How Indigenous Knowledge of Fishing is Failing to Cope with Climate Change in Karachi, Reshaping the Coastal Livelihoods, Traditions, and Community Resilience

[1]Haider Ali, [2]Rahm Dil, [3]Kiran Saeemab

[1]Department of Economics, Gomal University Dera Ismail Khan, Pakistan

[2]Department of Economics, Islamia College Peshawar, Pakistan

[3]Unversity of Sargodha, Sargodha, Punjab, Pakistan

Abstract

The paper examines particularly the impacts of climate change and modernization within the indigenous fishing communities in Ibrahim Hyderi, Rehri Goth and Keti Bandar in Karachi. Using a qualitative ethnographic approach, participant observation, interviews and oral histories, this research unravels disruption in traditional ecological knowledge and fishing calendars due to altered environmental patterns erratic tidal cycles and altered fish migrations. While elders stress the erosion of ancestral practices and inter-generational knowledge loss, fishers are creatively combining indigenous knowledge with modern approaches. Yet, increasing socioeconomic disparities and the institutional exclusion of small scale fisheries, especially women, further exacerbate these vulnerabilities. The findings emphasize the need to integrate indigenous knowledge into inclusive climate adaptation politics, which can support both ecological sustainability and cultural resilience. Recognition of fishing communities as active stewards of their maritime heritage provides a route to equitable and effective coastal governance a midst the climate crisis.

Keywords

Climate Change Adaptation, Coastal Fishing Communities, Indigenous Ecological Knowledge, Cultural Resilience, Socioeconomic Transformation, Karachi, Pakistan

1. Introduction

The Karachi fishing community is an important outpost in which indigenous ecological knowledge meets the environmental challenges of our day. Local fishermen have traditionally had a wide base of indigenous ecological knowledge passed down for generations from coastal villages like Ibrahim hyderi, Rehri Goth, Baba bhit island, and Manora island. This ancient knowledge is the sum of vivid observations regarding tidal rhythms, seasonal fish migrations, wind patterns, and other ecological changes that get passed through generations by oral tradition and life experience. Knowledge of this kind is the real foundation for sustainable harvesting of marine resources and their continued cultural and spiritual ties to the sea-which they do not regard merely as a resource but as an ancestral partner. Various effects of climate change are starting to disrupt this close relationship. The social and economic systems of these fishing communities, as well as ecological systems, are all disturbed by rising sea temperatures, unusual monsoons, coastal erosion, and diminished fish stocks, not to mention floods, saltwater intrusion, and erosion [1].

The communities' preceding dependence on climate systems' reliable and predictable seasonal shifts and patterns makes the currently unpredictable fishing seasons all the more shocking. The social systems of these communities are already vulnerable and marginalized due to poverty, the lack of means to diversify livelihoods, and political disenfranchisement. These are all compounded by the ecological damage occurring the further fishing communities are forced to go. Another layer of transformation that hits Karachi's fishermen is in the form of climate migration. Progressive land submersion and fresh water scarcity due to rising sea levels and anthropological upstream have made places such as Keti Bandar and Creek uninhabitable. A sizeable number of displaced fisher families have migrated towards the periphery of Karachi, namely Rehri Goth and Ibrahim hyderi, in search of refuge and a means to continue their traditional livelihood. Extra stress is imposed by this influx upon the receiving area, already strained for its very limited infrastructure and freshwater resources as well as fish stock, thereby fuelling socioeconomic tensions [2].

Despite these challenges, Karachi's fishing communities show remarkable resilience based on adaptive practices drawing from their indigenous knowledge systems. These range from practical adaptations-which include changes in calendars, the modification of boat design to withstand rougher seas, shifting fishing grounds, and the forming of cooperative networks for the sharing of resources and knowledge-to name a few. There are growing concerns about the erosion of traditional knowledge, particularly among youth. The introduction of modern fishing technologies—GPS, sonar systems, and mechanized boats—enhances operational efficiency, but one consequence of this technological change has been the decline of the ecological wisdom that gets passed on through lived experience and sensory

interactions with the environment. Many elder's express grief and resentment, observing that "the sea no longer speaks to the youth." They mourn a loss of spirituality, culture, and guidance towards the sea, all of which formerly instilled a sense of connection and sustainability. At the societal and institutional culture, the Indigenous knowledge systems of climate adaptation, fishing, and resource management are still largely ignored and undervalued, despite Government policies [3].

Though essential, climate policies also tend to overlook this knowledge, which indicates exclusion from decision-making and resource allocation to small-scale fisher folk. This exclusion is much more than a simple oversight; it reduces Indigenous knowledge to a static relic while, in reality, it is a system that is dynamic, evolving and capable of complementing the scientific system, and improving the sustainability and equity of coastal governance. The socio-economic impacts of the shifting of these climates are significant, yet they remain largely invisible.

The social cohesion and respect for nature that were historically fostered by communal rituals- festivals, oral traditions, and songs- are diminishing. Urban education's socio-economic expectations, coupled with development, and migration trends, are destructive factors. Loss of dialects and storytelling traditions carry away socio-ecological wisdom. Thus, cultural fragmentation threatens not only the identity of the fisher folk of Karachi, but also the collective action needed to tackle numerous ecological challenges. Understanding and analysing these transformations is essential to comprehend the coping strategies of marginal fishing communities amid declining environmental and socio-economic conditions. Traditional knowledge embodies the environmental wisdom of patience and respect for limits, and the ecology of attention to subtle signs, and other qualities that are missing in the big picture, top- down climate narratives and are needed for local adaptation. It is not static knowledge but continuous innovation shaped by empirical observation and communal learning. It can provide valuable insights into resilient fisheries management and climate policies [4].

The present research paper, therefore, tries to explore indigenous knowledge about climate variability and change in the fishing communities of Karachi. Semi-structured interviews and observations have been conducted in order to capture the perception of the fishermen regarding environmental change, the dynamic nature of traditional knowledge, and shifting social relationships. Such a context underlines how such communities may form a contribution to local adaptation strategies yet will suffer at the hands of urban growth, policy neglect, and cultural erosion. To this effect, the paper calls upon the incorporation of indigenous knowledge within discourses of climate change through a necessary coming together of ecological science with social equity. It claims recognition for the experience and respective values of the fishermen for the betterment of coastal governance while furthering sustainability and social justice. Such a condition may play an important role in community resilience and protection of the cultural and ecological heritage for the fishing communities of Karachi within the climate crisis. Such a condition also emphasizes having and valuing indigenous ecological knowledge to support resource sustainability and cultural identity. Detailed analysis of indigenous knowledge systems: In fact, indigenous ecological knowledge among the fishing communities in Karachi represents generation-spanning and complex knowledge about marine ecosystems, far beyond the simple ways of fishing. Such a complex system comprises highly specific meteorological observations whereby, by observing cloud formations, wind patterns, and even the behaviour of birds and marine life, fishermen are able to predict changes in the weather [5].

The traditional fishing calendar, called Panchh Baras, contains detailed knowledge of seasonal variations, tidal patterns, and routes of fish migration, which was refined over the centuries. They learn about particular fishing grounds from the color and temperature of the water, the presence of certain bird species, and the movement of currents. Similarly, different winds have specific names such as Baad-e-Sarhad for western winds and Baad-e-Qabail for northern winds; each has its implications concerning fishing conditions. Spiritual dimensions cannot be underplayed-the sea is reverenced as Darya Pir, or saintly sea-and there are several taboos, rituals, and traditional practices that govern fishing activities so as to ensure that harvesting is sustainable and ecological balance is maintained. These include specific closed seasons for certain species and community managed conservation areas that had traditionally protected marine biodiversity.

Climate change Impacts:

A multidimensional crisis These various changes in climate are interconnected and threaten the very livelihood and cultural survival of the coastal communities in Karachi. The Arabian sea saw a steep rise in sea surface temperature, which resulted in altering the pattern of distribution and migration of fish [6]. Fish species like pom fret and jumbo shrimp, which were easily available at one time in the waters of the coast, have retreated into cooler and deeper waters. This therefore means that fishermen must now embark on longer voyages and risk themselves more. Warming waters have led to frequent algal blooms and oxygen-deficient zones which, in turn, are responsible for mass mortality events of fish; catches get devastated. Changes in the pattern of monsoons disturbed the traditional fishing calendar which generations had relied upon. Unpredictable weather patterns make planning fishing trips more difficult. Erratic rainfall means river Indus inflow. Coastal waters changing salinity means fish species commercially important. Elevated sea level rise becomes one of the top threats to fishing settlements. Rehri Goth and Ibrahim Hyderi face high tide floods every couple of hours. Families lose their homes and the sea takes their belongings. Loss of protective mangrove swamps due to poor climate change governance and unsustainably weak coastal and forest resource use increase vulnerability. Socioeconomic challenges and the climate change impacts posing. Most of Karachi's fishing households

are in chronic poverty. The climate change impacts on these fishing households are bottomless because fishing families will have to uncompensated loss. With the loss comes the unrelenting the lack of education, healthcare, and social safety nets [7].

They will economically trap these families in the loss of fishing. The traditional fishing economies function in relations with middlemen who advance seasonal loans for the purchase of fishing gear and supplies. Cycles of debt bondage limit economic mobility, and reduced fish catches due to climate impacts mean that families can barely afford to repay these debts, further increasing financial stress and occasionally even the loss of fishing assets. These challenges have prompted communities to develop remarkable and highly complex adaptation strategies incorporating local knowledge. For instance, numerous fishermen have altered their equipment to pursue different species that become more plentiful during these fluctuating circumstances. Others have adapted changes in fishing grounds by applying their traditional knowledge and identifying new productive areas. Changes in fishing gear and boats have been made in regard to efficiency and safety, considering evolving marine conditions. Community-based responses have also been very important because the traditional, cooperative organizations known as Mohran systems have enabled knowledge sharing, mutual aid, and collective action in response to disasters. These social networks provide the crucial safety nets that become so important for communities when families are in emergencies or face economic hardship due to climate-related disasters. However, the rate and magnitude of climate change increasingly outpaces that which indigenous adaptation strategies can adjust to in light of changes well beyond what these communities have faced in a historic perspective. Complex Dynamics of Climate Migration Climate-induced migration has been termed an imperative issue affecting the fishing communities of Karachi; it creates complex social and economic dynamics [8].

The Sindh coastal regions, particularly the Indus Delta, including Keti Bunder, Shah Bunder, and Jati, have suffered from rising seawater levels, decreased Indus River freshwater inflows, and increased salinity. These changes have made many traditional livelihoods progressively unsustainable. Moreover, internal migration to the coastal fringe of Karachi aggravates challenges in already overcrowded communities, such as Rehri Goth and Ibrahim Hyderi. These migrants often settle in unprotected zones, lacking essential amenities and services, and facing larger infrastructure deficits. These could be exposed fringes of coastline or under unstable ground. Sometimes, tensions are also created and fanned between established residents and newcomers over competition for scarce resources, mainly fishing grounds, freshwater access, and living space. Extra pressure put by migrants on local ecosystems is brought about mainly by increased pressure on already dwindling fish stocks. It's not always a single event but rather a complex process whereby one family maintains ties with the home village, while also embarking on a new life in the city. Migrants felt a profound sense of loss, dislocation, and ambiguity regarding the future. They also experience complex psychological burdens. The Crisis in the Transmission of Intergenerational Knowledge The ongoing, relentless march of climate change and modernization are impact the intergenerational transfer of traditional indigenous ecological knowledge. Fishing elders are worried; their time-honoured practices are not being taught as the younger generation shows little interest in learning them. Most of the modern fishing technologies, particularly GPS devices, echo-sounders, and motorized boats, keep on increasing the dependency on technology rather than traditional ecological knowledge [9].

While this may contribute to short-term gains in efficiency, such technologies fundamentally alter how young fishermen learn. Rather than developing ecological intelligence around ocean currents, bird behaviour, and water coloration among other natural indicators, youth increasingly depend on digital interfaces that yield instant answers but little deeper ecological knowledge. At the same time, this shift in technology occurs with changing aspirations for education and employment, as many young people within fishing communities seek formal education and livelihoods outside the fishing sector. This loss of inter-generational knowledge is further compounded by the loss of those traditional cultural practices that encoded ecological knowledge, including folk songs, stories, and rituals. For many elders, this phenomenon is best described as "the sea no longer speaking to the youth," reflecting deep cultural and spiritual disconnection accompanying this erosion. This is not only a loss of practical competencies but the unravelling of an entire cultural worldview which has sustained these communities over generations. Policy Gaps and Institutional Challenges The institutional framework and government policies have not responded to the complex challenges that face Karachi's fishing communities in light of the climate change issue. Management of fisheries remains largely commercially based, where little respect is accorded to traditional knowledge systems or community-based management. Similarly, climate adaptation policies focus on technological fixes and infrastructural projects at the expense of indigenous adaptation strategies inspired by indigenous knowledge. Besides, developments along the coast for commercial and industrial use often take place without proper consultations with the fishing communities, leading to displacement of such communities and loss of access to traditional fishing areas, coupled with environmental degradation. Generally, fishing communities have minimal political representation and poor channels for the expression of their concerns in key policy debates affecting their ways of life or their livelihoods. Legal and administrative regulations that govern fisheries and coastal management often fail to recognize customary rights and traditional governance systems, further marginalizing such communities. International mechanisms of climate finance and development programs often face numerous challenges in reaching and benefiting small-scale fishing communities, given the complex application procedures, mismatched funding criteria, and implementation approaches insensitive to the local context. This reality of institutional neglect further exacerbates vulnerability within fishing communities and erodes their capacities to adapt to climate-related impacts through both traditional and modern knowledge systems. Cultural Impacts and Identity Transformation: Climate change, modernization, and policy neglect are combining to

create far reaching cultural changes in Karachi's fishing communities. Specific practices passed down through generations reinforce social cohesion and the relevant environmental ethic [10].

For example, seasonal festivals celebrating the opening and closing of fishing seasons, which always served to play a part in knowledge transmission and bonding amongst members, become less frequent or lose their cultural meaning. Oral traditions in the form of folk songs (Maaro) containing detailed information on fishing techniques, navigation, and marine ecology are forgotten as the younger generation moves into modern forms of entertainment. Local dialects with specialized vocabularies related to marine phenomena, weather patterns, and fishing techniques have given way to dominant languages, entailing loss of nuanced ecological concepts encoded in traditional terminology. Traditional systems of governance regulating resource use and conflict resolution within the community are weakened by the penetration of formal state institutions and commercial interests. Social status accorded to fishing knowledge and fishing skills is lost as alternative livelihoods assume higher prestige.

The cultural changes imply not just the loss of particular practices but also the disintegration of an entire way of life and worldview that has enabled these communities to live and use coastal ecosystems sustainably for centuries. Indeed, the disintegration of culture poses serious implications for community resilience since it cuts into the social fabric and shared values of collective action in response to environmental challenges. Integration of Indigenous and Scientific Knowledge Systems One of the critical challenges toward enhancing climate resilience in the fishing communities of Karachi pertains to the building of frameworks that enable effective integration between indigenous and scientific knowledge systems. It has to be synergistic rather than competitive or mutually exclusive; this needs to be the relation between such knowledge systems, recognizing strengths each brings. Though scientific monitoring and climate modelling can indicate large-scale changes to the environment and future scenarios, it is indigenous knowledge that reflects place-based, detailed understandings of ecosystem dynamics and practical adaptation strategies developed through long-term observation and experience. Knowledge production through joint research initiatives involving fishermen, scientists, and policy makers will result in the development of more comprehensive understandings of climate impacts and effective responses for adaptation. This includes the systematic recommendation of indigenous observations of environmental change under traditional and scientific community-based monitoring programs.

The resultant data will lead to the development of hybrid early warning systems that merge scientific weather forecasting with traditional ways of prediction in efforts toward enhancing preparedness of local communities against extreme weather events. Inter-generational education programs bring elders and youth together with scientists in processes through which traditional knowledge is documented and revitalized, breaking the inter-generational divide and constructing new knowledge relevant for contemporary challenges. These integrative approaches underpin fundamental shifts in how knowledge is valued and who are recognized as legitimate producers of knowledge, thus challenging entrenched power dynamics and epistemological hierarchies that have historically marginalized indigenous knowledge systems. Conclusion: Toward Climate Justice and Sustainable Futures The plight of Karachi's fishing communities in the face of climate change carries within it a microcosm of broader challenges at the nexus of environmental sustainability, cultural preservation, and social justice. Their situation makes poignantly salient how climate impacts fall disproportionately upon communities that have contributed least to global greenhouse gas emissions, yet hold knowledge invaluable to navigate environmental change. Complex challenges require approaches which can address immediate vulnerabilities but support the building of resilience into the long term. This includes the recognition and protection of customary rights to coastal resources and fishing grounds, ensuring meaningful participation in decision-making processes, and investment in basic infrastructure and services in fishing settlements. Of equal importance is the need to support the revitalization of indigenous knowledge systems through inter-generational learning programs and community based documentation initiatives.

At the most basic level, there is a need for a rethink of how coastal governance makes space for co-management approaches that value scientific and indigenous knowledge systems as coequals. This requires closing the gaps between fishing communities, scientists, policymakers, and other stakeholders in the co-development of scientifically sound but culturally applicable adaptation strategies. Knowledge, skills, and practices developed by Karachi's fishing communities over generations form irreplaceable parts of our common human heritage, carrying important lessons for the uncertain climate future. Safeguarding such heritage amidst serious challenges in this respect is not only a cultural concern; it also goes to the core of any effort to build sustainable and equitable futures along coastlines worldwide. That their resilience exists a midst pressures of many kinds brings forth hope and inspiration, while their struggles continue to remind us of the pressing needs for action on climate change, with recognition of justice, equity, and wisdom from those who have deep roots into our shifting planet.

2. Methodology

long term ethnographer fieldwork was conducted for this research in the Karachi's coastal fishing communities of Ibrahim hyderi, Rehri Goth, and Keti Bandar selected for their ecological vulnerability, rich cultural heritage, and exposure to the change and urban expansion. These communities are home to some of the oldest fishing settlements along coastline of Pakistan, where artisan fishing practices, spiritual links to the sea, and indigenous ecological knowledge continue to nurture local identity and livelihood. This research was carried out in three major phases : an initial 30_day preliminary visit in march 2024 to gain rapport among the community people, identify key in formats, and observe the fishing routine; a six month extended phases from April to September 2024 devoted to in- depth

interviews, participate observation, and oral history documentation and a 90 day follow up phase between November 2024 and January 2025 for verification of data and additional focus groups and sharing of preliminary findings with the community for feedback. This study draws on a broad set of qualitative and participatory method to understand how indigenous knowledge articulates with climate change and sociocultural transformation. In keeping with ethnographic traditions, participant observation was the component of this research and provided an opportunity to participate in daily life at harbors, fish landing sites, and community congregation. The research joined more than 25 fishing trips with local fishermen, observing how traditional indicators of wind directions, color of tides, the movement of clouds, and the behavior of seabirds are used to find the right time to go fishing and foresee weather changes. Participation in religious ceremony, seasonal festivals, Marriages, and communal rituals helped provide symbolic and cultural meanings associated with marine life [11].

Complementary participant observation, 38 semi structured and informal interviews were conducted with participants:

Fishermen, women involved in net mending and fish processing, youth engaged in alternative livelihoods and local elders considered custodians of traditional knowledge. The interviews each lasted 60-90 minutes, were conducted either in Sindhi or Urdu, and were translated into English for analysis. Topics discussed included shifting weather and fish migrations patterns, the inter-generational transmission of knowledge, modernization and the adoption of technology, erosion of cultural identity, and community responses to environmental stress. Oral histories were gathered from elders aged 60 to 80, whose stories captured their indigenous ways of reading the sea, the stars, and seasonal winds. These accounts showed the continuity as well as erosion of traditional ecological wisdom in light of mechanized fishing and lack of interest from the younger generation in generation in traditional practice. In developing an understanding of community perspectives, four FGDs were prepared around the themes of livelihood transitions, migration, and adaptation strategies for the demographic groups of senior fishermen, women, youth, and community leaders. To contextualize the community experiences within wider institutional and policy frameworks, community experiences were also included in the in depth key informant interviews with officials of the Sindh Fisheries Department, local NGOs working on coastal resilience, and marine scientists knowledgeable about the Arabian Sea ecosystem. A literature review conducted prior to fieldwork and based on published and unpublished works, historical records, and folk literature on the coastal ecology of Sindh and indigenous marine knowledge, helped in constructing the research framework and in channeling field inquiries. All data field notes, interviews, and oral histories were transcribed, translated, and thematically coded using Braun and Clarke 2006 approach to thematic analysis. The themes of ecology of memory, adaptive reliance, loss of culture and sea spiritually were of concern. The analysis primary employed a narrative and interpretive framework, highlighting the testimonies of the participants and local metaphors to illustrator the impacts of climate change on the disruption of livelihoods and the loss of culture. The quantitative data was structured using ANOVA software for systematic coding and cooperative analysis across field sites [12].

Sample Data:

Accounts of field work done around the coastal Rehri Goth, Ibrahim Hyderi, and Keti Bandar fishing settlements highlight the convergence of adaptive transformation, environmental change, and a unique cultural shift. Participant observations revealed the extent of the change, whereby the older fishermen relied on time-honored weather predicting techniques based on the wind and sea conditions, while the younger generation relied on mobile apps for their weather predictions, only to be astonished when rainstorms came and the older fishers were able to accurately predict the storm. Conversations with older fishermen, like Bashir Ahmed and Haji Suleiman, articulated a human-sea-nexus that was echo less, with passive knowledge of the sea based on star, wind, and tide reading, and still no answer to the problem of unpredictable and changing seasons. Other participants like Fatima Bibi noted the economic toll of migrating families as their chapters of sea related work were closed because the rising tides and saltwater intrusion and relentless waves. Leg/by Nadeem Khan, showed the shift in ecological dependence with the increasing use of technology and mechanical gaps and sonar for fishing. Focus group discussions perpetuated the same discourse about the sea warming, the decline in fish abundance and diversity, and the increase in coastal pollution and the loss of cultural identity [13].

3. Results

These research findings indicate that the Karachi coastal ecosystem is a site of far-reaching ecological, cultural, and socioeconomic transformations encouraged by climate change and modernization. Field observations from Ibrahim Hyderi, Rehri Goth, and Keti Bandar present clear environmental instabilities: shifting wind patterns, erratic tides, and changed fish migrations disrupting traditional fishing calendars and decreasing predictability of indigenous forecasting.

The sea still provides a lively cacophony of sights, sounds, and even smells to the fishermen among them, Abdul Razzak, who continued interpreting its condition through wind stillness and cloud movements. Yet, climatic variability undermined this kind of ancestral indicator's predictive power, reflecting what terms the "destabilization of ecological memory." As environmental uncertainty increases, livelihood insecurity heightens; smaller catches and unpredictable seasons become threats to community sustenance.

Other significant consequences include the erosion of traditional knowledge among the younger generation. The elders kept reiterating, "The language of the sea is being forgotten," while the youth are more reliant on GPS and mobile apps rather than oral traditions or navigation by stars. Field data are also revealing a growing gendered impact. For instance,

women like Fatima Bibi become increasingly vulnerable due to tidal surges affecting drying areas and household income.

Finally, data reveal how fisher folk are creating a new pattern of "blended adaptation" by melding ancestral practices with modern tools-solar-powered lights to attract fish, modified drying techniques to counter pollution, and the balancing of traditional lunar calendars with digital weather forecasts. Such adaptive practices underpin the idea that indigenous knowledge is a dynamic system rather than a static relic.

4. Discussion:

The results present a paradox: the traditional knowledge of Karachi's fishing communities continues to age, yet it is also being re-created. This back-and-forth reflects what [11] calls "cultural resilience in motion," where decay algorithms happen not to traditions, but because of a need to change. This inter-generational disconnection is more than a practical loss; it is an epistemological loss of knowing-and a knowing that is respectful of natural cycles and collective wisdom. As noted in, the modern technologies and formal education's expansion has caused a loss of marginal local knowledge and the cultural capital that once sustained coastal communities. At the same time, communities have also experienced an increase in socioeconomic inequality. Mechanized fishing and disproportionate capital access have created a chasm, which, according to, "uneven adaptation" fractures industrial fishers from small-scale, traditional ones. And there is still institutional exclusion: small-scale fishers' policy 'voice' for coastal governance and co-management remains absent, as revealed in interviews with Sindh Fisheries Department and NGO representatives. The industrial fishery and export-oriented coastal governance of the Sindh province imposes local resilience to the bottom of the governance hierarchy. As content for climate justice to prevail, Indigenous knowledge needs to be equally treated as epistemology on par with scientific expertise, which is missing in Pakistan's policy frameworks so far. And yet a midst these structural deterrents, Karachi's fisher folk display surprising strengths emanating from their cosmological connection to the sea. For example, elders like Noor Muhammad referred to the sea as a living ancestor that breathes with the moon and focuses a moral and spiritual reciprocity with nature.

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