frontiers | Frontiers in Human Dynamics

TYPE Original Research
PUBLISHED 25 August 2025
DOI 10.3389/fhumd.2025.1583234

OPEN ACCESS

EDITED BY
Mussarat Hussain,
University of Sargodha, Pakistan

REVIEWED BY
Amaia Albizua,
Basque Centre for Climate Change, Spain
Maryna De Wit,
University of the Free State, South Africa
Wayde Pandy,
North-West University, South Africa

*CORRESPONDENCE
Kablan Antoine Effossou
✉ kablanef@gmail.com

RECEIVED 25 February 2025
ACCEPTED 05 August 2025
PUBLISHED 25 August 2025

CITATION
Effossou KA, Maphosa M and Moyo P (2025) Assessing climate change impacts in conservation areas and on food systems in the Eastern Cape, South Africa.
Front. Hum. Dyn. 7:1583234.
doi: 10.3389/fhumd.2025.1583234

Assessing climate change impacts in conservation areas and on food systems in the Eastern Cape, South Africa

Kablan Antoine Effossou*, Mandlenkosi Maphosa and Philani Moyo

Faculty of Social Science and Humanities, University of Fort Hare, East London, South Africa

Biodiversity conservation through protected areas has expanded across sub-Saharan Africa (SSA), and South Africa is no exception. However, the interplay between conservation governance, climate change, and food systems remains understudied in rural contexts. This study examined the interconnections among biodiversity conservation, climate variability, and food systems resilience in Alicedale and Seven Fountains in South Africa's Eastern Cape province. Using qualitative methods, the research highlighted key challenges such as limited land access, unequal water availability, high unemployment, and climate induced agricultural disruption. Findings revealed that conservation-related restrictions, coupled with unpredictable weather patterns, undermine local food production and access. Participants proposed adaptive strategies, including shared land access, community boreholes, and small-scale farming initiatives. The study concludes that integrating food security concerns into conservation planning, especially in privately owned reserves, require participatory governance models and attention to historical and institutional inequalities. By contributing empirical insights to debates on environmental justice and climate adaptation, this study highlights the need for inclusive, locally responsive natural resource management in marginalised rural areas.

KEYWORDS

climate change, food systems, biodiversity conservation, environmental justice, resilience, Eastern Cape, South Africa

1 Introduction

Climate change remains one of the most pressing global challenges, profoundly affecting biodiversity conservation and food systems, particularly in sub-Saharan African (SSA) (Wang et al., 2024). According to Sintayehu (2018), anthropogenic climate change, has led to biodiversity loss, ecosystem degradation, and the disruption of rural livelihoods, especially for communities near conservation areas. Approximatively 75% of terrestrial ecosystems and 66% of marine environments, have been adversely impacted by human activities, placing 25% of global species at risk of extinction (Bongaarts, 2019a). In SSA, rural livelihoods are especially vulnerable to climate variability, with impacts varying across ecological zones (Roy et al., 2024).

Protected areas, covering roughly 13% of Earth's land and 1.5% of oceans, play a critical role in biodiversity conservation (Boucher et al., 2013). However, they may unintentionally affect this food insecurity in surrounding rural communities by limiting access to natural resources essential for livelihoods (Masuku et al., 2023). Women, who often depend more directly on land and ecosystems, are particularly affected (Lima and Cunha, 2024). Over 200 million people in SSA remain undernourished, highlighting the urgent need to reconcile

environmental goals with local development needs of addressing these interconnected challenges (Zenda, 2024).

While conservation initiatives aim to safeguard biodiversity and maintain ecological services essential for climate change resilience (Meilani et al., 2021), they sometimes result in the displacement or exclusion of local and indigenous populations from decision-making process (Abukari and Mwalyosi, 2020). The establishment of protected areas has, in some contexts, led to conflict and undermined local food production systems, especially when ecotourism, game farming, or habitat protection priorities overlook community needs (Lambi et al., 2013; Coad et al., 2008).

Developing countries in Africa contribute the least to global greenhouse gas emissions yet face disproportionate climate risks (Fonjong et al., 2024). Food production across SSA is projected to decline by 5% for every degree of temperature rise (Simane et al., 2025; Gashu et al., 2019). Currently, 22% of Africa's population suffers from hunger, a number expected to rise by 2050 without effective adaptation measures (Wudil et al., 2022). Climate data confirm accelerating change (Pisor et al., 2023). The IPCC report in 2018 predicts global surface temperature may rise by 1.4–5.8 °C by 2,100 (Bongaarts, 2019b). Regional trend aligns with this projection: Ghana has experienced a 1.8 °C temperature increases rise over 40 years, alongside with 20% decline in rainfall and a 30% in runoff (Klutse et al., 2020). Similarly, Zimbabwe has recorded a 2.6 °C increase in daily minimum temperature and 2 °C rise in daily maximum, over the past century (Mushawemhuka, 2021). Rising temperatures and extreme weather events, exacerbate food insecurity in SSA, where declining agricultural productivity further deepens poverty (Furtak and Wolińska, 2023).

To address these challenges, a rethinking of the relationship between protected areas, climate change and food systems is needed. Policies must not only promote ecological sustainability but also support rural livelihoods, especially in vulnerable regions. While protected areas deliver critical ecosystem services, their role must be harmonised with the socio-economic realities of nearby communities through inclusive governance and adaptative land use planning.

South Africa exemplifies these complex dynamics, given its rich biodiversity, enduring socio-economic disparities, and evolving conservation landscape (Driver et al., 2012). The Eastern Cape Province, particularly areas such as Seven Fountains and Alicedale, offers a compelling case study. As Cho et al. (2023) note, food systems encompassing production, distribution, and consumption, are closely interconnected with biodiversity and climate dynamics. Rural communities in Alicedale and Seven Fountains, rely heavily on subsistence farming and access to natural resources to sustain food availability and affordability. However, conservation-related land restrictions and climate-induced resource scarcities have increasingly undermined these systems. Here, rural populations depend on subsistence agriculture and natural resources, making them vulnerable to climate-driven shifts in rainfall patterns, droughts, and ecosystem pressures (Amoah and Simatele, 2021). Building on this context, the present study investigates the interconnections between climate variability, conservation areas, and food systems in Seven Fountains and Alicedale. By integrating ecological, social, and agricultural perspectives, this research aims to: (i) assess local perceptions of climate change among rural residents and game reserve mangers; (ii) examine food access and availability in the context of conservation activities; and (iii) propose adaptive strategies that align ecological protection with the development needs of these marginalised rural communities.

2 Theoretical framework for understanding biodiversity conservation, climate change, and food systems

This study is framed through a political ecology lens, which critically examines the socio-political dimensions of environmental change and resource control. As scholars in political ecology have argued, conservation practises often reflect entrenched power dynamics rooted in historical land governance and postcolonial socio-economic structures (Arjaliès and Banerjee's, 2024; Coad et al., 2008).

Rather than presenting these dynamics as uncontested truths, this study draws on established literature as interpretive lenses. For instance, protected areas in South Africa are understood, through the lens of political ecology describes as legacies of colonial resource management. According to Coad et al. (2008) and Abukari and Mwalyosi (2020) colonial conservation policies dispossessed indigenous populations of their land, wildlife, and livestock, often through forced relocation to marginal and ecologically degraded areas. These historical processes continue to influence ecological and social inequalities within contemporary conservation zones.

In response to these developments, researchers have identified the emergence of "fortress conservation" models, approaches that prioritise wilderness preservation while marginalising local communities (Das, 2024). Arjaliès and Banerjee (2024) argue that such models replicate colonial logics of exclusion and reproduce environmental injustice through state-private conservation partnerships that often sideline community participation.

To further analyse these dynamics, this study drwas on Amartya Sen's entitlement theory (1981), which provides a framework for understanding food insecurity not solely as a lack of food, but as a failure of legal and institutional access to food through recognised entitlments. In rural areas like Alicedale and Seven Fountains, entitlements to land, water, and other natural assets are shaped by historical dispossession and governnace structures that prioritise conservation and tourism over subsistence livelihoods. Climate change further exacerbates these structural inequalities by intensifying droughts, increasing rainfall variability, and reducing agricultural output, especially for those already marginalised in their access to land and livelihoods options (Bongaarts, 2019a; Berteaux et al., 2018), as outlined in Figure 1.

Protected areas themselves are not immune to such disruptions, which challenge both their ecological integrity and the subsistence strategies of adjacent communities.

To guide the analysis of food system vulnerability, this study applies the FAO's four pillar food security framework, which conceptualises food secucity through the dimensions of availability, access, utilisation, and stability (FAO, 2006). Availability refers to the physical presence of adequate quantities of food, which is influenced by conservationrelated restrictions and climate variability. Access involves the economic and pysical ability to obtain food, often undermined by unemployment and exclusion from land use decisions. Utilisation relates to food quality and safety, which are compromised

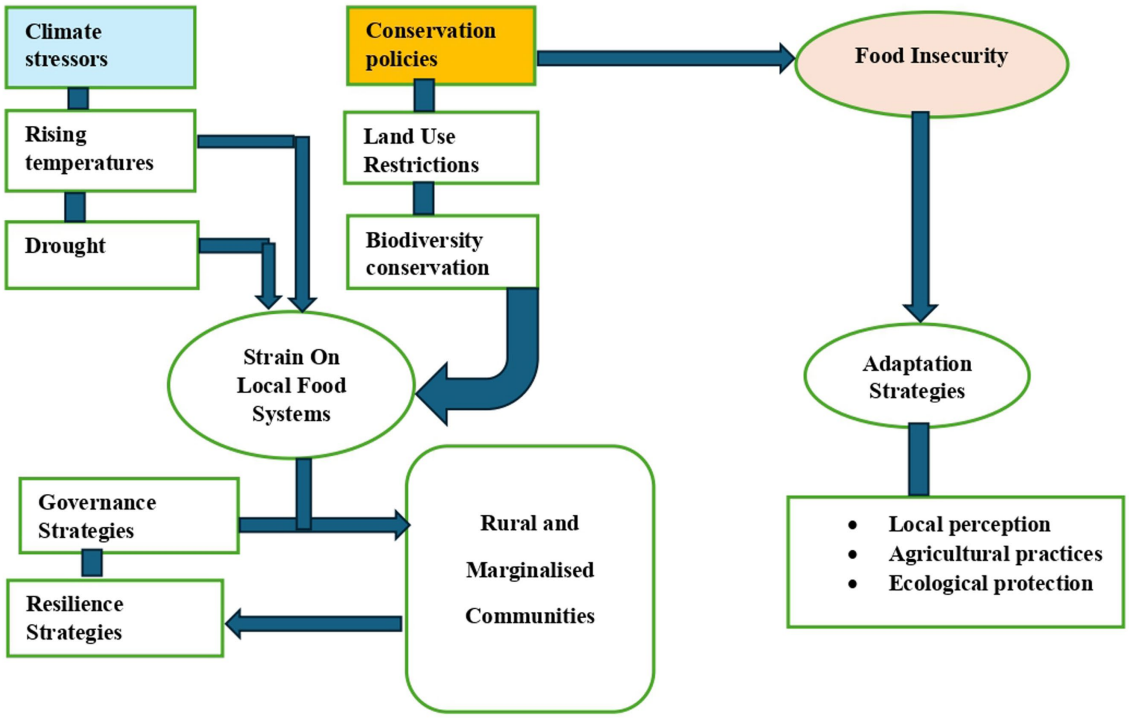

FIGURE 1
A conceptual diagram linking climate stressors, conservation policies, and food security outcomes. Source: Authors, 2025.

in regions lacking services and infrastructure. Stability refers to the consistency and reliable supply of food over time, which remains precarious under conditions of environmental stress and socio-political marginalisation.

These frameworks are not applied prescriptively, but rather as analitycal tools to structure the interpretation of the empirical data. In doing so the study contributes to a growing body of reserch that calls for inclusive, community-responsive conservation strategies that are ecologically sustainable and socially just.

3 Study area, background, materials and methods

3.1 Study area background

South Africa has achieved significant agricultural success, with a 12% increase in production and exports by 2024 through commercial and small-scale farming (Edwards, 2024). The country ranks among the top global producers of chicory root (4th), grapefruit (4th), cereals (5th), green maize (7th), and pears (9th). In 2022, livestock production was dominated by cattle and pigs, which together accounted for approximatively 43% of total livestock output, while sheep made up about 57% (FAOSTAT, 2024). In the Eastern Cape Province, animal production drives 75% of agricultural output, while horticulture (primarily export-oriented and dominated by large -scale white farmers) contributes 20% (Tokozwayo et al., 2018). However, black small-scale family farmers remain marginalised in the food value chain. They typically grow subsistence crops such as maize, beans, sorghum, and leafy vegetables, and often face insecure land tenure under communal systems (Aliber and Hall, 2012). Many do not own the land they farm, face insecure tenure arrangements, and operate on rain-fed plots with minimal access to irrigation or mechanised equipment. These farmers generally do not participate in commercial agricultural markets and have limited access to credit, extension services, and agro technologies (Fanadzo and Ncube, 2018). Some also work seasonally on large white-owned farms, often without formal contracts. The province contributes 7.7% to South Africa's GDP, with rural areas accounting for 34% of its economic growth [ECSECC (Eastern Cape Socio Economic Consultative Council), 2022]. The province is situated within the Albany Thicket biome, a biodiversity rich area characterised by spiny shrubs, various succulents, and scattered forest patches. The landscape is predominately hilly, with elevations ranging from 300 to 700 metres above sea level (Lubke et al., 1986).

Rain-fed agriculture dominates rural South Africa, rendering it highly climate-sensitive (Juana et al., 2013). Projected temperature increase (1–3 °C) and rainfall reduction (5–10% by 2050) may reduce yields by 10–20% (Jones and Thornton, 2009). These impacts disproportionately affect most disadvantaged Eastern Cape communities, where land access is constrained by expanding game reserves (Molua, 2009; Chanamuto and Hall, 2015; Stuma, 2020). The Eastern Cape is the poorest province in South Africa (Statistics South Africa, 2017) and relies heavily on land and natural resources for livelihoods (Shackleton and Shackleton, 2004). However, inequitable resource sharing between local communities and game reserves does appear in many circumstances to exacerbate poverty, intensifying pressure on conservation areas and the adjacent population (Thondhlana and Cundill, 2017). The study area, encompassing Seven Fountains and Alicedale is characterised by extensive private game reserves, which are predominantly owned and managed by private South African companies. These sites exhibit

regional variations in water access, with Seven Fountains having more acute water scarcity due to informal settlement patterns and limited infrastructure.

3.2 Study area, materials and methods

This study used a mixed-methods approach combining in-depth interviews and focus group discussions (FGDs), which were conducted between July and August 2024 in the Makana local municipality of South Africa's Eastern Cape province, (33.3089 ° S, 26.5373 ° E).

A stratified random sampling (SRS) technique was employed to ensure representation across key variables, including gender, ethnicity, and proximity to game reserves. The final sample comprised 60 participants: 40 females and 20 males; 45 Black, 12 Coloured, 3 White South Africans. Participants ranged in age from 21 to 75 years. These strata were selected based on demographic patterns observed in the 2017 Statistics South Africa community profile of Alicedale and Seven Fountains. Participants were drawn from two target groups: (i) adjacent rural communities (Seven Fountains, and Alicedale) and (ii) private game reserves: stakeholders (Amakhala and Lalibela game reserve) along the N2 highway, hosting the 'Big five' (lion, elephant, rhino, buffalo and leopard) and other wildlife species. All the target groups were selected because of their involvement in game reserves and have knowledge of climate change and food systems. Participants were initially recruited through interviews with local community leaders, thereafter, snowball sampling, and the SRS technique were employed to identify additional and hard to reach participants who were not initially accessed through these local networks, ensuring diversity across key demographics (Mack, 2005). Data collected from early interviewees also informed identification and recruitment of suitable participants for the FGDs.

A total of 60 participants were engaged in the study. Of these, 58 were community members: 35 from Alicedale and 23 from Seven Fountains who took part in individual interviews, and three FGDs. In addition, four key informants were interviewed: one each from Alicedale and Seven Fountains, and one each from the Amakhala and Lalibela game reserves. A detailed participant profile is provided included in Appendix A as well as participants profile summary in Appendix E which includes information on gender, age category, location, and participant roles.

The sample comprised community members from each of the selected rural communities as well as two managers from the game reserves. The reserves are privately owned, and the communities consist of ethnically diverse South Africans. Seven Fountains lacks formal educational infrastructures. Residents live in an informal settlement approximately 5 km from Lalibela Game Reserve along the N2 highway. In contrast, Alicedale is a semi-rural area located about approximately 35 km from Lalibela Game Reserve and 30 km from the N2. Both communities face high unemployment rates (> 80%), rely on informal sector, and limited access to water and arable agricultural land (Statistic, South Africa, 2017).

The research method comprised of key informant interviews which targeted individual respondents and focus group discussion (FGDs) (Frost, 2011; Anderson, 2010). Those two survey tools were used to assess the participants' perception on the impacts of climate change on biodiversity conservation and food systems in the selected study zones.

The FGDs were conducted in Alicedale and Seven Fountains with the participants' consent to obtain in-depth information from rural communities who have experienced climate change and conservation effects on their food systems. However, participants who do not have experience in climate change effects or on restricted measures on biodiversity conservation were not excluded as participant as, they were all knowledgeable about the research topic (Joshi et al., 2017). Three FGDs were conducted, one consisting solely of males, one exclusively of females in Alicedale aged 21 to 65 and one mixed gender in Seven Fountains age 25 to 75 to capture gendered perceptions and ensure safe space for expression. Facilitators were gender-matched where possible. Separate groups allowed for freer discussion, particularly for women who may have been silenced or marginalised in mixed groups. Although ethnicity-based segregation was not applied, facilitators were trained to be sensitive to ethnic power dynamics and ensured all voices were heard equally. No significant inter-group conflict emerged during the discussions, though some participants expressed distrust toward conservation managers.

Each FGD included six to ten participants and was audio-recorded with participants' consent (De Vos, 2011). Open-ended questions were used to guide the discussions, which focused on the impacts of climate change, biodiversity conservation, and local food systems. In-depth interviews were conducted individually and lasted approximately 30 to 45 min, while each FGDs lasted around 45 to 60 min. The interview and FGD protocols were semi-structured. Sample interview questions included: "what changes in weather patterns have you observed over the past ten years?" "How have conservation areas affected your farming or food access?" and "Do you feel included in decision-making about land use or game reserves?" A completed set of guiding questions is provided in Appendix F, comprising prompts designed to stimulate and structure the discussion. Confidentially and anonymity were ensured during the fieldwork. According to MacMillan et al. (2002) this method was used because the intention was to allow the researchers' to better access the real perception of the respondents of the game reserves and rural communities' opinion on the relationship between climate change effects, conservation areas and food systems. Inform consent was obtained from all participants prior data collection. In addition, ethical clearance for this study was obtained from the University of Fort Hare Inter-Faculty Human Research Ethics Committee (IFHREC).

Manual coding of interview and FGD transcripts was conducted using thematic analysis (Saldana, 2009), with data organised by location and participant type. A folder was created for each area where the data was collected with name given to each. Such manual coding allowed the researcher to transcribe exactly what the respondents said in each page with a clear title, which was critical for interpreting the data collected (Bailey, 2008). Each transcript was labelled, and pseudonyms were used to protect identities. The results from interviews and FGDs are presented in the form of descriptive narratives. The quotations in the results section are derived directly from participants' contribution during the fieldwork.

4 Results

This section presents the empirical findings derived from key informant interviews and focus group discussions conducted in Seven Fountains and Alicedale. Thematic analysis identified four majors' themes: (i) perceptions of climate change effects, (ii) food availability, (iii) food access, and (iv) adaptation strategies. Each theme is presented with illustrative quotes and contextual information about the participant, to enhance analytical transparency and ensure representation of different voices.

4.1 Perception of climate change effects

The feedback from participants indicated that climate change was widely recognised as a major challenge affecting food production in the Eastern Cape. Participants consistently reported significant climate change-related disruptions, especially water scarcity, prolonged droughts, and unpredictable rainfall patterns. Based on the participants' point of view during key informant interviews, household interviews and focus group discussion highlighted this weather pattern have led to declining agricultural productivity and disrupted livestock management. As stated, by, Tintswalo, a male ward leader from Seven Fountains:

> *'In Seven Fountains irregular rain patterns make it hard to maintain crops and livestock, local water supplies aren't sufficient. We do not have reliable water sources to water our crops*. (Key informant interview (KII), Tintswalo, Seven Fountains July, 2024).

Similarly, rural community members in Alicedale discussed during gender-specific FGDs how climate unpredictably negatively affects planning agricultural yields activities due to unpredictable weather patterns, resulting in reduced crop yields. Senzo, a young male FGD participant, described the compounding impact of land scarcity and change weather:

> *"We used to plant maize in summer, but now we do not know when the rain will come. Sometimes it rains, sometimes it does not. Our land is small, and near the game reserve, we cannot expand."* (Senzo, Alicedale, August 2024).

In addition, Nokuthula, a middle-aged ward leader in Alicedale, highlighted inequality in water:

> *"There is a lack of support or infrastructure to mitigate these climate changes effects. However, game reserve developers have more access to water resources during dry season with five boreholes in one game reserve.'"* (KII, Nokuthula, Alicedale, August 2024).

Participants across both sites expressed that conservation practises exacerbate community vulnerability to climate change by prioritising wildlife and tourism needs. Itumeleng during the female FGDs in Alicedale said:

> *'The establishment of those game reserves has restricted farming activities and access to essential resources."* (FGDs, Alicadale, July 2024).

Interestingly, the two game reserves managers interviewed held similar concerns, although from an ecological standpoint, particularly around wildlife impacts due to reduced water availability. Even Gift, a male game reserve acknowledged ecological strain. As stated by Gift:

> *"With rivers drying up, we are losing waterbirds. There has been a drastic reduction in bird and antelope life around the rivers, which is connected to water availability."* (KII, Gift, game reserve 1, August 2024).

These reflections underscore the shared recognition of climate change across community and reserve actors although from differing perspectives.

Participants widely reported that these reserves are privately owned by South African companies. They are operated for ecotourism and conservation purposes, with limited public oversight and community co-management. As Dekersen, a male game manager stated:

> *"The reserve was sold about six or seven years ago by previous owner to the current owners and transformed into a conservation project. Tourism now funds our conservation work."* (KII, Dekersen, game reserve 1, August 2024).

Their private ownership structure means decision about land use, water access, and employment are primarily controlled by reserve management, which has created tensions between local community interest and conservation goals.

4.2 Food availability

Participants noted that conservation-related land restrictions limited agricultural space, affecting household food production. In both villages, participants rely on subsistence gardens, but yields are insufficient. Njabulo a retired male in Alicedale explained:

> *"Households cannot store much food and forcing communities to rely on external markets. This dependence increases food costs and reduces the quality of available food."* (Njabulo, Alicedale August 2024).

Without local food processing and storage infrastructures, dependence on external food systems amplifies food insecurity. Climate change and conservation areas appear to be affecting food availability. Transport challenges were raised repeatedly. Ntokozo, a youth community member from Alicedale stated:

> "*The distance to town is far, and there is only one gravel road. If it rains or animals are loose, we are stuck*." (Ntokozo, Alicedale, July 2024).

Maloba, Alicedale community elder noted:

> *"Sometimes elephants block the gravel road from here to the highway. In the rainy season, that road becomes dangerous and slippery"* (Maloba, Alicedale, August 2024).

4.3 Food access

The study found that social, physical and financial vulnerabilities intersect to restrict food access. As shown in Table 1, both Seven Fountains and Alicedale possess weak physical infrastructure and limited economic opportunities. This makes communities members more reliant on natural resource as their primary asset intensifies community dependence on natural resources.

The results of the study showed that all the participants held similar opinions on weak physical and economic assets. This dynamic significantly influences the relationship between food access and game reserves. During key interviews and FGDs, participants explained that conservation land use patterns prevent them from farming and raising livestock. Participants highlighted unemployment and high food prices as central concerns. Hulisani, a community member from Alicedale, said:

> *"Most community members do not have a stable income, probably around 90% do not. A few have seasonal work in the game reserves or odd jobs, but there's no reliable source of income, which makes life very hard."* (Hulisani, Alicedale, August 2024).

Another participant in Seven Fountains held a similar opinion to the community member in Alicedale regarding the financial assets and access to food. Siyabulela, a male youth in Seven Fountains, said:

> *"The food prices have really gone up. I think part of that is due to transport costs and the fact the food is coming from far away."* (Siyabulela, Seven Fountains, August 2024).

TABLE 1 Participants' views on the interactions between climate change, services and infrastructure and food systems in Seven Fountains and Alicedale.

Services and infrastructure	Description	Impact of climate change on infrastructure/services	Impact of infrastructure/ services on food systems
Roads	No all-weather roads in the area; subserviced gravel road; not functional during heavy rain.	Heavy rains cause flash floods which exacerbate road damage, making transport unreliable and impeding access to markets and essential services.	Poor road infrastructure limits access to food markets, hinders transport of agricultural inputs and outputs, and increases food transportation costs.
Health centres	One mobile clinic (Seven Fountains) with very limited infrastructure, offering only basic health services. Neither Seven Fountains nor Alicedale has the capacity to handle critical health case.	Increased heat stress and disease outbreaks due to climate change strain limited health resources, further disrupting service delivery.	Poor health services lead to increased vulnerability to malnutrition and disease, affecting the ability to work and produce food.
Market area	No formal market in the area, except for a few "spaza" shops in Alicedale that provide minimal daily necessities.	Climate-related disruptions to supply chains sometimes leads to shortages and price fluctuations in the limited available goods. Extreme heat can affect the storage of food in the household.	Lack of formal markets limits access to diverse and affordable food options, increasing dependence on unreliable external sources.
Transport	No public buses serve the area. Residents rely on private local commuters or walking to the N2 highway to catch a bus to the nearest town like Grahamstown.	Extreme weather events such as flooding disrupt transport routes, isolating communities and hindering access to essential goods and services.	Limited transport options restrict access to food markets, employment opportunities, and essential services, impacting food security.
Access to clean water	Two boreholes service all the villages.	Drought conditions and increased evaporation reduce borehole yields, leading to water scarcity and potentially affecting water quality. In addition, some game reserve animals escape from the reserves to seek for water outside.	Insufficient access to clean water impacts agricultural production, livestock health, and household food preparation, compromising food security.
Agriculture extension services	Limited agricultural services are provided by the government or local authorities	Climate change necessitates adaptive agricultural practises, but the limited extension services provisioning hinders the dissemination of relevant information and support. Surrounding game reserves not doing much to support the communities with respect to climate change education	Limited extension services limit the adoption of climate-resilient farming techniques, reducing crop yields and impacting food production.
Social welfare services	Poor social welfare services within the area	Increased vulnerability to climate-related shocks and stresses places additional strain on already limited social welfare resources.	Inadequate social welfare services leave vulnerable populations without safety nets, exacerbating food insecurity during times of crisis.

Source: Field study, 2024.

Although the Lalibela game reserve employs more people from Seven Fountains (68%) than from Alicedale (32%) due to proximity, unemployment remains a major constraint.

Certain communities in Seven Fountains and Alicedale held a similar opinion during the FGDs. Rabokala, community member from Seven Fountains, added:

> *"The reserve takes up a lot of land, which limits the farming space. Some plots of land have not been used since the previous white owners left; it has gone unused. If the reserves could open up some of this unused land, interested people could use it to grow their own crops and keep livestock. Many eat from government social grant, of R350."* (FGD, Rabokala, July 2024).

In contrast, Dekersen a game reserve manager, acknowledged local communities' frustrations:

> *"The unemployment rate is high. We cannot hire anyone. The government was supposed to support more job creation, but has not happened"* (KKI, Dekersen, game reserves 2, July 2024).

All these factors hinder access to food in Seven Fountains and Alicedale. Each of the two villages' participants indicated that the most important source of food was the external market. However, a little quantity of food is produced in the back yard and cannot meet the household food requirement. This is happening in both villages, in a context where high unemployment rates have exacerbated food insecurity. Addressing these issues will require a balanced approach that considers both conservation goals and the socio-economic needs of local communities around the conservation areas.

4.4 Adaptation strategies

The study revealed that the Eastern Cape has faced the region's most severe drought conditions in the past two decades.

Adaptation measures were identified at both community and institutional levels. According to the game reserve managers, to face water resources issues within the game reserves, additional boreholes were drilled, and herbivore numbers were reduced to maintain ecological balance during prolonged drought. While communities have begun rotating livestock during droughts. Nokuthula, a ward councilor in Alicedale, described informal adaptation:

> *"During drought, we move our livestock closer to urban zones to improve resources access. It's not ideal, but there is more water. However, challenges such as disease transmission among animals and restricted land access in the Makana local municipality remain key barriers."* (KII, Nokuthula, Alicedale, August 2024).

The study also highlighted the importance of community involvement, particularly in conservation and anti-poaching efforts. Additionally, reserve managers confirmed some collaboration efforts, such as giving leftover wood to community members under controlled conditions, promoting sustainability while supporting local needs.

Several community members suggested that unused land within or near conservation areas could be made available for small-scale farming to improve local food production. Others noted that most food consumed in the area is brought in from outside, with minimal local processing, largely due to inadequate infrastructure and lack of investment in community-based agriculture. As Tintswalo from Seven Fountains explained:

> *"There is land that just sits there inside the fences, no animals, no farming, nothing. If we were allowed to grow just vegetables, it would help a lot."* (KII, Tintswalo, Seven Fountains, July 2024).

According to the two game reserves managers surveyed, addressing basic community needs such as access to water and transportation, could improve food security and provide economic opportunities. While small-scale gardening and livestock farming help sustain communities, they remain insufficient to meet overall food needs. Greater support from local agriculture departments is necessary. These efforts require collaboration between game reserves, local communities, and external stakeholders for sustainable outcomes.

5 Discussion

This study offers an in-depth examination of the intersection between biodiversity conservation, climate change, and food systems in South Africa, focusing on the communities of Seven Fountains and Alicedale. Drawing on theoretical ecology perspective and food security frameworks, the study explores how climate variability and conservation-related land governance intersect to influence rural vulnerability. Through the lenses of environmental governance and dependency theory, it critically interrogates how legacy policies and current conservation models reproduce historical inequalities in land access, food sovereignty, and adaptive capacity.

Participants widely perceive climate change as a significant challenge, citing specific experience such as prolonged droughts, erratic rainfall, and declining agricultural productivity. These empirical insights, supported by quotations from ward leaders and community members, echo existing literature linking rural food insecurity to ecological shocks and infrastructure deficits (Amoah and Simatele, 2021; Wang et al., 2024). Orimoloye (2022), for instance, examined the impacts of drought on maize and sorghum production in the Free State Province, revealing how drought-induced yield declines affect food security.

Importantly, perceptions of vulnerability were not monolithic. Many community members expressed frustration over unequal access to land and water, while game reserves mangers acknowledged environmental stressors and limited employment opportunities. This diversity of perspectives reflects a complex landscape of relationships and constraints, challenging any simplistic binary of inclusion versus exclusion.

Participants emphasised that food systems in both Alicedale and Seven Fountains are severely affected by water scarcity, flash floods, droughts, and unpredictable weather patterns. These hydro-climatic stressors have disrupted traditional practises, reducing both crops yields and livestock productivity. The lack of infrastructure and support systems to mitigate these impacts, such as road, and storage compounds these vulnerabilities, aligning with previous studies in sub-Saharan Africa trends (Adebayo, 2025; Kapuka and Hlásny, 2021).

From a theoretical perspective, this study highlights how structural inequalities, rooted in historical land dispossession

and reinforced by current conservation governance, lead to uneven food system outcomes. However, instead of assuming these dynamics, this discussion draws on participants narratives to demonstrate how exclusion is experienced and understood. For instance, Nokhutula's comments about unequal water access and Rabokala's observations on underused farmland illustrate the tensions between conservation priorities and household subsistence. These align with critiques of fortress conservation, which often marginalised groups from environmental benefits (Boucher et al., 2013; Abukari and Mwalozi, 2020).

Despite these challenges, adaptation strategies remain underdeveloped and insufficiently explored, complicating both conservation and development goals. The findings of this study support food system theories that emphasise vulnerability as a product not only of environmental shocks but also of infrastructural and governance deficits. From a dependency theory perspective, communities' reliance on external food and water systems reflects the ongoing historical legacy of exclusionary conservation policies (Arjaliès and Banerjee, 2024).

Participants noted that game reserves have worsened food system challenges by restricting access to arable land and water. Conservation policies that prioritise wildlife and tourism over community needs have exacerbated land-use conflicts and food insecurity. This supports critiques from scholars such as Rantala and Vihemäki (2011) and Cernea (2006), who argue that displacement from protected areas remains one of the most contentious aspects of conservation. Community members consistently emphasised the inequities in benefit-sharing, noting that despite the vast land allocated to conservation, tangible returns to local communities remain minimal. This reflects the broader political economy of conservation in post-apartheid South Africa, where power asymmetries between developers and communities mirror deeper socio-economic divides (Kegamba et al., 2023).

The legal and institutional context is equally critical. The game reserves studied such as Lalibela and Amakhala, are privately owned by South African companies. As one reserve manager explained: "*The reserve was sold about six or seven years ago…and transformed into a conservation project. Tourism now funds our conservation work.*" This private ownership model means that decisions on land, water, and employment are not subject to the same regulations as state-run protected areas. In South Africa's constitutional context, private property rights are strongly protected, which limits the applicability of certain inclusionary policy recommendation unless negotiated through formal agreements or voluntary benefit-sharing schemes (Murphy, 1993).

By contrast, Namibia's communal conservancies represent a more inclusive governance model, where local communities are legally integrated into tourism revenues-sharing and conservation decision-making. This model has fostered stronger local engagement and fairer benefit distribution (Naidoo et al., 2016). While South Africa's legal context differs, the Namibian example offers insights into more equitable conservation approaches. Similarly, Zimbabwe's CAMPFIRE initiative is referenced not as a prescriptive solution but as an illustrative model requiring contextual adaptation.

The findings also highlight the need for more stakeholders' engagement. While 58 community members were interviewed compared to only two reserves managers, this asymmetry reflects the study's focus on rural perspectives. However, the discussion acknowledges that greater representation of conservation actors would provide a more balanced understanding of their constraints, mandates, and internal dynamics.

Infrastructural inadequacies, such as poor roads and transport systems, further undermine food access, particularly during climate-related events like flash floods. Participants noted that conservation areas have failed to contribute meaningfully to local infrastructure development. These findings align with Ericksen's (2008), food systems model which shows how food security is closely tied to transportation, market access, and storage facilities. Theoretically, this illustrates that food insecurity emerges not just from ecological shocks but also from governance failures and uneven development planning.

High unemployment rates, limited access to resources, and reliance on external food markets have left these communities economically marginalised and food insecure. Game reserve managers themselves acknowledged high unemployment as a key concern. Participants called for interventions such as access, to underutilised conservation land, investment in climate-resilient agriculture practises, and more benefit-sharing models. These align with participatory governance principles, that advocate for devolved decision-making and co-management of natural resources. The results of this study are in line with previous findings by Newing et al. (2024) who show that effective conservation includes indigenous people and local communities, an approach endorsed by the Kunming-Montreal Global Biodiversity Framework in 2022. Key adaptation strategies include temporary livestock relocation during drought, community-based water management such as boreholes drilling, and benefit-sharing models like Zimbabwe's CAMPFIRE, which involve local communities in conservation and tourism revenue.

These examples reflect a broader shift in conservation thinking, from exclusionary, top-down models to approaches that value local knowledge, agency, and socio-ecological integration. However, climate change adaption strategies in Makana local municipality often lack clarity and fail to balance ecological preservation with community livelihoods. The study highlights the need to harmonise biodiversity conservation and food security goals by transitioning to inclusive conservation models that reflect the socio-economic realities of surrounding communities (Raymond et al., 2020).

Although South Africa has made substantial progress in biodiversity conservation, benefit distribution remains uneven and gains often come at the expense of local livelihoods. For instance, land acquisition for conservation frequently excludes adjacent populations, undermining their livelihoods and food security (Crane, 2006). The research undertaken highlights the complex challenges facing rural communities, particularly in terms of food insecurity, limited land availability, and climate change. To address these imbalances, there is a clear need for more effective action that enables communities to be more fully included in land use and conservation decision-making processes.

One potential solution lies in leveraging conservation areas to support community agriculture, thus achieving both ecological restoration and enhanced food security. Integrating agricultural practises with conservation efforts can create sustainable, mutually beneficial systems. Moreover, addressing systematic

issues such as inadequate infrastructure, limited market access, and weak social welfare systems is essential for building resilience.

Practical interventions include community training, promotion of climate resilient farming, and partnerships between conservation organisation and local groups. Such action can empower communities to adapt to environmental changes, while maintaining cultural and economic ties to the land.

Theoretically and empirically, this study shows that addressing food insecurity and biodiversity loss in the Eastern Cape requires dismantling historical structures of exclusion and promoting inclusive and participatory governance approaches. Terms such as exclusion, dependency, and injustice are used here not as normative judgements but as analytical terms grounded in participant testimony and the reference theoretical literature (Sen, 1981; Arjaliès and Banerjee, 2024). Where used, these terms are tied to specific empirical patterns, for example, high unemployment, lack of land access, and unequal water distribution. This approach aligns with qualitative research standard that emphasis transparency and interpretive grounding.

The study also acknowledges internal community tensions. For instance, while some participants prioritised access to unused land for farming, others emphasised infrastructure or water access as more urgent. These variations illustrate the importance of recognising intra-community divergence, which is often overlooked in conservation discourse.

Finally, the authors reflect on the research process itself. While their interpretation was influenced by a commitment to amplifying marginalised voices, they also recognise the importance of reflexivity, considering how theory, sampling, and fieldwork shaped the study's narrative. This transparency enhances the credibility and integrity of the study.

To summarise, the complex interplay between conservation, climate change, and food systems in the Eastern Cape highlights the trade-offs involved in pursuing sustainable development. This study calls for integrated, inclusive strategies that prioritise both environmental and socio-economic outcomes. By fostering equity and collaboration, a more resilient and sustainable future can be achieved for all stakeholders.

6 Conclusion

This study examined the intersection of climate change, biodiversity conservation, and food systems through the perspectives of rural residents and conservation managers in Seven Fountains and Alicedale, Eastern Cape. Using qualitative data from 60 participants, the study found that restricted land access, limited infrastructure, and increasingly variable climate conditions significantly constrain local food production and access. While game reserves play a significant ecological role, their private governance structure and limited community involvement have contributed to perceptions of exclusion and socio-economic marginalisation.

Participants described how unpredictable rainfall, declining crop yields, and high food prices have increased their reliance on external markets and social grants. At the same time game reserves managers acknowledged ecological stress and employment constraints. These findings underscore the need for integrative approaches that consider both environmental sustainability and rural livelihoods.

Rather than proposing one-size-fits-all solutions, the study suggests locally negotiated strategies such as improved benefit-sharing, community-led smallholder initiatives on underutilised land, and investment in climate-resilient infrastructures. These proposals are grounded in the lived experiences and suggestions of participants themselves. The findings also highlight the importance of recognising legal distinctions between public and private conservation areas in South Africa, as these determine the feasibility of reforms. Overall, the study contributes to growing scholarship on environmental justice by demonstrating how participatory conservation, equitable land governance, and climate change can be aligned through context-specific, inclusive decision-making, Future research and policy must focus on building institutional bridges between entities and the rural communities they affect.

The findings of the study have resulted in the following recommendation:

- Inclusive land access strategies: Local and provincial authorities, in collaboration with private conservation entities should explore the feasibility of community use agreement on underutilised land adjacent to game reserves. While full land redistribution may not be legally visible under current frameworks, negotiated access to non-ecologically sensitive land could support small-scale farming without undermining conservation goals.
- Improved water infrastructure: Participants across both communities identified water access as a critical constraint. Investment in boreholes, water tanks, facilitated by government or through partnership with conservation reserves, could enhance agricultural productivity and household resilience during drought periods.
- Context-specific benefit-sharing models: While international examples such as Zimbabwe's CAMPFIRE initiative offer useful insights, benefit sharing in South Africa must be designed within its legal and institutional context. This includes potential revenue-sharing agreements, expanded empowerment, or community development projects aligned with reserve operations. Transparent dialogue between reserves and communities is essential.
- Climate-resilient agricultural practises: Local agricultural department should increase support for community gardens, agroecological training, and access to climate-resilient seeds. These measures can empower residents to improve food availability without heavy dependence on external markets.
- Collaborative governance mechanisms: To address trust deficits and improve co-existence, mechanisms for structured dialogue and joint planning between game reserve managers, and community representatives should be institutionalised. These may include participatory forums, environmental education programs, and local grounded conflict resolution platforms.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by University of Fort Hare, East London Campus South Africa. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

KE: Conceptualization, Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. MM: Formal analysis, Validation, Writing – review & editing. PM: Formal analysis, Validation, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. This work was supported by the National Research Foundation of South Africa under the Future Earth Africa Hub Leadership Centre project [Grant Number: UID 151339].

Acknowledgments

The authors sincerely thank all community members and conservation managers in the interviews and focus group discussions. Their insights, time, and openness made this study possible. We are also grateful to Mr. Assielou Binde Ambroise, Mr. Sita Zolani, and Ms. Ngontsi Gcobissa for their invaluable field and logistical technical support during data.

Conflict of interest

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

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

Any alternative text (alt text) provided alongside figures in this article has been generated by Frontiers with the support of artificial intelligence and reasonable efforts have been made to ensure accuracy, including review by the authors wherever possible. If you identify any issues, please contact us.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fhumd.2025.1583234/full#supplementary-material

References

Abukari, H., and Mwalyosi, R. B. (2020). Local communities' perceptions about the impact of protected areas on livelihoods and community development. *Global Ecol. Conservation* 22:e00909. doi: 10.1016/j.gecco.2020.e00909

Adebayo, W. G. (2025). Resilience in the face of ecological challenges: strategies for integrating environmental considerations into social policy planning in Africa. *Sustain. Dev.* 33, 203–220. doi: 10.1002/sd.3113

Aliber, M., and Hall, R. (2012). Support for smallholder farmers in South Africa: challenges of scale and strategy. *Dev. South. Afr.* 29, 548–562. doi: 10.1080/0376835X.2012.715441

Amoah, L. N., and Simatele, M. D. (2021). Food security and coping strategies of rural household livelihoods to climate change in the eastern cape of South Africa. *Front. Sustain. Food Systems* 5:692185. doi: 10.3389/fsufs.2021.692185

Anderson, C. (2010). Presenting and evaluating qualitative research. *Am. J. Pharm. Educ.* 74, 141–147. doi: 10.5688/aj7408141

Arjaliès, D. L., and Banerjee, S. B. (2024). Let's go to the land instead': indigenous perspectives on biodiversity and the possibilities of regenerative capital. *J. Manag. Stud.* 4, 1–34. doi: 10.1111/joms.13141

Bailey, J. (2008). First steps in qualitative data analysis: transcribing. *Fam. Pract.* 25, 127–131. doi: 10.1093/fampra/cmn003

Berteaux, D., Ricard, M., St-Laurent, M. H., Casajus, N., Perie, C., Beauregard, F., et al. (2018). Northern protected areas will become important refuges for biodiversity tracking suitable climates. *Sci. Rep.* 8:4623. doi: 10.1038/s41598-018-23050-w

Bongaarts, J. (2019a). Intergovernmental panel on climate change special report on global warming of 1.5° CSwitzerland: IPCC, 2018. *Population Develop. Rev.* 45, 251–252. doi: 10.1111/padr.12234

Bongaarts, J. (2019b). Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the intergovernmental science-policy platform on biodiversity and ecosystem services, Population & Development Review, 45:3.

Boucher, T. M., Spalding, M., and Revenga, C. (2013). "Role and trends of protected areas in conservation" in book: Encyclopedia of biodiversity (Waltham, MA. Ed. Simon A. Levin Academic Press). London, UK: Routledge.

Cernea, M. M. (2006). Population displacement inside protected areas: A Redifinition of concepts in conservation policies.

Chanamuto, N. J., and Hall, S. J. (2015). Gender equality, resilience to climate change, and the design of livestock projects for rural livelihoods. *Gend. Dev.* 23, 515–530. doi: 10.1080/13552074.2015.1096041

Cho, M. A., Ramoelo, A., and Sibanda, L. M. (2023). Exploring the integration of the land, water, and energy nexus in sustainable food systems research through a socio-economic lens: a systematic literature review. *Sustainability* 15:16528. doi: 10.3390/su152316528

Coad, L., Campbell, A., Miles, L., and Humphries, K. (2008). The costs and benefits of protected areas for local livelihoods: A review of the current literature. Cambridge, UK., UK: UNEP World Conservation Monitoring Centre.

Crane, W. (2006). Biodiversity conservation and land rights in South Africa: whither the farm dwellers? *Geoforum* 37, 1035–1045. doi: 10.1016/j.geoforum.2006.07.002

Das, B. K. (2024). Beyond the 'protected Area'Paradigm in conservation: exploring India's Forest legislation as a new conservation model for developing countries. *Environ. Manag.* 74, 1223–1238. doi: 10.1007/s00267-024-02056-3

De Vos, A. S. (2011). Research at grass roots: For the social sciences and human sciences professions. Pretoria, South Africa: Van Schaik.

Driver, A., Sink, K. J., Nel, J. L., Holness, S., Van Niekerk, L., Daniels, F., et al. (2012). National biodiversity assessment 2011: An assessment of South Africa's biodiversity and ecosystems. South Africa: SANBI.

ECSECC (Eastern Cape Socio Economic Consultative Council). (2022). Economic review of the eastern cape, Bhisho, Eastern Cape, South Africa: Gross Domestic Product.

Edwards, L. (2024). Trade and industrial policy for South Africa's future: Policy paper 31. Pretoria, South Africa: Economic Research Southern Africa (ERSA).

Ericksen, P. J. (2008). Conceptualizing food systems for global environmental change research. *Glob. Environ. Chang.* 18, 234–245. doi: 10.1016/j.gloenvcha.2007.09.002

Fanadzo, M., and Ncube, B. (2018). Challenges and opportunities for revitalising smallholder irrigation schemes in South Africa. *Water South Africa* 44, 436–447. doi: 10.4314/wsa.v44i3.11

FAO. (2006). Food security: Policy brief. Food and Agriculture Organization of the United Nations. Available online at:https://www.fao.org/forestry/13128-0e6f36f27e0091055bec28ebe830f46b3.pdf

FAOSTAT. (2024), Food and agriculture organisation of the United Nations. Available online at https://www.fao.org/statistics/en. (Access February 2025).

Fonjong, L., Matose, F., and Sonnenfeld, D. A. (2024). Climate change in Africa: impacts, adaptation, and policy responses. *Glob. Environ. Chang.* 89:102912. doi: 10.1016/j.gloenvcha.2024.102912

Frost, N. (2011). Qualitative research methods in psychology: Combining core approaches. London, England: Mc Graw Hill.

Furtak, K., and Wolińska, A. (2023). The impact of extreme weather events as a consequence of climate change on the soil moisture and on the quality of the soil environment and agriculture–a review. *Catena* 231:107378. doi: 10.1016/j.catena.2023.107378

Gashu, D., Demment, M. W., and Stoecker, B. J. (2019). Challenges and opportunities to the African agriculture and food systems. *Afr. J. Food Agric. Nutr. Dev.* 19, 14190–14217. doi: 10.18697/ajfand.84.BLFB2000

Jones, P. G., and Thornton, P. K. (2009). Croppers to livestock keepers: livelihood transitions to 2050 in Africa due to climate change. *Environ. Sci. Pol.* 12, 427–437. doi: 10.1016/j.envsci.2008.08.006

Joshi, A. S., Ganjiwale, J. D., Varma, J., Singh, P., Modi, J. N., and Singh, T. (2017). Qualitative assessment of learning strategies among medical students using focus group discussion and in-depth interviews. *Int. J. Applied Basic Med. Res.* 7, S33–S37. doi: 10.4103/ijabmr.IJABMR_144_17

Juana, J. S., Kahaka, Z., and Okurut, F. N. (2013). Farmers' perceptions and adaptations to climate change in sub-Sahara Africa: A synthesis of empirical studies and implications for public policy in African agriculture. *Journal of Agricultural Science* 5, 121.

Kapuka, A., and Hlásny, T. (2021). Climate change impacts on ecosystems and adaptation options in nine countries in southern Africa: what do we know? *Ecosphere* 12:e03860. doi: 10.1002/ecs2.3860

Kegamba, J. J., Sangha, K. K., Wurm, P. A., and Garnett, S. T. (2023). Conservation benefit-sharing mechanisms and their effectiveness in the greater Serengeti ecosystem: local communities' perspectives. *Biodivers. Conserv.* 32, 1901–1930. doi: 10.1007/s10531-023-02583-1

Klutse, N. A., Owusu, K., and Boafo, Y. A. (2020). Projected temperature increases over northern Ghana. *SN Applied Sci.* 2, 1–14. doi: 10.1007/s42452-020-3095-3

Lambi, C. M., Kimengsi, J. N., Kometa, C. G., and Tata, W. S. (2013). The management and challenges of protected areas and the sustenance of local livelihoods in Cameroon. *Environ. Nat. Resources Res.* 2, 10–18. doi: 10.5539/enrr.v2n3p10

Lima, H. S., and Cunha, H. F. (2024). The role of women and the obstacles to biodiversity conservation in developed and developing countries. *Environ. Dev. Sustain.* 1-25. doi: 10.1007/s10668-024-05407-6

Lubke, R. A., Everard, D. A., and Jackson, S. (1986). The biomes of the eastern cape with emphasis on their conservation. *Bothalia* 16, 251–261. doi: 10.4102/abc.v16i2.1099

Mack, N. (2005). Qualitative research methods: A data Collectors's field guides. North Carolina, US: Family Health International, USAID.

MacMillan, D. C., Philip, L., Hanley, N., and Alvarez-Fari, B. (2002). Valuig the non-market benefits of wild goose conservation: a comparison of interview and group-based approaches. *Ecol. Econ.* 43, 49–59. doi: 10.1016/S0921-8009(02)00182

Masuku, M. M., Mthembu, Z., and Mlambo, V. H. (2023). Gendered effects of land access and ownership on food security in rural settings in South Africa. *Front. Sustain. Food Systems* 7:1158946. doi: 10.3389/fsufs.2023.1158946

Meilani, M., Andayani, W., Faida, F. R., Susanti, F. D., Myers, R., and Maryudi, A. (2021). Symbolic consultation and cultural simplification in the establishment of an Indonesian national park and its impacts on local livelihoods. *Forest Soc.* 5, 494–505. doi: 10.24259/fs.v5i2.11875

Molua, E. L. (2009). The consequences of inaction: Climate change and the challenges for rural and agrarian policy in Africa. Global and Planetary Change. 67, 205–208. doi: 10.1016/j.gloplacha.2009.02.006

Murphy, J. (1993). Property rights in the new Constitution: an analytical framework for constitutional review. The Comparative Int. Law J. Southern Africa, 26, 211–233.

Mushawemhuka, W. J. (2021). A comprehensive assessment of climate change threats and adaptation of nature based tourism in Zimbabwe: University of Johannesburg (Johannesburg: South Africa).

Naidoo, R., Weaver, L. C., Stuart-Hill, G., and Tagg, J. (2016). Effect of biodiversity on economic benefits from communal lands in Namibia. *J. Appl. Ecol.* 53, 96–105. doi: 10.1111/1365-2664.12545

Newing, H., Brittain, S., Buchadas, A., Grasham, C. F., Ferritto, R., del Giorgio, O., et al. (2024). Participatory'conservation research involving indigenous peoples and local communities: fourteen principles for good practice. *Biol. Conserv.* 296:110708. doi: 10.1016/j.biocon.2024.110708

Orimoloye, I. R. (2022). Agricultural drought and its potential impacts: enabling decision-support for food security in vulnerable regions. *Front. Sustain. Food Systems* 6:838824. doi: 10.3389/fsufs.2022.838824

Pisor, A. C., Touma, D., Singh, D., and Jones, J. H. (2023). To understand climate change adaptation, we must characterize climate variability: here's how. *One Earth* 6, 1665–1676. doi: 10.1016/j.oneear.2023.11.005

Rantala, S., and Vihemäki, H. (2011). Human impacts of displacement from protected areas: Lessons from the establishment of the Derema corridor, North-Eastern Tanzania. University of Helinski: University press.

Raymond, C. M., Cebrian-Piqueras, M. A., Andersson, E., Andrade, R., Schnell, A. A., Romanelli, B. B., et al. (2020). Inclusive conservation and the Post-2020 global biodiversity framework: tensions and prospects. *One Earth* 5, 252–264. doi: 10.1016/j.oneear.2022.02.008

Roy, A., Kumar, S., and Rahaman, M. (2024). Exploring climate change impacts on rural livelihoods and adaptation strategies: reflections from marginalized communities in India. *Environ. Develop.* 49:100937. doi: 10.1016/j.envdev.2023.100937

Saldana, J. (2009). The coding manual for qualitative research. Los Angeles, New Delhi, Singapore, Washington DC, USA: Sage.

Sen, A. (1981). Poverty and famines: An essay on entitlement and deprivation. Oxford: Oxford University Press.

Shackleton, C., and Shackleton, S. (2004). The importance of non-timber forest products in rural live-lihood security and as safety nets: a review of evidence from South Africa. *S. Afr. J. Sci.* 100, 658–664.

Simane, B., Kapwata, T., Naidoo, N., Cissé, G., Wright, C. Y., and Berhane, K. (2025). Ensuring Africa's food security by 2050: the role of population growth, climate-resilient strategies, and putative pathways to resilience. *Foods* 14:262. doi: 10.3390/foods14020262

Sintayehu, D. W. (2018). Impact of climate change on biodiversity and associated key ecosystem services in Africa: a systematic review. *Ecosyst. Health Sustain.* 4, 225–239. doi: 10.1080/20964129.2018.1530054

Statistics South Africa (2017). Census Data 2016. Pretoria: Statistics South Africa.

Stuma, P. (2020). Evaluating private game reserves' contribution to community development: A case-study of Kwandwe private game reserve (doctoral dissertation) Alice, Eastern Cape, South Africa: University of Fort Hare..

Thondhlana, G., and Cundill, G. (2017). Local people and conservation officials' perceptions on relationships and conflicts in south African protected areas. *Int. J. Biodiversity Sci. Ecosystem Services Management* 13, 204–215. doi: 10.1080/21513732.2017.1315742

Tokozwayo, S., Mopipi, U. K., Timpong-Jones, E. C., Thubela, T., and Nyangiwe, N. (2018). Pastoralists perceptions on the impact of Vachellia karrooencroachment in communal rangelands of the eastern cape, South Africa. *J. Agri. Extension Rural Dvelop.* 10, 222–233. doi: 10.5897/JAERD2018.1001

Wang, Z., Wang, T., Zhang, X., Wang, J., Yang, Y., Sun, Y., et al. (2024). Biodiversity conservation in the context of climate change: facing challenges and management strategies. *Sci. Total Environ.* 937:173377. doi: 10.1016/j.scitotenv.2024.173377

Wudil, A. H., Usman, M., Rosak-Szyrocka, J., Pilař, L., and Boye, M. (2022). Reversing years for global food security: a review of the food security situation in sub-Saharan Africa (SSA). *Int. J. Environ. Res. Public Health* 19:14836. doi: 10.3390/ijerph192214836

Zenda, M. (2024). A systematic literature review on the impact of climate change on the livelihoods of smallholder farmers in South Africa. *Heliyon* 10:e38162. doi: 10.1016/j.heliyon.2024.e38162