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Resource mapping amid climate crisis for protection of hunter gatherer community livelihoods in Northern Tanzania

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This paper examines the urgent need for integrated resource mapping to protect the livelihoods of Hunter-Gatherer (H&G) communities in northern Tanzania amid the escalating impacts of climate change. Focusing on the Akie and Hadzabe peoples residing in Manyara Region, the study employs ethnographic observation, focus group discussions, and participatory geographical information systems to analyze land use patterns and climate dynamics. Findings reveal that climate change, coupled with increased agricultural expansion and population pressures, has significantly disrupted traditional H&G mobility, resource access, and cultural practices. Once mobile communities reliant on hunting, honey, fruits, and roots are now increasingly confined to smaller areas, with women and children especially burdened by the search for diminishing resources. The shift from bushland and grassland to agriculture has degraded wildlife habitats, reduced beehive trees, and fueled land use conflicts with neighbouring pastoral and farming groups. These changes threaten not only the food security and cultural identity of H&G communities but also their very survival. The paper argues that current village-based land use plans are insufficient and sometimes exacerbate conflicts. It recommends that integrated resource mapping, which considers traditional livelihood routes and resource zones beyond administrative boundaries, is essential for safeguarding the rights and livelihoods of H&G communities and ensuring sustainable co-existence with other land users in the region.

KEYWORDS

resource mapping, hunter-gatherer livelihoods, climate change impact, land use, land use - land cover change

1 Background

Hunter-Gatherers (HGs) are among the earliest forms of human societies, characterized by subsistence strategies based on hunting wild animals, fishing, and gathering naturally available plant foods such as fruits, nuts, roots, and honey. Globally, HG communities represent the foundational stage of human adaptation, existing long before the development of agriculture and settled civilizations (Lee and Daly, 1999). Their livelihoods are intimately tied to ecological systems, relying on seasonal resource availability and deep traditional ecological knowledge to sustain their survival and social organization (Kelly, 2013).

These communities are distributed across all inhabited continents, with notable examples including the San (Bushmen) of Southern Africa, the Hadza of Tanzania, the Mbuti of the Congo Basin, the Inuit of the Arctic, and the Aboriginal peoples of Australia. Despite geographical differences, they share common social traits such as egalitarianism, mobility, and communal sharing of resources (Woodburn, 1982; Lee, 2018).

In the contemporary world, most HG communities face increasing threats from deforestation, habitat loss, land alienation, and climate change, which undermine their traditional ways of life (Marlowe, 2010; Reyes-García and Pyhälä, 2017). However, they remain crucial custodians of indigenous knowledge and biodiversity conservation, offering insights into sustainable living and human adaptation to environmental change (Hill et al., 2017).

Therefore, this paper calls for resource mapping amid the global climate crisis for the protection of the Hunter-Gatherer (HG) community livelihood in northern Tanzania. It acknowledges that now global climate change is factual, and it is evidenced by a myriad of related impacts resulting from the climate crisis (Martín-Esquivel et al., 2022; Skogen et al., 2018). The HG community's survival on earth depends on the hunting of wild animals and gathering of natural providence like honey, fruits and roots are more vulnerable to climate crisis (Summary et al., 2019) communities of this kind are famous in the African continent. For instance, the Mbuti Pygmies of the Democratic Republic of Congo (Hart and Hart, 1986). The Okiek in Kenya (Jones and Tibesasa, 2022; Jones, 2020), the Khoi-San in South Africa (Hitchcock, 2014) the Oldowan of Sudan, etc. Almost every east African country has these communities or shares a history of having the same, communities that depend solely on nature.

The Akie and Hadzabe are HG communities found in northern Tanzania, Akie in Kiteto District (Kimana and Ngapapa Villages) Hadzabe in Mbulu District (Yaeda Chini and Mongo wa Mono Villages) both in Manyara Region (Bwagalilo and Mwakipesile, 2012).

These communities' livelihoods are mainly hunting wild animals and gathering/collecting honey, fruits, and roots. However, due to increased interaction with other communities, there is little farming in patches of their communities. Despite that, the most privileged activity is hunting and collecting honey. These activities are moreover gender sensitive. Men are highly and mostly engaged in hunting and collecting honey while women are engaged in collecting fruits and roots and preparing food for the family. The main type of food is wild meat and a local drink known as Lukumee in the Akie language or Ngambu in Maasai (Baobab juice mixed with honey). Hunting used to be the main livelihood of the HG communities but currently ranks second. There is little agriculture in these communities by observation, but it is not very significant to be considered as one of the activities by HG communities. Based on the globally documented impacts of climate change around the world, immediate measures are needed to protect HG communities from the escalating direct and indirect impacts of climate change (Riggio et al., 2021; Thompson et al., 2021; Kimaro et al., 2020; Sangeda and Malole, 2022). Recent research highlights the importance of participatory resource mapping for safeguarding indigenous livelihoods and ensuring equitable land use in the context of environmental threats (Waldman et al., 2021; Komakech et al., 2023).

Based on data collected in Manyara region where the H&G communities are found, the paper calls for resource mapping over conventional village land use plans to enhance HG livelihoods. It employed observation, focus group discussion, and a participatory geographical information system. Findings call for Resource Mapping (RM) so as to document and assign the right of use to a different group in a community, in this case, the focus is on HG community livelihood. According to IIRR (1998).

Collating and plotting information on resources is referred to as Resource Mapping (RM) it is one of the participatory methods and it

involves the assessment of occurrence, distribution, and use of resources within the economic and cultural domain of a specific community. From this perspective, we call for RM that will consider the H&G community and protect their livelihood and rights of living (IIRR, 1998).

The Paper first outlines the climate and land use of the H&G community, then discusses how climate change affects their livelihoods, and concludes by arguing for the importance of RM in protecting the HG community's livelihood in Tanzania.

1.1 Statement of the problem

Hunter-Gatherer (H&G) communities in northern Tanzania, such as the Akie and Hadzabe, face mounting threats to their traditional livelihoods due to the accelerating impacts of climate change, agricultural expansion, and increasing population pressures. These forces have disrupted access to critical natural resources, undermined traditional mobility, and intensified land use conflicts with neighboring groups. Current land use planning frameworks fail to adequately protect the rights and resource needs of H&G communities, risking their food security, cultural identity, and long-term survival. There is an urgent need for integrated resource mapping approaches that recognize and safeguard the unique livelihood routes and resource zones of H&G communities, ensuring their sustainable coexistence with other land users in the region.

2 Materials and methods

In order to understand the challenges facing Hunter-Gatherer communities in northern Tanzania and to identify measures that could safeguard their livelihoods, this study employed a range of research methods tailored to the unique social and ecological context of the region. By integrating historical, descriptive, and analytical approaches, the research aims to provide an in-depth examination of resource use, land dynamics, and the impacts of climate change within selected villages. The following section outlines the material and methods utilized to achieve these objectives.

2.1 Study area

The primary focus of this study was on communities representing Pastoral, Hunter, and Gatherer (P & H-G) groups. To achieve the research objectives, six villages were selected for investigation: Mongo wa Mono (Mbulu District), Basutu (Hanang District), Kimana and Ngapapa (Kiteto District), as well as Namalulu and Terrat (Simanjiro District). These villages are recognised for their diverse populations of P, H & G communities. For example, the Hadzabe (H & G) reside in Mongo wa Mono village, the Bargaig (P) in Basutu Village, the Akie (H & G) in Ngapapa and Kimana Villages, and the Masaai (P) in Namalulu and Terrat Villages. Map below illustrates the geographical location of both the study area and the broader region. However, this paper focuses only on the H & G villages which are Ngapapa and Kimana.

2.2 Data collection methods

The study employed several approaches to gather comprehensive data, including direct field observations, historical survey with ethnography, and participatory mapping exercises. These varied methods enabled researchers to thoroughly examine the livelihood strategies, resource use, and environmental challenges faced by H&G communities. By integrating both qualitative and quantitative data collection techniques, the study ensured a holistic understanding of the complex social and ecological dynamics within the selected villages.

2.2.1 Historical survey with ethnography

This method combined historical analysis with ethnographic fieldwork to explore past events, land use transformations, and socio-cultural dynamics within the study area. Researchers engaged with local communities using participatory approaches such as semi-structured interviews, direct observation, field notes, genealogical tracing, and audiovisual documentation. This integrative approach enabled a deeper understanding of both insider and outsider perspectives on historical land use and livelihood changes, while preserving community narratives and local memory (Bernard, 2017; Creswell and Poth, 2018).

2.2.2 Descriptive survey

The descriptive survey approach involved systematic field observations aimed at documenting livelihood patterns, land-use practices, natural resource utilization, and socio-economic activities within the study area. Researchers employed direct observation to capture real-time conditions and human–environment interactions, providing an empirical basis for understanding local dynamics. To enhance reliability and validity, observational data were cross-referenced with findings from interviews, focus group discussions, and documentary reviews. This triangulation ensured comprehensive and credible insights into community practices and environmental change (Kothari, 2004; Creswell, 2014; Yin, 2018).

2.2.3 Analytical survey

Quantitative data on climate variables and land use/cover were obtained and analyzed using Geographic Information Systems (GIS) to assess spatial and temporal trends. Statistical techniques were employed to detect patterns, correlations, and dynamic forces influencing land use changes and climatic variations. Data validation was achieved by cross-verifying analytical results with findings from complementary qualitative and quantitative approaches, ensuring consistency and accuracy of interpretation (Bryman, 2016; Longley et al., 2021).

3 Results and discussion

3.1 The state of climate and land use patterns in H&G communities

Rainfall in the Manyara Region exhibits a bimodal pattern, which has shifted to a unimodal regime, indicative of semi-arid conditions (Nyembo et al., 2022). The daily average temperature is approximately 22 °C. The hot months are July, August, September, October, and November. The Cool months are March, April, May, and June.

Although there are remarkable variations for precipitation; the district is receiving an average of 350 mm - 700 mm of rainfall. There is only one rainy season which is between January and May.

Its land use always reflects the climate, norms, and values of a particular community; the way of life of a community defines both the level and type of interaction (Stehfest et al., 2019a,b; Kimaro et al., 2023). The Tanzania Land Act (1999) defines customary land use patterns that are historically based and culturally oriented. However, with the ongoing proliferation of land use conflicts, legalization of land use is becoming more important than ever—in Mbulu District for example, particularly in areas where the Hadzabe reside, there are both customary and statutory land use patterns. The same also manifests in the Akie community in Kiteto, where the coexistence of the two land systems is imminent. Like the Hadzabe community, where coexistence of land use patterns results from immigration and rapid change of land use to agriculture, the same also affects the Akie community in Kiteto (Bwagalilo and Mwakipesile, 2012; Kimaro et al., 2023).

Table 1, illustrates the distribution of livelihood activities, highlighting gender roles, relative importance, and seasonal patterns. Gathering of fruits and roots emerges as the most significant activity, accounting for 60% of livelihoods and ranked first. This activity is undertaken exclusively by women and is practiced in both the dry and rainy seasons. Hunting and the making of hunting gears, ranked second with 30%, is an activity carried out solely by men and occurs across both dry and rainy seasons. Honey collection, on the other hand, is primarily undertaken by men, though women occasionally participate. It ranks third with a 10% contribution to livelihoods and is predominantly carried out during the rainy season. Overall, the data reflects a clear gender division of labor, with women playing a dominant role in gathering activities and men taking the lead in hunting and honey collection, while seasonality influences the timing of each activity.

The HG way of living is typically nomadic, involving movement from one locality to another and coverage of a very large area. Information from focus group discussions has confirmed the way of life of these communities, which is shaped by their dependence on nature—they therefore move to anywhere that nature can support their needs. In this context, any land that provides their needs is customarily theirs. According to Lee (2001), before colonial rule in Africa, hunter–gatherer communities had sole dominion of the continent for millennia before the advent of agriculture, and 90 % of human history—in Africa and elsewhere—is a history of hunting and

TABLE 1 HG livelihood distribution by type, sex, rank, percentage, and season.

Livelihood	Sex distribution	Rank	%	Season
Hunting and making of hunting gears	Men only	2	30%	Dry season and rainy season
Honey collection	Men mostly and sometimes women also get involved	3	10%	Rainy season
Gathering of fruits and roots	Women only	1	60%	Dry season and rainy season

gathering. To date, in some places the dominion customarily exists, but in regions like Mbulu and Kiteto Districts in Manyara Region, it is threatened by the increased demand for land from non-indigenous communities (Bwagalilo and Mwakipesile, 2012; Kimaro et al., 2023) (see Figure 1).

3.2 Climate change impact on land use patterns of H&G communities

According to the United Republic of Tanzania (URT, 2021a), national climate observations indicate a consistent rise in temperature and increasing rainfall variability over the past five decades. The National Climate Change Response Strategy (NCCRS) 2021–2026 reports that the mean annual temperature has risen by 0.7–1.0 °C since the 1970s, with an average warming rate of about 0.2 °C per decade (as illustrated in Figure 2). Rainfall patterns show pronounced inter-annual and spatial variability, including prolonged dry spells and episodic heavy rainfall events (URT, 2021b; Tanzania Meteorological Authority, 2023). The National

Bureau of Statistics (NBS) 2019 Climate Change Statistics Report further confirms that both drought and flood frequency have increased, leading to observable environmental stresses in many regions (see Table 2).

Projections from URT (2021a,b) scenarios suggest that by 2050, average temperatures across northern Tanzania could rise by 1.5–2.5 °C as illustrate in Figure 3, accompanied by shifts in the timing of rainy seasons. Rainfall totals are expected to remain similar on average but with higher intra-seasonal variability, meaning shorter but more intense rainfall episodes. Such variability affects the stability of woodland, grassland, and freshwater ecosystems that hunter-gatherer groups rely on.

The Hadzabe community of Lake Eyasi Basin (Manyara and Arusha Regions) provides a representative case of the vulnerabilities experienced by hunter-gatherer (H&G) populations in Tanzania. Climate change interacts with land-use change and resource competition to create multiple stressors on their traditional livelihood systems.

Reduced Wild Food and Woodland Resources: Increasing temperatures and recurrent droughts alter woodland phenology, reducing fruiting and flowering of wild trees such as baobab and



FIGURE 1
Study area map.

TABLE 2 Impact of land cover change on livelihood and social set up.

Impacts on livelihood	Impacts on Social Set Up
<ul style="list-style-type: none"> • Lack of wild animals • Decrease in beehive trees • Collapse of the past mobility patterns from one area to another and coming back. The present mobility circle is too short only in the reserved area for Hadzabe in Mongo wa Mono and Domanga • Women and children are the most affected members of the community/family because are the one who collect fruits and roots, now they spent much time searching for food than they used to be • Elderly H&G do not have the capacity to hunt nor to conduct gathering 	<ul style="list-style-type: none"> • Land use conflicts There are land use conflicts particularly between farmers, pastoral and hunters • Loss of cultural strength of the H&G communities- for instance currently the H&G communities female are mostly married by the Maasai simple because the H&G males are not capable of paying the bride price, they used honey and meet previously to do the same but now they cannot use it because it is unavailable. This is threatening the sustainability of these communities, in some years to come there may be no H&G identity, this is calibrated more by the norm currently existing that the H&G males not only they cannot marry from the Maasai, but they can also not marry from their
<ul style="list-style-type: none"> • Men are least affected 	<ul style="list-style-type: none"> • Own communities.

tamarind. Prolonged dry periods also reduce small-game populations and edible tubers, diminishing food security [URT, 2021a,b; United Republic of Tanzania – National Bureau of Statistics (NBS), 2019].

Water Scarcity and Mobility Constraints: The variability in rainfall and increased evapotranspiration rates have caused a decline in seasonal springs and shallow wells, restricting water access during the dry season. Traditional seasonal mobility patterns are increasingly constrained by water scarcity and competing land uses such as agriculture and livestock grazing (URT, 2021a,b).

Habitat and Land-Use Shifts: Land-cover analyses comparing 2004–2014 and 2014–2024 indicate a progressive reduction in woodland area and expansion of cropland and settlement zones around the Eyasi–Yaeda–Manyara corridor. These changes reflect both climate-induced vegetation shifts and anthropogenic pressures, reducing hunting and foraging grounds (URT, 2021a,b).

Health and Nutritional Stress: Recurrent droughts and erratic harvests of wild foods contribute to malnutrition and disease vulnerability. Warmer conditions have led to higher incidences of vector-borne diseases such as malaria in zones previously considered low-risk (URT, 2021a,b).

Socio-Cultural Transformation: As environmental conditions change, many younger H&G members are transitioning toward mixed livelihoods involving agriculture and wage labor. While this diversification may reduce vulnerability, it also erodes traditional ecological knowledge and resource stewardship practices.

URT climate data confirm that climate variability and rising temperatures are already influencing the resource base of hunter-gatherer communities in Tanzania. The combination of increasing heat stress, declining woodland productivity, and competition over water and land is reshaping traditional livelihood patterns. Adaptation responses aligned with the NCCRS (2021–2026),

National Development Corporation (NDC) (2021), and URT (2012b) Adaptation Guidelines—such as community-based forest management, water-source restoration, and livelihood diversification—are essential to safeguard both ecosystems and cultural heritage. All these can be achieved through resource mapping.

Human activities contribute largely to climate change, which is a fact proven by several scientists (Du et al., 2004; Branch, 2009; Carmo, 2008). That is, land use activities among many other factors also contribute to climate change. However, as Gimmi (2010) notes, the nexus of the two impacts negatively the land use patterns of H&G. Recent studies further confirm that the interplay between shifting land use and changing climate accelerates habitat loss and resource scarcity for indigenous communities (Mwakatobe et al., 2021; URT, 2021a). Collection of honey, fruits, roots, and water is highly defined by the routes which, according to responses from the communities themselves, are now far more difficult to traverse than in the past. Among others, climate change appears to be a significant reason for the change in the way of life of hunter-gatherers. Although responses from HG communities (Akie and Hadzabe) do not refer to climate change as a significant reason for the change in their customary land use patterns, their pattern has significantly changed. Among many other reasons for the change, climate change cannot be ruled out as a driving factor in these communities. This is because climate determines the availability of water, fruits, and roots as well as the abundance of wild animals, to name a few (see Figure 4).

The illustrated land use pattern in Figure 2 no longer exists in the Hadzabe community. The H&G communities now spend much of their time in one locality. Unlike before when they used to move with their families and clans, currently, only the heads of the family (the father) move to search for honey and meat. Women and children spend time around the village collecting fruits and roots. The change in the illustrated pattern is due to more varied land use and population growth. The increased population is more engaged in agriculture which involves clearing forests, this has affected the livelihood of these communities since it has led to the destruction of bees' habitats resulting in the limited availability of honey. Bees make honey through pollination (State of the Coast Report (SCD), 2012). Clearing forests for agriculture drives bees to the remaining wooded areas. Moreover, the clearing of forests and rapid increase in population has increased disturbance to wild animals which also led to the migration of the animals to non-disturbed places. Our findings show that the convention of forests to agricultural land results from those who relocated from other parts of the country due to climate reasons and the hope of new life.

The mapping of the Akie livelihood mobility pattern (Figure 5) illustrates the mobility of the Akie in search of food and shelter is also disturbed. The coverage shows a large area of more than a couple of villages. A routine like that of the Hadzabe no longer exists, the Akie community is now hardly found in Kimana and Ngapapa Villages only in the Kiteto District. This brings a concern that the survival and growth of this community are at risk because there is not enough food as it used to be. From the illustration, every spot was for a different purpose in different seasons. For

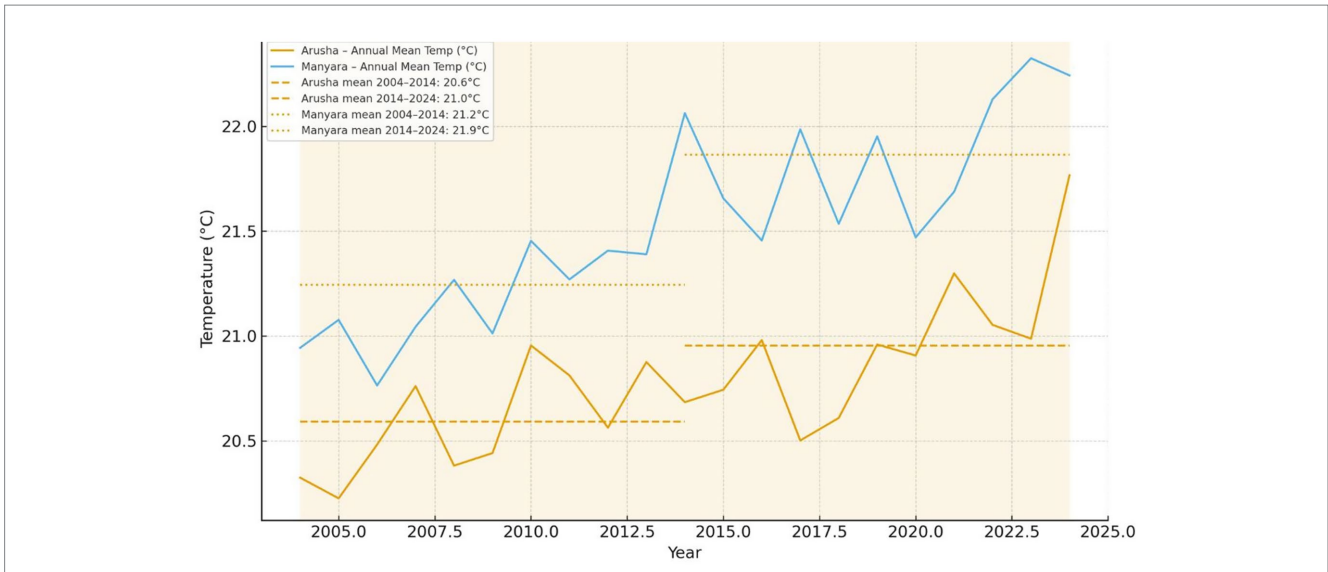


FIGURE 2 Annual mean temperature trends (Arusha and Manyara): 2004–2014 vs. 2014–2024.

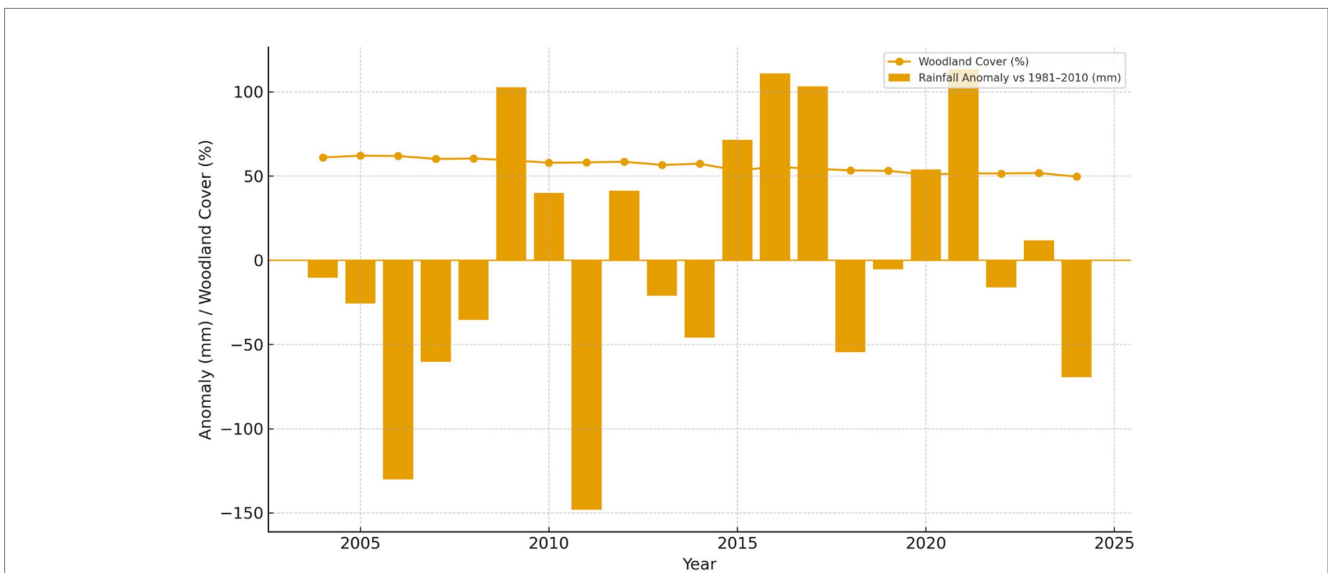
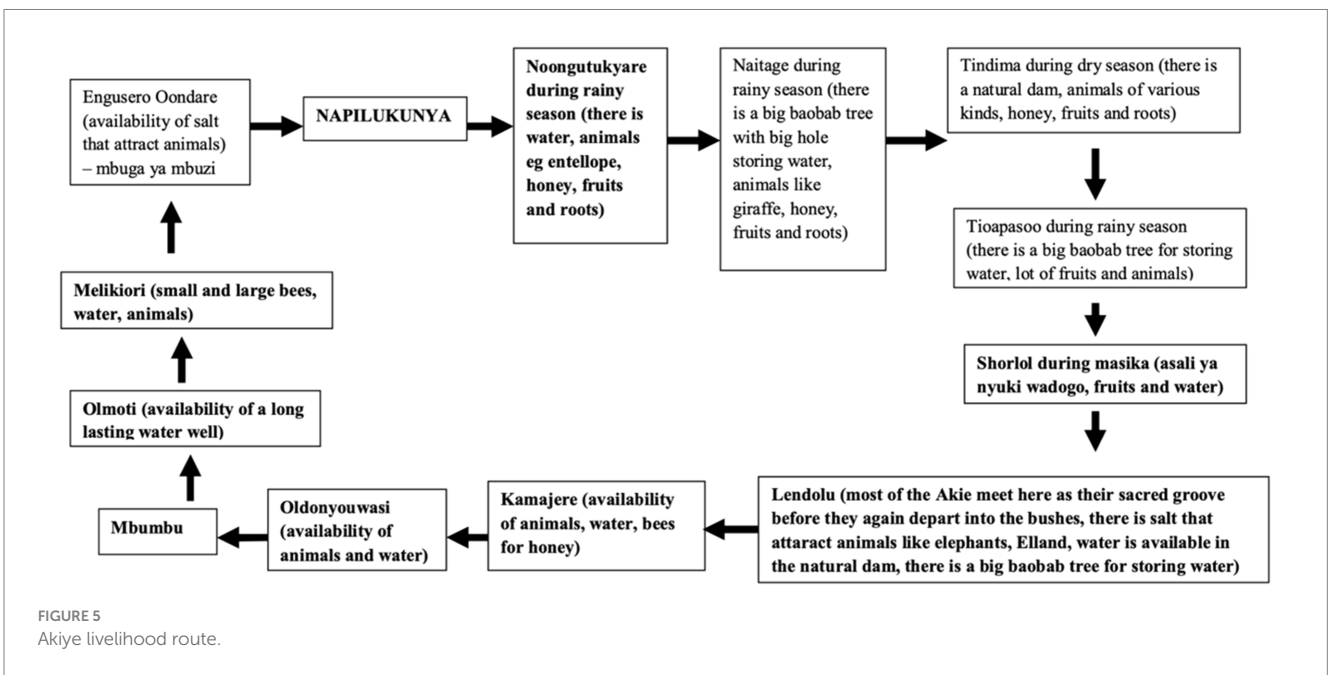
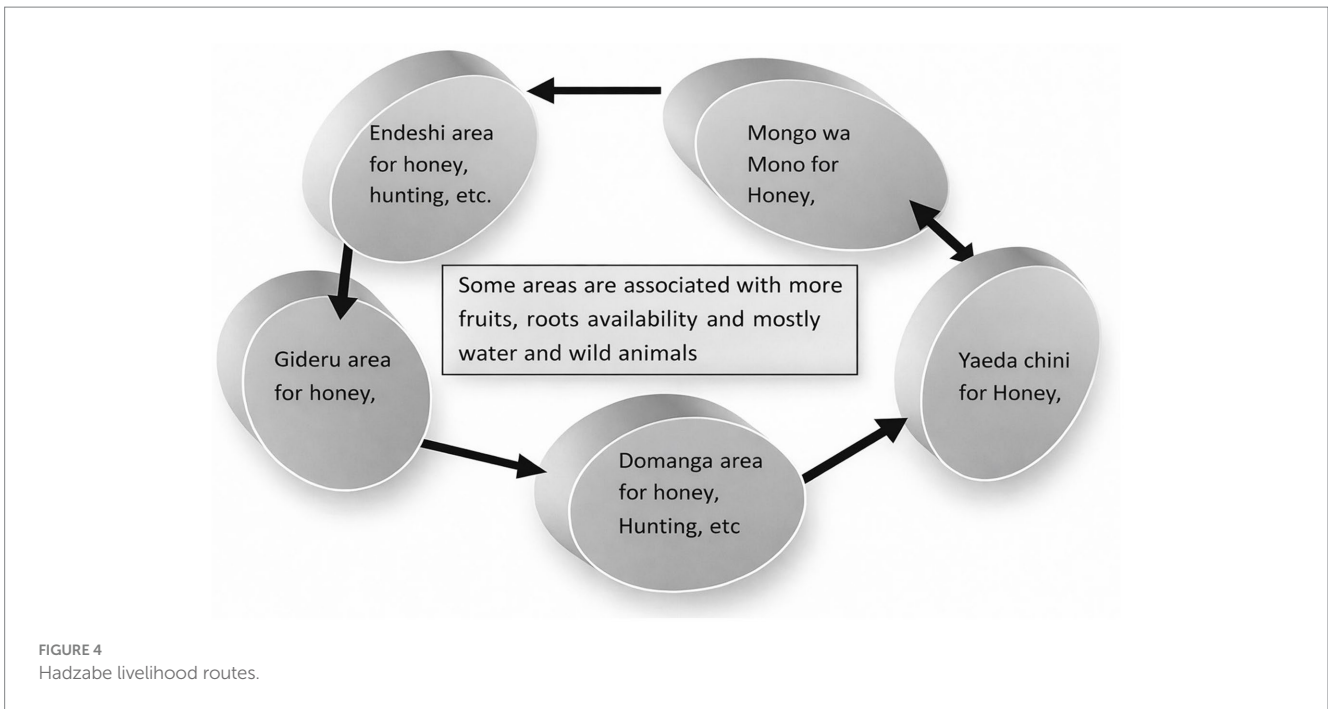


FIGURE 3 Rainfall anomalies and woodland cover change (Eyasi-Yaeda): 2004–2024.

instance, in *Melkiori* there is more honey than in *Enguseri* where there are more wild animals, *Tindima* during the dry season for water because there is a dam that keeps water in the dry season, and there are also various animals that follow the water much more there is honey, fruits, and roots. In *Tiopasoo* during the rainy season, there is big Baobab trees that store water and provide shelter, there are also honey and fruits in the area. Although these communities move from one place to another seasonally, still they have norms and values, and they have their own way of keeping their customs and transferring culture from one generation to another. The Akie for example revealed that they meet at a place

called *Lendolu* once a year, here is where all the Akie from various parts meet for their sacred groove before they leave for other areas. As per the illustration, there is salt that attracts animals like elephants, eland, water is available in the natural dam, there is a big baobab tree for storing water. These customary land use patterns no longer exist. The primary reason for this is the expansion of agriculture and the development of villages, as land previously used by hunter-gatherers for subsistence is now being distributed for different purposes. Among climate change impact is a shift of areas suitable for cultivation. This is true in the context of the HG community where their land has been turned into

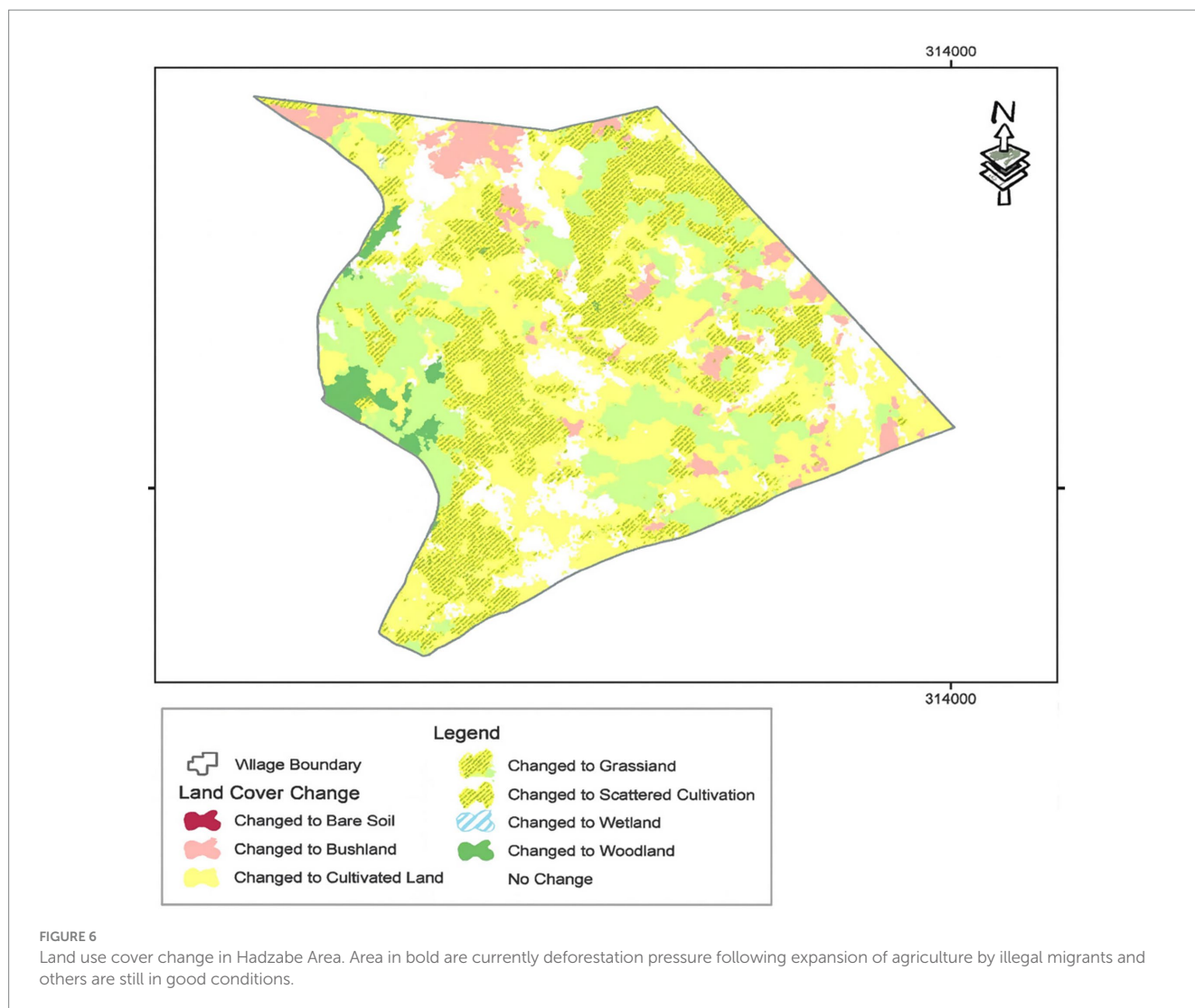


farmland by climate-desperate farmers in the hope of better yields (see Figure 6).

3.3 State of livelihoods in the HG communities

The H&G community’s livelihoods are now in jeopardy of disappearing, and their culture is mixed with other tribes. The main integrated aspect in these communities is agriculture. Hugu

farms have been set up in areas where these communities used to pass through for their survival. Forests have become farmland. There is a notable change in land use in the HG communities, for instance in Mongo wa Mono village, there is a significant transformation of land use, and agriculture appears to have taken a huge part of the transformed land. In the year 1990, the cultivated land was only 27% of the total area and in the year 2010, the cultivated area increased by 15% to make a total of 42% of the cultivated area of the total land of the village. The estimate counts for almost half of the total land of the village. Remote



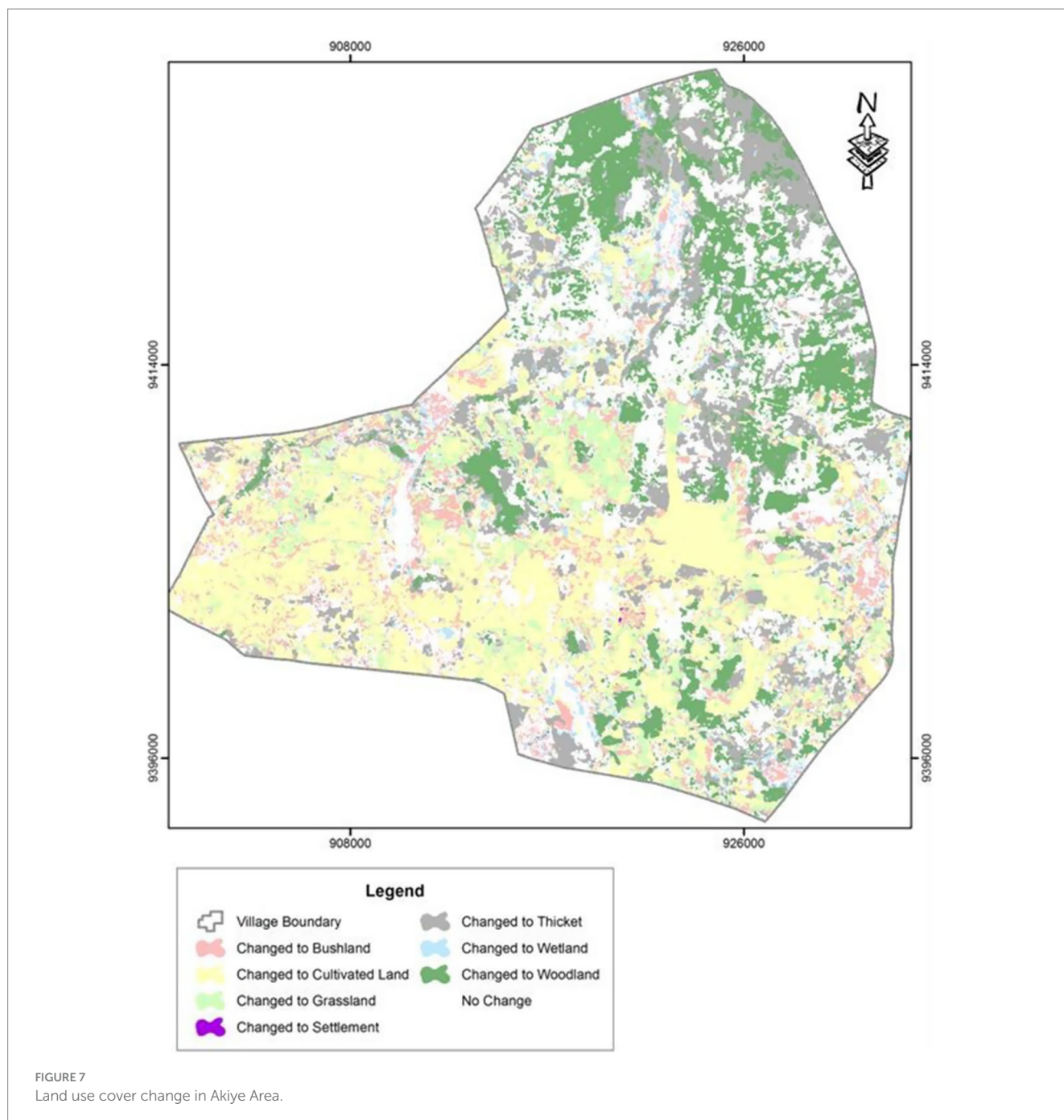
sensing images show that the village covers an area of 48,372 hectares, with 20,317 hectares used for agricultural purposes. Of the total area, 12,626 hectares (26%) are bushland, and 8,609 hectares (18%) have seen land use changes. Farmland now occupies 24% of former bushland and 11% of grassland. These changes give a picture of the distorted livelihoods of HG communities. The change affects the availability and collection of honey, wild animals, and availability of fruits and roots. They push these communities into a new life of cultivation and animal keeping which according to their hundreds of years of culture it is not practical and unviable. Wildlife habitats are highly disturbed and so chased animals away, this has affected the land use and livelihood patterns of these communities. The major change is either from bushland to agriculture, grassland to agriculture, or even wetland to agriculture. The images show agriculture has taken a huge land cover. In Kiteto District, Kimana Village, for example, statistics show a 2% decrease in bushland and a 21% increase in cultivated land, Thickets have also decreased by 21% and about 68 ha of wetland have been into

other use. More than 30% is given for agricultural purposes (see Figure 7).

4 Conclusion

The livelihoods and cultural heritage of Hunter-Gatherer communities in northern Tanzania are facing unprecedented threats due to the intersecting pressures of climate change, agricultural expansion, population growth, and rigid land use plans confined by administrative boundaries. Traditional patterns of mobility, resource access, and social organization are eroding, with women and children bearing a disproportionate burden as they search for increasingly scarce resources. Wildlife habitats and the availability of critical resources such as honey, fruits, and roots have drastically declined, undermining both food security and cultural continuity.

Current village-based land use planning has proven inadequate and, in some cases, has intensified competition and conflict between neighbouring groups. The loss of customary



lands, compounded by the breakdown of cultural norms and inter-community relationships, threatens the very survival and identity of these communities.

Therefore, this Paper strongly recommends the adoption of integrated resource mapping that transcends administrative village boundaries. Such an approach must respect and incorporate traditional knowledge, livelihood routes, and resource zones to ensure equitable access and sustainable coexistence among all land users. Only by embracing participatory, culturally informed mapping strategies can the rights and resilience of Hunter-Gatherer communities be safeguarded in the face of accelerating environmental and social change.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by SJUT-Internal Review Committee. Written informed consent to participate in this study was provided by the village government through relevant governing bodies of the hamlets,

villages, wards, districts, regional, and the Prime Minister's Office Regional and Local Government Authority.

Author contributions

FB: Methodology, Writing – original draft, Conceptualization, Writing – review & editing, Resources.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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