

# Climate Change Effects on Health and Coping Strategies of the Indigenous People: A Case Study of the Santal Community in Bangladesh

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**Abstract** Small ethnic groups in Bangladesh are particularly vulnerable to the effects of climate change. Climate disasters, both natural and anthropogenic, have made their lives difficult and dangerous, endangering their way of life. Increases in respiratory and cardiovascular disease, injuries, premature deaths caused by severe climate events, and shifts in the spatial distribution of food- and water-borne illnesses and other infectious diseases are among the health effects of these disruptions. With qualitative data, this study examines how the Santal community in Bangladesh, experiences climate-induced health vulnerabilities and develops coping strategies. While previous studies have often emphasized biophysical consequences of climate change. This study followed a political ecology framework to present how ecological stress interacts with institutional neglect and social exclusion to shape health impacts. The study employed a qualitative approach combining narrative interviews (NIs), focus group discussions (FGDs) and key informant interviews (KIIs) conducted in a Santal village in Dinajpur district. Data were transcribed and analyzed using thematic analysis to identify recurring patterns and unique insights into community perceptions of climate change, health impact and adaptation. Our findings indicate that the Santal community views climate change as legitimate in physical and spiritual terms. Decreased rainfall, drought and increased temperature are seen not only as changes in the

environment itself, but also as evidence of the anger of God and the disequilibrium of society. This leads to increased malnutrition, disease and mental strain. Women and children in particular are affected. Santal people draw on a diversity of indigenous approaches, such as herbal medicines, rain jars, mud-house construction, to a limited extent, and selected modern methods. However, their adaptive capacity remains constrained by structural inequalities including landlessness, lack of health infrastructure and exclusion. Effective adaptation requires justice-oriented policies that integrate indigenous knowledge, protect fundamental rights, and strengthen community participation in climate change and health governance. In this context, our study contributes to understanding the impacts of climate change, the health conditions of ethnic groups, local health-related knowledge and community-based climate solutions.

**Keywords** Community-Based Knowledge, Adaptation, Alternative Healthcare, Political Ecology, Santal Community

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## 1. Introduction

Climate change is one of the most pressing

environmental concerns we face today [1]. While 2022 was one of the warmest years, hot days and heat waves are becoming increasingly common worldwide [2]. Higher temperatures can make it harder to work and move around, as well as increase the risk of heat-related illnesses [3]. Climate change is a multifaceted concept with implications for the environment, economy, natural resources, and the basic resources of society [4]. Thus, the apparent consequences have resulted in hot temperatures, heat waves dominating summer, and fueling sporadic wildfires across the globe [5]. Simultaneously, rainfall shifts in response to temperature changes, with intense storms contributing to flooding and landslides, damaging life, and property [6]. Since water availability is becoming increasingly precarious in many parts of the world, understanding the interplay between climate and water is of paramount importance [7].

On account of these events, weather patterns are gradually shifting due to warming temperatures, upsetting the natural order, and endangering humanity as a whole. Human-induced global warming is causing significant changes in climate as a slow-onset phenomenon with irreversible consequences affecting nearly all facets of human society, including the production-consumption process [8]. Some of the health consequences of these disruptions include increased respiratory and cardiovascular disease, injuries and early deaths from extreme weather events, and changes in the geographic distribution of food- and water-borne illnesses and other infectious diseases [9]. Moreover, the burning of fossil fuels, i.e., excessive carbon emissions, deforestation, the construction of new industries and factories, etc., results in increased atmospheric temperatures, the melting of polar ice, along with sea level rise and displacement of people [10].

The challenges concerned with climate change are associated with the resource implications underlying the country's geographical and ecological characteristics. Primarily, climate change is already having an impact on factors essential to human survival, including air, heat, water, food, agriculture, ecology, and human health [11]. As a result, nutritional deficiencies will occur, health will deteriorate, and the immunity of the human body will decrease [12]. In contrast, heat and water-borne diseases will grow as a result of environmental change, and a considerable number of individuals will suffer from respiratory issues due to poor air quality [13]. Similarly, climate change is projected to exacerbate natural disasters, including rainfall, sea level rise, and tropical cyclones, that severely damage agriculture, water, food security, human health, and shelter [14]. It is also due to the proximity of Bangladesh to the Bay of Bengal, as well as low-lying deltaic reforms that have contributed to the critical hindrance to the vision of sustained socio-economic growth of the country [15].

Not to mention, the country is weighed down by rising poverty rates and population density, low adaptive capacity,

and poor local governance infrastructure [16]. In most countries, health systems have been slow to recognize climate change's severe effects on population health, instead reflecting the ineffective, individual-centred causation of the old "health" model [17]. However, the climate itself does not necessarily influence human health; rather, the environmental, ecological, and social repercussions of a changing climate have health consequences [18]. Provided that, natural elements such as temperature, humidity, rainfall, wind flow, etc. are affected by climate change, there are changes in the natural environment that directly affect public health [13]. However, owing to geographical factors, not all regions and populations in Bangladesh are equally affected by climate change; certain parts of Bangladesh are more impacted than others. In the same way, Bangladesh is home to a large population as well as numerous small ethnic groups that are more affected by climate change than the larger population [19]. Among them, the second largest ethnic group in Bangladesh is the Santal, who are suffering greatly from the effects of climate change [20]. Natural and manmade climate-induced calamities have made their living highly challenging as well as vulnerable, thus making their livelihoods at serious stake [21].

Until now, they had to adjust to specific challenges posed by the political, social, economic, and environmental changes over the last three centuries [22]. Furthermore, their availability of natural resources has been seriously depleted, followed by multi-sectoral and multi-dimensional investment [23]. Indigenous peoples have adjusted to local changes and seasonal shifts for millennia, in accordance with the natural rhythms and intricately bonded processes of the ecosystem [24]. Fundamentally, they are equipped with multiple facets of dynamic knowledge encompassing landscapes, plants, and animals that have been refined and corrected through generations of experiences [25]. Despite facing an overwhelming number of practical obstacles and rising strain in the context of diminishing common pool resources, the Santal community is found to be resilient and innovative [19].

On the positive side, they are consistently seeking to adopt a variety of indigenous techniques to overcome these obstacles and enhance their capital. However, most studies ignored indigenous health issues and adaptation strategies; rather, they focused on the impact of climate change. Similarly, in Bangladesh, most of the researchers focused on the adverse impact of climate change, where the issue of the ethnic minorities was absent, significantly focusing the research area only on the negative impacts of climate change. Consequently, it is worth researching the Santal community's behavioral intention to use indigenous knowledge and modern strategies to adapt to climate change. In this study, the researchers have tried to bridge the gap between the interplay of human health and climate change adaptation, shedding the sketch of the Santal community.

## 2. Theorizing the Political Ecology of Climate Change and Human Health

This study employs political ecology as its central theoretical framework. Political ecology emphasizes how relations of power, inequality, and history shape both environmental change and human well-being. Rather than treating climate as a neutral or external force, it shows that climate and society are mutually constituted through cultural, political, and economic processes [26], [27]. In this context, the health effects of climate change are inseparable from the structural conditions that create vulnerability, shape exposure and constrain adaptive

capacity [18]. The integration of political economy and ecological analysis [28], [29] political ecology challenges apolitical or technocratic explanations of environmental problems. It argues that environments and climate systems are historically produced through colonial expansion, capitalist development and unequal access to resources [30], [31]. therefore, climate change can be viewed both as a biological process and a political and moral issue. The risks and benefits of climate change are unevenly distributed throughout society and some of the most vulnerable and at-risk populations are typically marginalized and/or indigenous populations who bear the greatest burden [32].

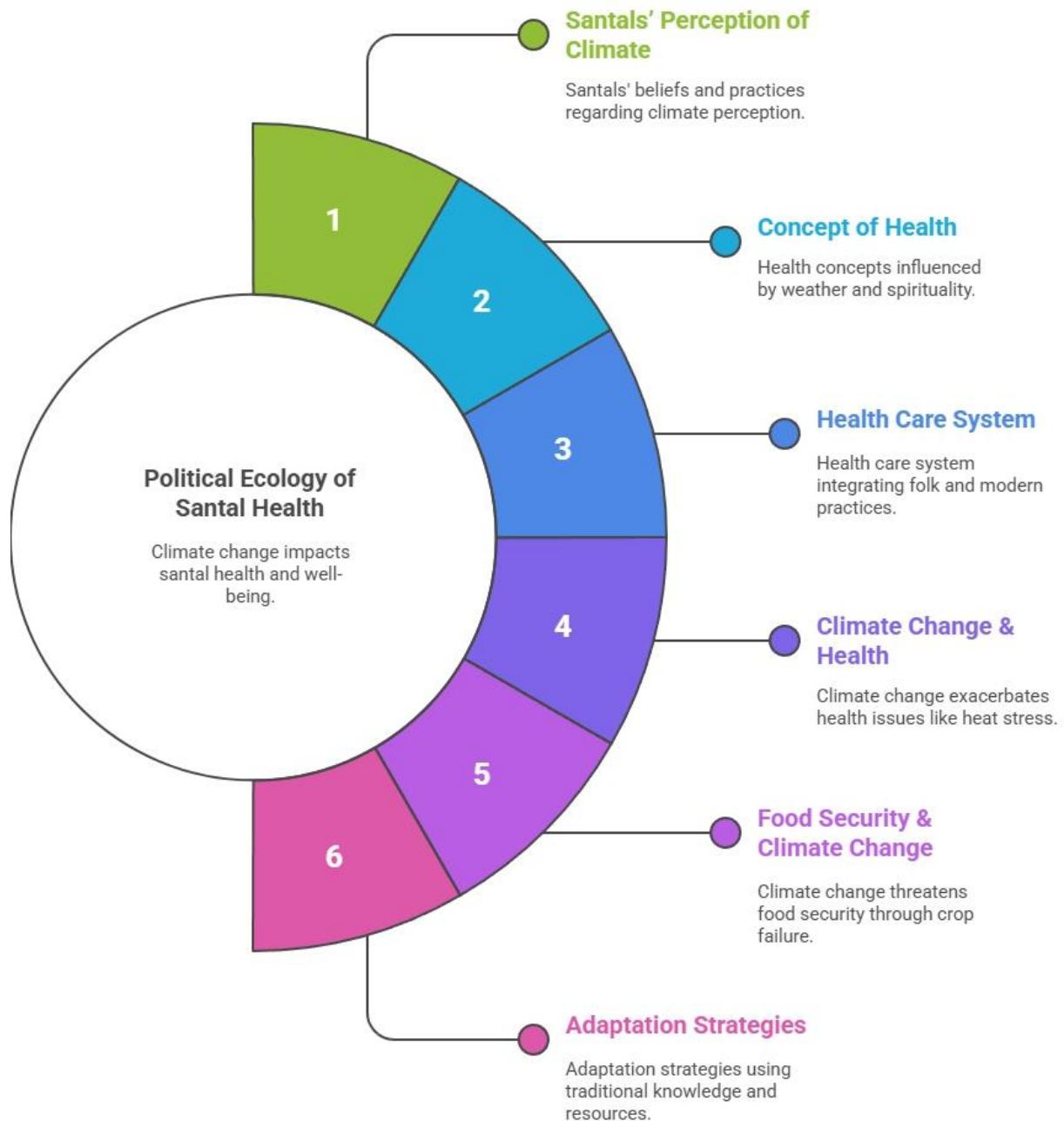


Figure 1. Political Ecology and Santal's Health

The political ecology of health describes how environmental changes intersect with social structures to produce illness and suffering [27]. For example, in Bangladesh, climate change has taken many forms (increasing temperature, irregular precipitation, drought and flooding) that affect food security and livelihoods, and result in embodied health impacts (malnutrition, heat-related illness, waterborne illnesses) [26]. The experience of climate change for the Santal people is linked to their daily livelihoods, cultural practices and spiritual relationships with nature; their responses to climate change (e.g., sharing common resources, traditional medicine and diverse cropping systems) demonstrate resilience, yet illustrate limitations resulting from structural barriers [26], [33]. Therefore, political ecology emphasizes that coping with climate change is both ecologically and politically complex [21], [34]. As depicted in Figure 1, political ecology offers a lens for linking the Santal people's perceptions of climate change, health impacts and lived health issues to larger structural inequalities, policies, and climate governance [35].

Additionally, this figure represents how the findings on the Santal community's perceptions of climate change, concepts of health, healthcare systems, health impacts, food security, and adaptation strategies are interpreted through the lens of political ecology.

### 3. Materials and Method

This study employed a qualitative research approach due to its strength in providing in-depth insights into complex social processes and human behavior shaped by environmental challenges [36]. Data collection was based on both primary and secondary sources. The study is based on a combination of primary and secondary sources of data. In order to collect primary data, we carried out fieldwork in a Santal village located in the Dinajpur district of Bangladesh, selected because it is one of the most densely populated Santal settlements in the region [37]. The village consists of 35 households with a total population of 209 individuals (107 males, 102 females). The primary livelihood is agriculture, with a significant majority (approximately 70%) engaged in sharecropping. Other occupations include day labor, mining, van driving, and small-scale trade. To capture a comprehensive understanding of climate change, health impacts, and adaptation strategies, multiple qualitative techniques were employed. These included 25 narrative interviews, 3 key informant interviews (KIIs), and 4 focus group discussions (FGDs). Narrative interviews were conducted within participants' natural settings to ensure authenticity while maintaining anonymity. FGDs were organized to generate collective perspectives, while key informant interviews were carried out with local leaders, elderly members, and health practitioners familiar with both community practices and environmental changes. After finishing the fieldwork, we transcribed all interviews and discussions were audio-recorded with participants' consent

and later transcribed verbatim. Data were coded systematically, and a thematic analysis approach was adopted following Braun and Clarke's [38] six stages: (i) familiarization with the data, (ii) generating initial codes, (iii) searching for themes, (iv) reviewing themes, (v) defining and naming themes, and (vi) producing the final report. This method allowed the identification of both recurring patterns and unique insights into the community's lived experiences of climate-related health challenges. To enhance credibility, this research used a triangulation method. Data collected from narrative interview and key informant interview were compared with FGD data. The data were acquired in their original form by audio recording and then transcribed. The data analysis incorporates verbatim quotations to enhance the precision of the data and provide a comprehensive understanding of the real-life circumstances of the research population. The research has adhered to ethical norms in several respects, such as acquiring informed permission from participants, upholding confidentiality and privacy, and guaranteeing voluntary participation.

## 4. Results and Findings

### 4.1. Santals' Perception of Climate Change

The Santal community, which historically lived in close harmony with their natural surroundings, now perceives climate change as a profound disruption to their lives and livelihoods. Many participants described environmental changes such as reduced rainfall, rising temperatures, and the drying of rivers, ponds, and canals, which have intensified water scarcity. In this context, Russell Murmu (42), explained:

*“These days our weather has changed a lot. The rivers and ponds have dried up; rainfall has decreased; and the temperatures have risen. Because of this, our fields have dried out, and we now rely on deep pumps and tube wells even for drinking water.”*

Climate change is also interpreted through spiritual and cultural lenses. Several participants expressed the belief that environmental changes are linked to divine displeasure. For instance, Puti Mandi (50) connected climatic instability to declining religious practices:

*“We are har-hopan that means us ‘immaculate children of mankind’. Our deity, Bonga, brings prosperity when pleased, but misfortune when angry. In the past, we performed rituals and festivals for balance, but now people have changed, the environment is being destroyed, and with it our health and peace of mind.”*

These narratives interpret how cosmological beliefs intertwine with environmental observations, highlighting a moral and spiritual interpretation of climate change. This reflects earlier anthropological findings that indigenous groups often interpret environmental change not only as ecological shifts but also through religious and cultural

worldviews [26], [39]. Moreover, participants also emphasized how seasonal patterns have become unpredictable. Traditionally, six distinct seasons shaped agricultural and social life in northern Bangladesh, but community members reported that deforestation and ecological imbalance have blurred these cycles. As Sadesh Mandi (67) shared,

*“Last month was unbearably hot, and the same continued this month. Big trees have been cut down, the rains no longer come in time, and reservoirs dry up in summer. The groundwater level is sinking, irrigation is difficult, and storms like Amphan destroy crops and trees.”*

Overall, these narratives suggest that perceptions of climate change are not limited to physical shifts in rainfall or temperature. They are embedded in histories of deforestation, unequal control over natural resources and spiritual frameworks that reflect the community’s marginal position within broader socio-ecological systems [40], [41]. Thus, climate is perceived both as an ecological crisis and a socially produced phenomenon shaped by human actions and structural inequalities [30].

#### 4.2. Santals' Concept of Health

Santals believe that health and illness are mostly related to surrounding weather conditions, environment, social conditions, and spiritual influences, as visually present in Figure 2. This figure represents the Santals' holistic concept of health, which interconnects spiritual influences, environmental conditions, social conditions, and surrounding weather as key determinants of well-being and illness. Previously they used to practice ceremonies, sacrifices, but now they think many of their issues of health and illness relate to climate change. Majority of participants explained that illness increases when climatic conditions worsen,

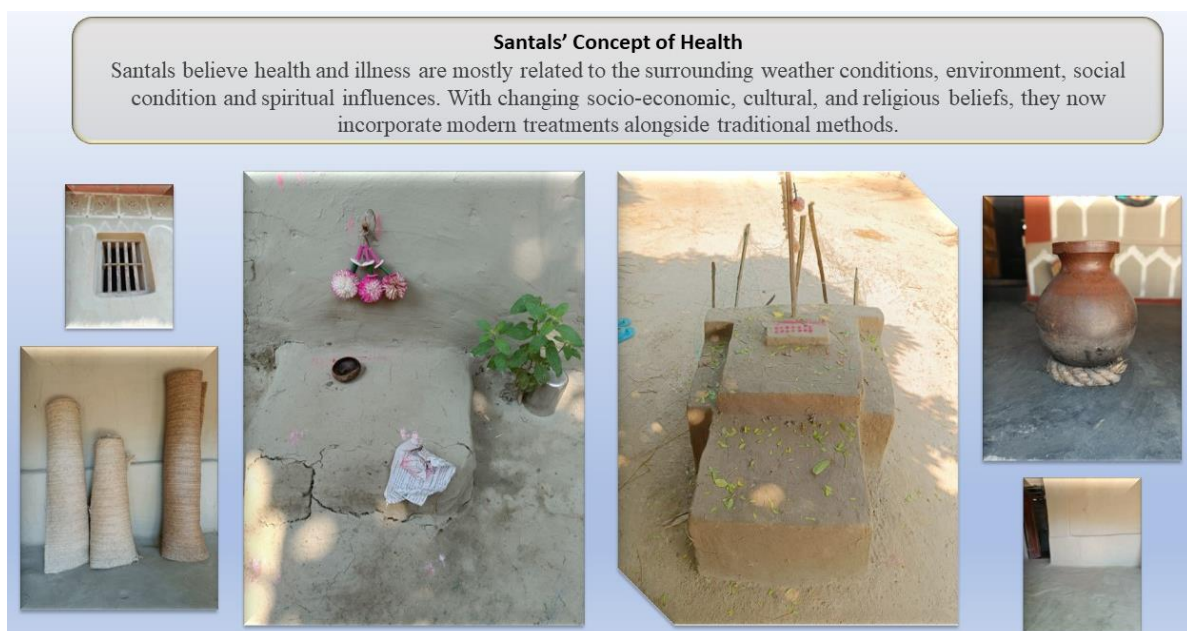
especially during droughts, heat waves, and periods of water scarcity. As one respondent, Vijay Murmu (40) shared,

*“When the weather is too hot, with drought and no irrigation water, I feel weak and tense. How can I stay healthy if my food becomes tainted by the heat?”*

Traditionally, the Santals also attributed illness to supernatural or spiritual forces, such as black magic or displeased deities. However, as climatic variability has intensified, they increasingly link health problems to environmental stress. As shown in Figure 2, environmental degradation is now a primary lens for interpreting illness, supplementing and at times supplanting spiritual explanations. One of the participants Puthi Maddi (30) said,

*“...water scarcity is becoming increasingly acute in our reddish land. We are all dependent on paddy cultivation. Paddy needs enough water. We live with these bad situations and tensions. We also suffer from weakness, shortage of blood, and acute tensions. Cold, black fever, jaundice, diarrhea, pneumonia, stomachache, itching, dysentery, scabies are common among us. For solving health problems, we go to the village doctor and folk healer or to the nearest health center.”*

These narratives reveal that health is not understood narrowly as a biomedical issue but as an outcome of social and ecological imbalance. They emphasized that water shortages, reduced crop yields and environmental degradation impact not only physical health but also psychological well-being. This reflects broader anthropological findings that indigenous communities often conceptualize health holistically, encompassing spiritual, ecological and social dimensions [18], [27]. At the same time, the Santals’ interpretations of illness explain how health vulnerabilities are shaped by structural inequalities.



**Figure 2.** The Four Pillars of Santal Health: Spiritual, Environmental, Social, and Climatic Factors, as taken from Habiba [58]

### 4.3. Past and Present of Santal Healthcare System

Santals have long used traditional medical systems, relying on plants and herbal medicines for disease treatment. They believe in the power of God, nature and environment, black magic, ghosts and spirits. However, with changing socio-economic, cultural, and religious beliefs, they now incorporate modern treatments alongside traditional methods. They used to take treatment from folk healers of the local area. A participant named Vijay Murmu (40) said,

*“In the old days, Kaviraj provided us medicine for various diseases, such as jaundice, fever, and cold, using Orion leaves and sugarcane juice.”*

Likewise, Montu Hemaram (45) said,

*“We believe in herbal medicine of Kaviraj. The medical plants have many qualities to heal our diseases. You know people are greedy and dishonest who have destroyed the environment and plant diversities. Due to natural calamities of droughts, and hot air, we are now suffering from deadly disease. Doctors cannot treat fear, wind, and nausea. When Kaviraj sprinkles them, we get better.”*

Folk healers also experience challenges in providing indigenous medical services due to the reduction in forest. Santals have converted to Christianity, changed beliefs system, and got more literacy rate than past. Of late, some of us have started to rely on modern treatments. In this regard, a participant named Sajib Kisku (26) mentioned,

*“...now both plant-based and modern treatments exist in our society. If we become ill, sometimes we seek treatment at neighboring hospitals or almost everyone goes to Kaviraj.”*

This coexistence of indigenous and biomedical healthcare reflects a pattern observed in many indigenous societies globally, where traditional medicine persists alongside modern interventions [42], [43]. It explains not only cultural resilience but also the pragmatic strategies of marginalized groups who balance affordability, accessibility and cultural legitimacy in health-seeking practices. Moreover, the transition in healthcare among the Santals is shaped less by “choice” and more by structural pressures. The loss of land and forests, coupled with unequal access to public health services. As a result, they are constrained in their ability to rely solely on indigenous knowledge systems [44].

### 4.4. Climate Change and Santal's Health

Climate impacts human health, with deforestation threatening traditional Santal hunting and gathering occupations, affecting their mobility and effectiveness. In this context, Montu Hemram (50) stated,

*“...sometimes the temperature is very high, sometimes no rain for a long time. We suffer from shortage of water in the body and stroke during drought.”*

Others linked unusual weather fluctuations to the emergence of new health risks. Sadesh Mandi (60) noted, *“When the weather is bad, I feel sick and mentally restless. Many of us now suffer from breathing, heart problems, and allergies.”*

These narratives explain how the Santals perceive climate as a direct determinant of illness through heat stress, malnutrition, and insect-borne diseases. Excessive high temperatures cause colds, fevers, and diarrhea, leading to water shortages and farming challenges. They believe climate change causes new maladies that traditional herbal medicine and Kabiraj cannot treat, causing increased health strain and medical assistance seeking. Likewise, Sohagi Maddi (40) said,

*“Climate change has led to warmer summers and colder winters, we see infectious disease around us, and a new thinking is that many people have had strokes due to the heat. As there is shortage of water and food, our children and we suffer from malnutrition.”*

The increase of excessive heat and mosquitos causes human diseases like fever, diarrhea, cholera, jaundice, and cold fever, cough, and pneumonia in winter. In particular, women and children were described as highly vulnerable to diarrhea, malnutrition, and fever, echoing broader findings that climate impacts intensify pre-existing health inequalities among marginalized populations [33], [45].

In addition to physical ailments, participants also highlighted psychological stress caused by resource scarcity, water conflicts, and food insecurity. As Philip Hamrom (30) explained, disputes sometimes arise over access to deep-tube wells:

*“Sometimes in need of water there is conflict with other communities. We live with tension every night. Heat, dehydration, and stroke are common for us farmers.”*

Regarding the effect of climate change on health, Puthi Maddy (30) said,

*“Adverse weather impacts the health of our men, women, and children causing diarrhea and allergies because trees have declined, ponds and water reservoirs become waterless.”*

Likewise, Sajib Kisku (28) said,

*“...drought is becoming increasingly common for weather change. The ponds become dried up for extra drought. We do not get enough water for bathing and sanitation, and enough drinking water.”*

The impact of climate change leads to a scarcity of natural resources, which is harming human health. Such accounts resonate with anthropological research that shows climate change not only exacerbates disease burdens but also contributes to mental distress and social conflict [12]. Additionally, these health impacts are not merely “natural” outcomes of environmental change, but rather they are socially produced vulnerabilities. Deforestation, unequal control over water resources, and marginalization from

state health systems make the Santals disproportionately exposed to risk compared to dominant populations [46]. In addition, increasing use of various agricultural technologies. They also feel that the nutritional value of food is decreasing. Sajib Kisku observed,

*"...foods which are produced directly from nature are good and useful for our health. We did not know the usage of fertilizers...now we use fertilizers. I feel these chemical fertilizers foods cannot provide us any fresh energy, but we are losing energy day by day, and we are suffering from numerous ailments."*

#### 4.5. Food Security and Climate Change

The Santal community, historically isolated, relied on hunting and crop production for food. They hunted fish, turtles, birds and other species to meet their need of food. However, climate change has limited their ability to grow crops naturally, leading to a situation of food insecurity. In this context, Nagen Hemram (60) mentioned,

*"In some years, we do not get rain for about six months. Due to no rain during this farming period, the level of ground water goes low, and scorching heat, severe drought and lack of trees are reasons of no rain. We could not cultivate enough crops. For these causes, we live in food insecurity all-round the year."*

These less rainfall, drought and temperature rise have brought deforestation in the locality. Thus impacts of climate change are causing a shortage of poaching and water scarcity, which has resulted food insecurity among the community. They are compelled to reduce their reliance on nature; these contribute to food insecurity owing to fewer hunting possibilities. Bimal Saran (40) said,

*"Hunting is no longer exist in our society due to the lack of prey and there is no need to teach preying rituals and techniques to children, as it no longer exists animals in the nearby areas due to drought and deforestation."*

Although there was an abundance of food sources due to crops farming, and hunting and gathering traditions in the past. As there is lack of food security due to climate change, they shift themselves from simple technology to technology-based agriculture. Sifanil Murmu (45) said,

*"...although we work hard in the drought land to grow more food but without rain water it becomes more expensive to provide water to the land. We have to buy irrigation water and pay this money from taking loan others person or selling cattle from our house. When I am in debt, I cannot buy enough food for my family."*

One farmer, Philip Hemrom (30) said,

*"...for weather change we see long drought and sometimes untimely rains in every year. Sometimes*

*winter is getting shorter or longer. The temperature has increased due to uneven weather. And because of this, the production of some crops including wheat, chickpea, lentil, mug dal has decreased...our food variety is about lost."*

These narratives highlight how food insecurity is both an ecological and structural issue. While climatic stresses reduce yields, social conditions such as sharecropping arrangements and lack of state support further entrench vulnerability. Studies across South Asia show that indigenous farmers often face double burdens: they are on the frontlines of climatic shocks but remain excluded from agricultural subsidies and adaptation programs [47]. Furthermore, climate change has disrupted the Santals' traditional hunting occupation, leading to modern agriculture and uncertain food security. As sharecroppers, they cannot grow crops on the land, resulting in an insufficient food supply.

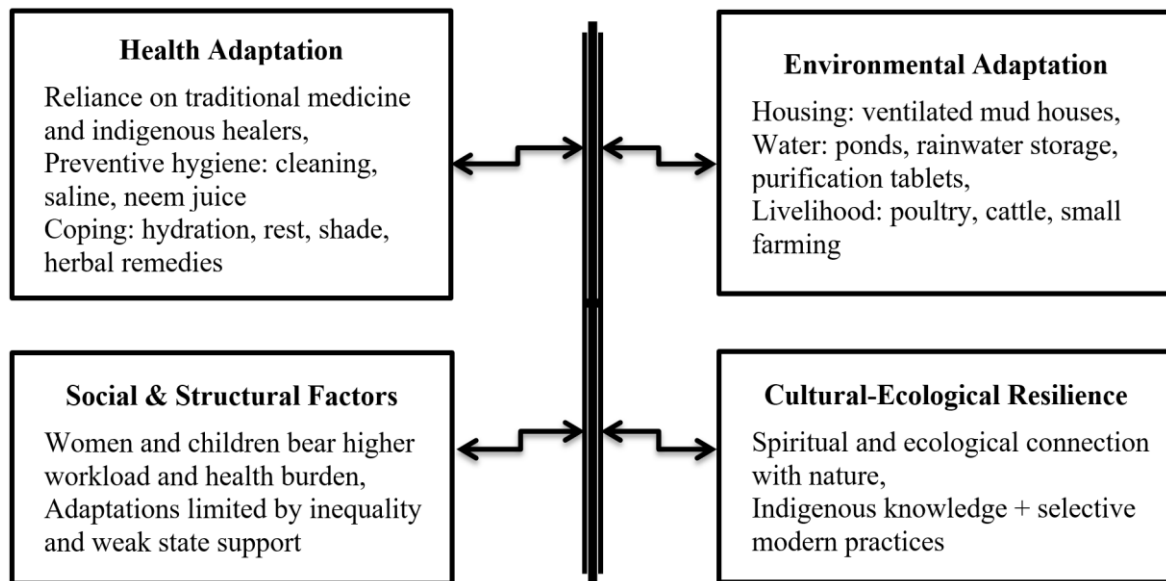
#### 4.6. Adaptation Strategy

Santals have lived closely with nature, worshiped nature, sacrificed for nature's protection, used an economy dependent on nature for survival and are currently transitioning to adapt to climate change through local resource utilization. The adaptive strategies listed in Figure 3, while relying upon the community's collective ecological knowledge developed over generations, continue to be shaped by ongoing social and structural constraints. As stated in the interviews, the most significant trend is the continued use of traditional medicine as a means of maintaining health in the face of environmental degradation. In this context, Vijay Murmu (40) said,

*"...during Corona when thousands of people died in the country. We also suffered from corona symptoms. But Kaviraj has given us various medicines made from trees and plants. Some people have recovered very quickly with this medicine. Again some took a little time. But none of us died in Corona."*

This collective trust in indigenous folk healer focused how traditional systems continue to fill the void left by inadequate formal healthcare access [25]. In addition their believe living separately from mainstream population reduces disease risk. In addition, maintaining clean surroundings, and a congenial relation to nature contribute to their health. As Montu Hemram (50) said,

*"I always keep the surroundings of the house clean and tidy that reduces the possibility of being infected by the infectious disease. Various diseases are born from unclean, dirty garbage. I do not store any garbage around my homes."*



**Figure 3.** Santal Adaptation Strategies and Challenges

Practices for everyday adaptation focus on health maintenance and hygiene through preventative practices. Families maintain regular cleanliness around them, in order to prevent mosquito borne illnesses; drink coconut or saline water to help prevent dehydration and drink herbal concoctions (such as neem juice) to increase immunity. The ongoing practice of maintaining an environment free from germs is a way families have adapted to understand how to prevent illness, and has substituted for lack of health information dissemination from the government. As depicted in **Figure 3**, we observed various adaptations within household housing and water and food production systems. Many households create new ventilation systems into mud homes to lower heat related stresses, construct ponds to collect rainfall, and grow trees to provide shade. One of our key informants Phillip Hamram (30) described:

*“As the animals are about to be lost, we have stopped hunting. Rather we are domesticating cattle and poultry...we are trying to reproduce lost medicinal plants near our homes, creating ventilated mud houses, digging ponds, and storing rainwater.”*

This is an example of how the Santals have shown flexibility in their ecological adaptations by modifying their long-established traditions and practices; they do so to improve them and are not simply giving them up. The increased frequency of participants reporting illness, i.e., fever, diarrhea, jaundice, and mosquito-borne disease, etc., can be attributed to the increased temperature from climate change and the irregularity of rainfall in the area. These risk factors were minimized through the use of basic but effective methods adopted by the community including increasing the amount of water consumed and/or adding salt for better hydration, resting in a shaded area, using clay/earthen pots to cool water prior to consumption, and

wearing warmer clothing during winter. In this regard Philip Hemrom (30) said,

*“...excessive heat makes us sick. We suffer from dehydration, diarrhea and diarrhea. Now stroke for hot weather is common while working in the field. To avoid such diseases, we drink more water, use earthen pots to keep drinking water cool during hot weather, rest after returning from the field, and many people build huts on the ground next to the ground so that they can come and take rest during extreme heat.”*

Additionally, gendered disparities in adaptation are pronounced. Women and children carry the heaviest burdens fetching water, maintaining nutrition, and caring for the sick. In this context, Puthi Maddy (30) noted that

*“due to weather change women and children are affected by diseases. Women face diarrhea, allergies, and other health issues during hot weather...when we get sicker, we go to medical for treatment.”*

Similar observations have been reported in earlier studies that highlight how climate adaptation responsibilities and vulnerabilities are unevenly distributed, often disadvantaging marginalized groups [48], [49]. Overall, the Santal community’s adaptation strategies represent a layered, evolving response to climate stress, merging cultural traditions, ecological intelligence, and selective adoption of modern tools. While their local knowledge supports continuity and survival, it remains constrained by systemic inequities that limit access to healthcare, infrastructure, and policy inclusion. Their experience underscores both the strength and fragility of indigenous resilience in the face of accelerating climate change, providing critical insights into how adaptation is socially and politically shaped [50].

## 5. Discussion

Adapting to climate change is not only a technical or ecological matter but a deeply political and social process. As political ecology reminds us, environmental change is mediated by histories of power, colonialism, and capitalism rather than being neutral or “natural” forces [30], [40]. Our findings showed that the Santal community’s health vulnerabilities emerge at the intersection of ecological stressors and structural inequalities. Climate change for them is not merely a shift in rainfall patterns or an increase in temperature, but a social and political experience embedded in everyday livelihood. Furthermore, our study reveals how the Santals interpret climate change through both material and spiritual dimensions. This holistic understanding of health and environment reflects broader anthropological insights into how indigenous groups conceptualize well-being as inseparable from ecological and spiritual balance [43]. Yet, this cultural worldview cannot be isolated from the realities of structural exclusion. Moreover, the Santals have limited access to good agricultural land, and nearby forests are disappearing. Because they depend on unfair sharecropping, their risk of hunger and illness is very high. Especially, Santal women and children are affected, carrying the heaviest burdens in collecting water, maintaining nutrition, and caring for the sick [19]. Other indigenous communities highlight both the uniqueness and universality of the Santal experience. For instance, studies among the Borana pastoralists in southern Ethiopia show that adaptation relies heavily on indigenous weather forecasting systems and community-based resource sharing to cope with recurrent droughts and water scarcity [51].

Similarly, a study on Adivasi groups in central India demonstrates how forest-based livelihoods, shifting cultivation, and spiritual rituals link ecological balance with health and well-being [23]. Like the Santals, both groups face structural challenges such as land dispossession, limited access to state support and exclusion from policy processes. Our study highlights their strategies demonstrate resilience rooted in ecological knowledge and cultural practices. Situating the Santal life experience within this global pattern reinforces the need for climate adaptation policies that value indigenous knowledge, secure resource rights and address structural injustice [23], [51]. Within Bangladesh, indigenous groups in the Chittagong Hill Tracts (CHT) offers further insights. Climate change has become a serious threat to agriculture, forests, and food security in the CHT, where high temperatures and uncertain rainfall reduce crop productivity and shorten the growing season [52]. Earlier Ethnographic study shows that CHT communities such as the Chakma, Marma, Garo, and Hajong have been forced to abandon or significantly alter jhum cultivation. This shift happened due to landslides, soil degradation and rainfall variability. They have also adjusted their housing styles to cope with environmental hazards [53]. These groups face

limits on their movement and have less access to forests and water.

As a result, they are becoming more dependent on markets and other ways of earning a living. In contrast, Santals in the plains confront challenges of limited infrastructure and exclusion from state services like irrigation or healthcare [54]. The comparison shows that both communities rely heavily on natural resources. However, their ways of adapting differ because of variations in topography, resource access and policy history. This highlights the risk of viewing all Indigenous groups as the same. The Santals need support that focuses on land rights, health care, and irrigation systems. In contrast, the CHT communities require help with forest management, soil protection and sustainable hill farming. Most previous studies on climate and health have focused on biomedical outcomes, such as illness due to heat exposure, respiratory disease, and infectious disease outbreaks [17].

Although these health outcomes are visible among the Santal, the results of the current study extend this notion of vulnerability to the social construction of vulnerability. For instance, water scarcity is due not only to decreased rainfall but also to inequitable access to tube wells and irrigation. Food insecurity is a function of crop failure, but it also derives from exploitative land arrangements and debt cycles linked to agricultural production. These patterns suggest that climate change does not produce entirely new forms of vulnerability but serves to heighten old inequalities [55]. The effects of scarcity extend beyond physical well-being, affecting psychological and social wellness. Heat waves and prolonged droughts and crop failures cause stress, anxiety, and conflict over scarce goods, etc. Farmers reported disputes with neighboring communities over access to water, and women were constantly worried about feeding children and keeping water clean, and things of that kind. These findings align with global research indicating that climate change causes eco-anxiety, stress factors, and social conflict [56].

The Santals’ lives and identity are closely bound up in the natural resources, and these pressures meant an existential crisis. The historical marginalizing effects made worse the crisis felt, and they have been excluded from mainstream race health and adaptation programs [34]. Despite these challenges, the Santal community shows great resilience by utilizing indigenous knowledge systems. Practices such as reserving the rain water, growing medicinal plants, building mud houses to have ventilation, and relying on local healers illustrate an adaptive capacity rooted in cultural memory and ecological consciousness [25], [57]. During the recent health epidemics, traditional healers have supplied herbal medicines, and households have taken on preventative work such as keeping clean and modifying food. But these efforts cannot be idealized. These practices are forced on people and are not easily allowed. They are rendered impracticable by the teachings of deforestation and loss of biodiversity, and lack of

interest on the part of the state. As Robbins [40] argues, resilience is deeply political; it is shaped by structural exclusions and not simply by cultural continuity.

By emphasizing a political ecology perspective, our study shows that climate change adaptation goes beyond technical fixes. It is part of a wider struggle to address deep-rooted inequalities and to build a fair and sustainable future for marginalized communities. Therefore, adaptation to climate change is a more challenging matter for the Santal community. In this study, the Santals community members, according to the researchers, need instruction and psychological meditation, but they are unaware of these choices. Therefore, since they mostly rely on their indigenous knowledge, they learn how to deal with climate change from nature. They are now employing indigenous and modern technologies natural medicine rainwater reserving, digging new ponds, water purifying table eats, Building mud house to cool their residence, and eating farm meat and egg to meet their daily demand of protein. Our study also found the Santal to avoid working during hot hours of the day by taking regular breaks to avoid heat issues. When working during the daytime, they also consume saltwater and green coconut for energy replenishment. Not to mention, the members of Santals community face monetary trouble owing to the drought as it impacts the surroundings.

## 6. Conclusions

Previous studies on the Santal community emphasize the socio-economical aspect, often centering on livelihood and vulnerability context. However, indigenous knowledge of health and climate adaptation has been overshadowed by the broader discourse on climate change and its impacts. In this study, we have interpreted the adverse effect of climate change on the Santal community's health and how they could gradually adapt themselves by using local indigenous knowledge and modern strategy. Indigenous people have garnered their traditional methods of describing and interpreting nature, as well as indigenous practices and beliefs in agriculture, medicine, and food gathering skills. We observe that they are trying to cope with limited natural resources, and are slowly adapting pragmatic applications of modern strategies. Against this backdrop, the capitalist growth model is causing inequities within the Santal population, depriving them and driving them to favor unsustainable and harmful practices. For example, the Santals are deprived of employment opportunities, genuine leadership, and education, coupled with minuscule knowledge of belongings and land. Moreover, the stakeholders provide little concentration on the structural development of the Santal community people. Therefore, it is imperative that measures be taken to conserve and restore their traditional socio-cultural ecology and community rights to their natural resources, followed by non-capitalist paradigm. Moreover, local control over natural resources,

local body administration, and democratic control of the people over natural resources are essential. The study is not without limitations. Data were drawn from a single Santal village in Dinajpur, which may limit generalizability across Bangladesh. Additionally, the qualitative approach provided deep insights but did not allow for statistical validation. So that, future research should expand through multi-sited and comparative studies of different indigenous groups, with a stronger focus on gender, youth, and intergenerational knowledge transfer. The main contribution of this study is its use of a political ecology approach to show that the Santals' health vulnerabilities are not only ecological or medical. They arise from the overlapping effects of climate stress, weak institutional support, and social marginalization. In addition, by bringing together cultural perspectives, spiritual understandings and Indigenous coping practices, this study expands the climate-health discussion. It includes forms of knowledge and everyday experiences that are often ignored in mainstream policy debates.

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