion was held between the interviewer (RAM) and Papanie to review what was said and parse out the contexts of the conversation. Each night, the interview notes and other observations from the day, as well as a running journal, were typed and the previous days' notes and interviews reviewed.

Individual unstructured, but guided, interviews (see below) were conducted with fishermen in Mabureh and Manoni villages ( $N = 17$ ) and focus group discussions with fishermen in Manoni and Maseri villages ( $N = 21$  total fishermen). These totals reflect the fact that all adult fishermen in Manoni and Mabureh participated in individual interviews, and all adult fishermen in Manoni and Maseri participated in the focus group discussions, thus capturing the whole fishermen population in each village. All interviews with fishermen took place either before or after a day of fishing with them in

their village, helping to fully situate their responses in shared experience and understanding. Other activities undertaken together with fishermen included net mending, fish sorting and cleaning, canoe maintenance, hook-and-line rigging, and trying out rod-and-reel fishing for the first time (brought by RAM to fish with). The interviews started with basic demographic questions and then turned to their profession—how they learned it and why, changes in it and the implements used for it, etc.—and the ecological contexts within which they employ their profession, i.e. the river. On average, the fishermen had been fishing on the Pampana for 22 years, with a range of 12 to 43 years. For each fisherman, fishing was their primary source of livelihood or income, and all sold their fish either in their village, neighboring villages, or at the Komrabai Ferry market (see Figure 2). Some fishermen said that they also farm a small plot in addition to fishing, and others noted they had recently begun this practice in response to ongoing challenges with fishing. Fishing is a male-gendered profession in local contexts; however, women are the primary cooks of fish and purchasers of it at market. Therefore, women have essential insights into changes in fishing despite not practicing fishing, and the Pampana and the local ecosystem more broadly.



**Figure 2.** Map of the partnered villages and the Pampana River [59]. The center grid of the map is UTM 28 P 821792 E 940423 N.

For the non-fishermen interviewed ( $N = 33$ ), all were a convenience sample—most often initiating an interview after we had undertaken some activity, such as cooking or gardening, together—with a roughly evenly stratified distribution of interviews across the six partner villages ( $\sim N = 5$  per village). About two-thirds of these interviews were conducted with women ( $N = 21$  of 33). The age range of respondents was 18 to 63. While the interviews conducted were unstructured, each person was asked a very similar flow of questions, beginning with basic demographic information—name, age, how long they had lived in their village, etc.—and then moved towards questions about their livelihood production, perceived changes in the ecology of the area, what types of challenges they face and ways they respond to these challenges, and other similar questions. The question flow was determined based upon answers the respondent provided and what follow up or transition question was most appropriate given the context. On average, individual interviews lasted about an hour and the focus group discussions lasted about 2 h each. The focus group discussions followed similar lines of questioning as the individual interviews upfront, but the majority of the questions and resultant discussion were specific to fishing on the Pampana. The discussions took place in an open-air communal structure—called a Palava hut—which each village has for meetings and other community activities. Questions were posed to the group, often first being responded to by the more

senior fishermen, and then we intentionally called on all other individuals to respond as well to facilitate full participation and to inspire group dialogue and consensus negotiation, which did occur more often than not during this process.

Augmenting the interviews and focus group discussions, one of us (RAM) spent each day in the area participating in everyday life activities: Cooking and doing laundry with women in the village; fishing with fishermen, employing each of the different methods of fishing to understand the complexities and challenges of each; fetching water and swimming with children in the river; and visiting the local market at Komrabai Ferry Junction to purchase goods. Detailed written notes were made throughout this process to document the different experiences and to look for any differences encountered while conducting these activities in each of the partnered villages. Visual data of these experiences were also collected using photographic and video recording devices, after verbal consent was received from each person included in the images, to best capture the aesthetics of the area that were often described by respondents, such as the yellowish-brown hue of the river.

All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol (#17-03-3691) was approved by the Ethics Committee of the University of Notre Dame.

### 3. Results and Discussion

#### 3.1. Fishing in Turbulent Waters

The initial expectation in asking people in Tonkolili about how their local ecosystem has changed over time was that all the responses would be about land-use change and the shift in the local fallow period intervals. For many reasons, such as population increase and the effects of climate change on local precipitation patterns, the fallow period for farmland—when land is allowed to rest in between cycles of growing field crops—has decreased in recent years, straining subsistence farming practices and destabilizing food security. However, it quickly became apparent that the most salient change people perceived and were concerned with was the change in the river.

Homing in on one section of our heuristic model, as shown in Figure 1, above, we can start to understand the interconnection of that part with others, outlining its place and roles in the larger system and local contexts. Drastic changes have been observed in the Pampana. The range of impacts felt, perceived, and known by the fishermen we engaged are revealed, as well as their surrounding contexts, providing critical insights into local human niche construction processes, suspected causes, and realized consequences.

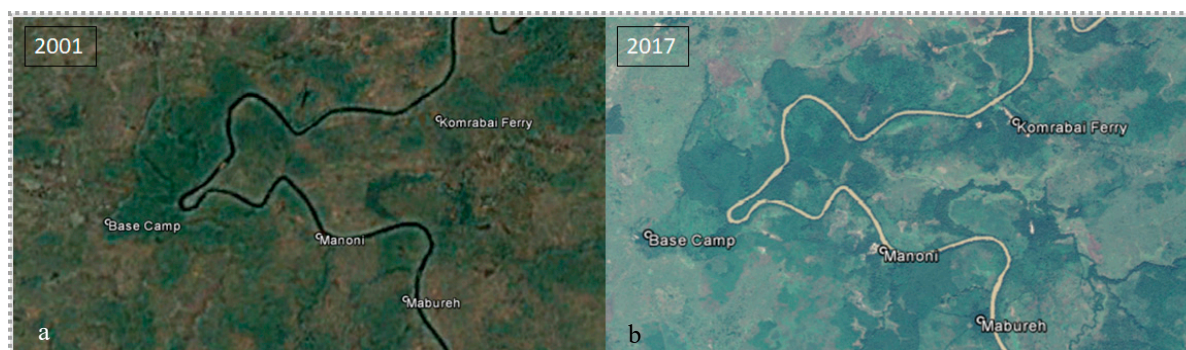
The drastic changes in the river perceived by people in the last decade and a half significantly exceed patterns of fluctuation that are considered normal or recurring. As fisherman Mahmad Khan put it,

*“The river used to be clear. You could see the bottom, rocks, fish and all. Now the river has turned sour. The water is yellowish and brown, you can’t have any idea what is in the water at any spot.”*

The Pampana is now so turbid that when you put your arm into the water, you cannot see your hand.

The yellowish and brown hue of the river is due to high levels of silt being entrained in the water way from increased upstream erosion due to human activities, namely gold mining upriver at Lake Son at the top of the river, as noted by most interviewees though none had ever been there to see it firsthand. Figure 3 shows satellite imagery of the Pampana along the villages in January of 2001 and 2017 [59]. As silt particles move into the river, it can have systemic effects on the aquatic ecosystem [60]. Increased levels of entrained silt decrease fish populations by restricting reproduction, inhibiting feeding for fish that are visual predators, clogging the gills of fish and stunting their growth, and causing other harm [61].





**Figure 3.** Satellite imagery corroborates the change noted by community members. Both images were recorded in January of their respective year. Other imagery collected at the same times but through different sources show the same change in hue despite using different remote sense systems, demonstrating the visible change is not a result of differences in the collection method or mechanism [59]. (a): Imagery taken in 2001 (b): Imagery taken in 2017

Almost unanimously, people recalled the time marker for when the river changed from clear and blue to opaque and yellowish-brown as the end of the tumultuous Sierra Leonean civil war. For the people of Tonkolili, the war was a massive upheaval as the Revolutionary United Front, the main antagonist to the national government during the war, maintained their stronghold in the eastern part of the country near them [41,62]. As the war came to a close, aid organizations and foreign investment began pouring into the country [36,37]. Much of the private foreign investment was dedicated to mineral extraction operations [63]. At this point, foreign mining operations expanded significantly [39,63,64]. The expansion of extraction operations included the Pampana River watershed, with several new gold mining operations established near Lake Sonfon, the headwaters of the Pampana River [65]. Our model captures the cascade effect in the local human niche after the war ended as human activity at the top of the watershed, namely mining, rapidly increased. As we follow the trajectory from this inflection point, we can see that it threads together multiple interactive effects in the local human niche, from ecological outcomes, such as dirtied and warmer water, to cultural outcomes, such as changing choices in livelihood production methods.

As mining increased the tax revenue of the national government and the wealth of a handful of Sierra Leonean elite [45], it led to troubled waters for fishermen on the Pampana:

*“The end of the war was supposed to bring peace and stability. We moved back to our home and I began fishing again. In a few years, peace and stability left us, as did the fish, as the river became nasty and dirty.”* - Fisherman Hassan Kama

The change in the river did not occur all at once but rather has been slowly building over time, insidiously creeping into many different facets of life. People noticed the initial changes most significantly at the beginning of the wet season and in the peak of the dry season. The beginning of the wet season, which brings about 3200mm of rain on average [66], flushes loose or exposes sediment and other particulates, along with whatever else it contains, into the Pampana in a process referred to as hysteresis [67]. In the peak dry season, when the water level is at its lowest, suspended solids in the water become more concentrated so that the river “becomes like a hot soup of dirt and muck,” as the fisherman Mr. Kamara put it. The effects of these processes have become more pronounced as they have accumulated over time, and the Pampana has become more turbid year-round.

*“The river has become worse and worse, so that now you cannot see fish swimming—either because they are not there or because there are so few now or because the water is simply too filthy. In the beginning, the dirtiness came and went for several years. But now, it stays and just goes from bad to worse.”* - Fishermen Omar Karoma

The increased turbidity in the Pampana and concomitant decreased presence of fish is demonstrative of the cumulative effect of upstream operations on the river. People’s recollections of disruptive change in the river describe a gradual process. The perceived change matches what we might expect from changes in land use for mining along a river [64]. Human activities upstream of the Pampana communities engaged in this study have shifted the local human niche, degrading the



ecological contexts and inheritances with concomitant shifts in local cultural practices and inheritances. The fishermen have experienced significant difficulties because of the lack of fish to catch, increasing food insecurity as a selective pressure, and driving the fishermen to consider seeking alternative livelihoods, i.e., shifting cultural contexts and thus inheritance.

However, while our model demonstrates the cascade effects in the local human niche of people along the Pampana, it is part of a larger ecosystem and is directly impacted by trends in the larger system and changes in adjacent systems, with the boundaries between them all really only serving an analytical function rather than being a real separation [14].

### 3.2. *Living Change: Being Infringed upon while Living on the Fringe*

The accumulation of change in the Pampana has led to a composite of ecological and cultural processes and inheritance disruptions. Livelihood production, especially in subsistence communities, directly affects social stature and perceived quality by members of the community [68]. Many sociocultural roles in the village are tied to the Pampana, ranging from fishing to clothes laundering, so any disturbances in the river reverberate throughout the community and affect people's ability to perform their expected role or function. The effects of ecological changes that make fishing harder, then, directly affect fishermen's abilities to perform their expected social role. Homing in again on another section of the heuristic model, as shown in Figure 1, above, we can connect the changes in the river to a range of social or cultural outcomes in the system, demonstrating shifts in the local human niche.

Fishermen on the Pampana use a range of methods to catch fish. Baskets woven from dried tree bark are placed in streams to capture fish as they move downstream. Trotlines, a rope with multiple strings with hooks and bait hanging from it, can be run across the river, bisecting the Pampana. Handlines, fishing line wrapped around a stick or a bottle with a hook and a lead weight on one end that is slung out into the water, are also used with some success. However, the primary fishing method is cast net fishing. A cast net is a circle of woven monofilament or nylon with lead weights evenly spaced along its circumference and a drawstring that connects to strings running along the inside of the net that attach to the spaces on the circumference of the net between the lead weights (see Figure 4).



**Figure 4.** A fisherman throwing his cast net while his apprentice steers the canoe.

To use a cast net, the fisherman stands at the end of his canoe, visually scanning for fish, either through the water or by looking for swells on the surface from the tail or head of a fish breaking the surface of the river, while giving instructions to his apprentice to best position them to toss their net

at a located fish and, if successful, haul it into the boat. Unfortunately, this craft is being quickly degraded by changes outside of the control of the fishermen, by their changing ecological inheritance.

The increased turbidity in the Pampana makes visually scanning for and targeting fish very difficult: *“How can you throw your net at what you can’t see?”* asks fisherman Sulei Mansuri. Many fishermen spoke of standing at the end of the canoe and looking over and into the river and hardly being able to see below the surface. The increased turbidity has forced fishermen increasingly to rely on hook-and-line fishing and trot lines. However, these modes of fishing are more difficult: You catch less, you lose more gear as hooks break off the line frequently or get lost to hazards in the river, and you have to dig for bait if using worms or catch small bait fish to start the day, increasing the labor cost of fishing, i.e., culturally inherited fishing practices must be adapted to the changing ecological contexts.

The turbidity in the river also affects cast net fishing in another way. When throwing the net in clear water you can see what you are casting over and avoid hazards, such as downed trees or large rocks in the river. It is now much more difficult to spot these hazards, increasing the rates of snags and lost gear. If a fisherman gets his net hung on a tree, for example, he or his apprentice must dive into the water and manually untangle it (Figure 5). These hazards often cause damage to the nets requiring additional time, effort, and money to repair. Catching an unseen hazard significantly compounds the strain of turbidity on fishing as a livelihood, potentially increasing the labor cost of fishing and forcing the fishermen to adapt their fishing techniques to the new ecological contexts that they have inherited.



**Figure 5.** A fisherman and his apprentice work to free their cast net from a tree hidden under the surface of the murky river.

Submerging yourself in the Pampana, especially in the dry season, brings its own host of issues to fishermen:

*“When you get out of the water the silt covers your body. The sun dries the water but the silt stains your body with a powdery dust. It gets in your eyes and your mouth, you feel grit between your teeth and in your nose.”* - Fisherman Mohammad Sesai

Just the experience of being in the river causes discomfort. Yet, it is from the river that these communities obtain their drinking water, bathe, launder their clothes, and so many other everyday activities. The fishermen drink from it directly while fishing. The turbidity of the river affects each of these other practices, dirtying them, making them more difficult, and requiring corresponding changes in everyday life practices, such as letting the silt settle in the water bucket before drinking from it: The average settling time reported by interviewees was 45 min. All these seemingly minor



responses have a cumulative impact on the time and effort needed to produce a livelihood, increasing the pressures people face to survive and decreasing their ability to maintain their niche.

The increased turbidity in the river has taken its toll on the fish population. Fishermen frequently talked about how when they used to throw their nets they would only do so at schools of fish: “You never wasted a throw on a single fish when there were many to be had in a group”. It used to be common to catch three to four dozen fish on a day’s outing, starting at sunrise and ending around midday to get the fish to shore in time to be sold. However, now, it is uncertain whether you will come back with just one or two fish or, in those rare instances where you are lucky enough to blindly hit a school, two dozen.

Decreased fish populations significantly reduce the stability of fishing as livelihood, a keystone of the local human niche. Before the Pampana turned sour, only a handful of fishermen also farmed, and even that was only on small plots. Now, however, more than three-quarters of the fishermen said that they also farm because it ensures that they have something to eat and provides more stability. That many fishermen have had to turn to farming demonstrates the growing instability of fishing as a viable livelihood and fish as a secure source of protein for nutrition needs. Fishermen are straining to adapt in response to ecological pressures on the river caused by the practices of upstream users.

Decreased fish populations have also strained the ability for non-fishing families to get fish, significantly impacting their protein access. Fish is the primary source of protein for these riparian communities. To replace the loss of river fish, people are either purchasing coastal fish at the Komrabai Ferry market (Figure 6) or consuming bush meat. For coastal fish to be brought the seven-hour trek from the nearest port, they either must be frozen or smoked, both of which are perceived as less tasty and less desirable. Fishermen and other villagers, especially women who are the primary cookers of fish, noted that the lack of river fish not only disrupts access to protein but also local sociocultural norms. For example, soup is part of most evening meals, and fish is the expected ingredient:

*“There is always to be fish; you cannot serve soup without fish.”* - Mrs. Soka, Fish Trader

To not have fish in the soup is seen as a failure by the cook to effectively procure it and therefore a failure of the cook to perform their expected social role.



**Figure 6.** Coastal fish that have been smoked and then transported to the Komrabai Ferry market for sale.

There is also a socio-economic hierarchy of fish. River fish are the most valued because they come from the same land and place where the villagers live, creating an intangible but prized

connection. Coast fish are not valued in this same way but rather are negatively viewed as “strange” or “from outside”, so even though they may fulfill the gap in protein they do not fill the full social role of river fish. In this way, as well as others, the reduction in fish stocks in the Pampana is disrupting the ecological and sociocultural landscape of people living along the Pampana.

All these lines of evidence associated with people’s perception of the current though ever-changing state of the Pampana ecosystem do not act in isolation: They are interactive and often mutually reinforcing. Increased turbidity decreases fish populations and size and makes targeting the few fish left more difficult; turbidity increases the rate of snags on unseen underwater hazards, increasing the total time needed to catch a day’s haul and time spent repairing nets. Again, as with all the other changes in the Pampana, the ecological interacts with the cultural and vice versa, driving the dynamism of the system. Noting the rapidness with which this shift in their niche has come, many fishermen perceive the future to continue down this challenging trajectory, without any reprieve on the horizon.

### 3.3. *Contemplating the Future*

Over the past 15 years, fishermen and other village members have watched their river turn from a source of life to a source of uncertainty and instability. Many people believe that it is due to an aristocratic elite lining their pockets that they have less fish to eat and dirty water to drink:

*“Why would the government or mining companies change their ways? We do not provide them anything with our fish and crops, but gold makes them rich. We cannot make them rich, but they can make us poor and they have.”* -Fisherman Abu Turei

Most fishermen do not expect the Pampana to improve in the future because there is no incentive or reason for those currently degrading it to change their behavior. The perception is that they have no bargaining power or ability to influence the government or the mining companies. While the fishermen could not know for certain that the increased turbidity is solely due to mining, in the focus group discussions and in almost every individual interview, it was stated that the disruptive change was solely due to mining occurring at Lake Sonfon. When the focus groups were asked if anyone had tried any form of activism or to plead their case to the government, the response each time was rhetorical questions referencing power differentials and status:

*“Who listens to rural fishermen and farmers? Aren’t we all just uneducated laborers that give nothing back to the government? Why would a mining company care about my fishing when they can have shiny gold? Who has come here to ask us about these problems? No one.”*—collective responses from focus group discussions

The last remark of these rhetorical questions about power and awareness came up several times: How can the future be different if no one is even asking about the problem? Many people felt that without awareness, without the government or any other person of power knowing about the disruptive change in the Pampana human niche, no movement towards positive change could be seeded and grow. Power differentials inhibit the capacity for self-organization, a critical component of complex adaptive systems. It is in this way that the cultural production of power differentials can be internalized into ecological inheritances, just as different ecological contexts can facilitate the aggregation of power to some groups and not others.

In response to their perception that no reversion of the degradation of the Pampana was yet on the horizon, many fishermen were already farming more than fishing, an alternative livelihood that no fishermen was satisfied with and yet many more planned to start. Fishing is seen as more valuable in the cultural contexts of the villages because it produces the prime source of protein and it used to be more economically productive than farming. Many fishermen noted feeling emasculated by failing to produce fish from the Pampana like they did in the past. Turning to farming was a sign of failure and a blow to their status.

Not all fishermen and villagers held a bleak view of the future, with several saying that *“God will take care of us; it is in his hands”*. Additionally, while all the people we engaged with presented a similar historical account of the ecological change in the Pampana, each expressed a different way in which they thought they would have to adapt their daily life practices in the future: Using well water

to do laundry instead of washing clothes in the river; using cloths to strain river water before drinking it to reduce time spent letting the silt settle in the bucket; and hunting bush meat to meet protein needs in lieu of fish, etc. Each person's individual perceptions of their ecological and cultural contexts, of their human niche, shaped the way they viewed their future and what they expected they would have to do to navigate everyday life in a persistently disrupted human niche.

People along the Pampana may resign their fate into God's hands in some ways, but they are actively reshaping their future—they are constructing their niche. They are invoking their agency in co-evolving with(in) their ecosystem, a pattern that all humans will have to replicate in the Anthropocene, where rapid disruptive ecological change is becoming the norm.

#### 4. Conclusions: Turbulent Water and Living Change Together

By homing in on sections of the complex adaptive system along the Pampana, and working through the lens of people's perceptions of change and concomitant responses, we have outlined the process of co-evolution between ecological and cultural inheritances, i.e., the dynamic and ongoing local human niche construction process. People's perceptions, whether representative and perfectly congruent with measurable change or not, drive what decisions they make, their quality of life, and their sense of self; this has the potential to shape their local ecologies in ways that have substantive effects not just on their present lives but on the biology and ecologies they will pass on to subsequent generations. Perceptions are thus constitutive of and internalized into the local human niche and are transmitted transgenerationally, perpetuating the ongoing dynamic cycle that is the human niche construction process, with the potential for substantive and lasting ecological effects.

In response to the drastic changes in Pampana, local fishermen are changing their fishing practices and livelihood production, in response to the fact that their ability to perform their role has significantly degraded. Through listening to the words and observing the actions of the fishermen and other inhabitants of this region, we documented the changing pattern. It is through local perceptions and experience that we were able to identify actual shifts in local ecological and cultural pressures and the means by which people are responding to, pushing back against, and preparing for these pressures. The fishermen shifting part of their day usually spent on the water fishing to working the land for crop production instead due to decreasing fish populations, actively pushing back against the pressures stemming from silt and other ecological shifts in the river, is a prime example of this process.

All of the local processes we described are situated in and contribute to an ongoing and rapidly increasing process of regional, national, and global ecological change driven by human action. Regionally, ecological changes in the Pampana extend from the top of the watershed in the very northeast of the country to the river delta in the southwest corner, resulting in local human niche shifts occurring all along its banks and reverberating shifts for all people, economies, and everyday life practices tied to it. Nationally, increased rates of foreign investment and resource extraction are greatly shifting the ecological and cultural contexts, the human niche, of much of Sierra Leone, with much of the value of the extracted mineral resources being accrued outside of the country while inside the country lands and waters are becoming permanently altered. Internationally increased rates of toxic and non-toxic pollution emissions are vastly reshaping global ecological and cultural inheritances, constructing the Anthropocene: Much in the Anthropocene emerges from human niche construction processes. Additionally, just like the fishermen and other people living with change along the murky Pampana, populations writ large are, and will continue to have to, respond to, push back against, and prepare for the building pressures of the Anthropocene.

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