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Ecosystem services and livelihood pathways: The nexus between biodiversity governance and environmental justice in rural Eastern Cape, South Africa

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Abstract

Mountain ecosystems in sub-Saharan Africa provide critical services such as water regulation, soil fertility, and biodiversity conservation, yet they face increasing vulnerability from climate variability and weak governance. This study examined how climate change, governance structures, and environmental justice intersect to shape community resilience in South Africa's Amathole Mountains, focusing on the communities of Hopefield, Bold Point, and Hogsback. Using a qualitative approach, we conducted semi-structured interviews, focus group discussions, and key informant interviews with rural households and tourism stakeholders to capture diverse perspectives. Findings reveal that erratic rainfall, declining soil fertility and reduced water access are reshaping livelihood pathways and intensifying food and income insecurity. Governance shortcomings, including limited institutional capacity, weak extension support, and exclusion from adaptation planning, further constrain equitable access to ecosystem services, deepening environmental injustices. Despite these challenges, communities employ indigenous practices, informal knowledge-sharing, and small-scale conservation initiatives to sustain resilience. We argue that ecosystem-based, participatory governance rooted in local knowledge and attentive to differentiated livelihood pathways is essential for biodiversity conservation, rural well-being, and climate adaptation in mountain socio-ecological systems. Insights from this study contribute to broader debates on sustainable governance and environmental justice in climate-vulnerable highland regions across Africa.

Keywords: Environmental justice; climate adaptation; Governance; community resilience; ecosystem services; livelihood pathways; Amathole Mountains.

Introduction

Mountain ecosystems across Africa provide essential ecosystem services such as freshwater, soil formation, biodiversity conservation, carbon storage and cultural value that support both highland and downstream communities, earning them the reputation of "water towers" and biodiversity hotspots (Tefera et al. 2024). According to Ngwenya et al. (2019) even settlements in South Africa located more than 20 km from mountainous areas depend heavily on these services. However, increasing climate variability and governance challenges increasingly threaten these ecosystems (Ioan et al. 2025). Rising temperatures, projected to increase by 1.4 to 5.8 °C by 2100 (IPCC 2018), are altering rainfall patterns and degrading soil fertility, with direct implications for the availability and access to ecosystem services that underpin rural livelihoods. In regions such as the Amathole Mountains, historical inequalities and fragmented governance structures leave vulnerable communities disproportionately exposed to climate stress risks.

Climate change, defined as long-term shifts in temperature and weather patterns driven by natural variability and human activities, has significant implications for governance, environmental justice, and resilience (IPCC 2018; Engelbrecht and Monteiro 2021). Human-driven warming has already increased global temperatures by approximately 0.6°C since the twentieth century, destabilising food systems, intensifying water scarcity, and threatening rural livelihoods. In sub-Saharan Africa (SSA), shifting rainfall patterns and prolonged dry spells undermine agricultural productivity, with countries such as Zimbabwe experiencing recurrent droughts (Phiri et al. 2021). These climate pressures interact with governance arrangements producing uneven livelihood outcomes and environmental injustices.

The concept of vulnerability, first developed in hazard and disaster studies, refers to susceptibility to harm arising from environmental and social change and is shaped by both biophysical and socio-political factors (Proag 2014; Azong and Kelso 2021). Vulnerability reflects unequal exposure, sensitivity, and adaptive capacity, influenced by institutional weaknesses, power imbalances, and limited participation in decision-making processes (Bassett and Fogelman 2013; Jozaei et al. 2022). In many mountain regions of the Global South, overlapping social, economic, and environmental disadvantages amplify climate risks (Pearse 2017; Huynh and Resurreccion 2014). Understanding these dynamics is essential for analysing how governance gaps and unequal access to ecosystem services shape livelihood pathways and community resilience.

Across SSA, climate variability manifested through erratic rainfall, prolonged droughts, and shifting growing seasons, continue to undermine agriculture, water supply, and food systems, particularly in areas charaterised by weak governance and persistent socio-inequalities (Codjoe and Owusu 2011; Phiri et al. 2021; Ezeh et al. 2020). Many rural communities depend heavily on mountain ecosystem services, making equitable access and adaptative governance critical. Although regional initiatives such as the African Highlands Initiative and the Maloti-Drakensberg Transfrontier Programme demonstrate progress, comprehensive framework for sustainable mountain governance remain limited (Roga et al., 2017). Climate impacts also impose substantial economic costs, with SSA countries losing an estimated 2–5% of GDP annually and facing adaptation needs of USD 30–50 billion per year (World Meteorological Organization 2024; Nor and Mussa 2024). In mountain regions, adaptation often depends on local and indigenous knowledge systems, yet governance barriers frequently constrain their integration into formal planning progresses (Downing et al. 2023; Falayi et al. 2021; Teklu et al. 2023; Aggrey et al. 2024).

In South Africa, mountain systems such as the Drakensberg and Amathole ranges play a critical role in supporting water security, biodiversity, and rural livelihoods. Around Mariepskop for example, approximately 90% of low-income households depend on mountain-derived firewood and water (Ngwenya et al. 2019). The Maloti-Drakensberg wetlands buffer seasonal extremes and sustain perennial water flows (Mathinya et al. 2022), while the Amathole catchment supports endemic species such as the Amathole Toad and Afromontane fynbos patches (Nama 2020). Despite their ecological and economic value, estimated at over US $528 million (Musetsho et al. 2022), these ecosystems face increasing pressures from climate variability, land degradation, and competing land uses. Historical dispossession, weak land governance, and large-scale land acquisitions for agriculture, tourism, and biofuels further exacerbate inequalities in access to land, forests, and water (Rulli et al. 2013; Mbaiwa 2009; Anseeuw et al. 2012). These dynamics highlight how environmental justice concerns, particularly the fair distribution of ecosystem services and decision-making power, are closely linked to governance and resilience challenges.

The Amathole Mountains illustrate these intersecting challenges. Communities in Hopefield, Hogsback, and Bold Point depend on ecosystem services such as water, fertile soils, forest and tourism opportunities for their livelihoods. Climate variability has reduced rainfall reliability, and soil productivity, while governance shortcomings, characterised by limited institutional support,

weak coordination and exclusion from decision-making, further constrain adaptive capacity. Yet community-based forest management, informal knowledge-sharing, and small-scale conservation initiative demonstrate locally grounded pathways of resilience and adaptative livelihoods.

This study therefore examines how climate variability and governance interact to shape community resilience livelihood pathways, and environmental justice in Hopefield, hogsback and Bold Point in the Amathole mountains. Grounded in principles of equitable access, fair distribution of ecosystem services, and inclusive participation, the study draws on community and stakeholder experiences to explore how governance arrangements and local initiatives influence access to ecosystem services under changing climatic conditions.

. To address these gaps, the study is guided by the following questions:

i. How does climate variability affect access to and the functioning of key ecosystems services in the Amathole Mountains?
ii. How do governance structures enable or constrain equitable access and participation in resilience planning?
iii. What local and community-driven adaptation strategies exist, and how can they inform more just, ecosystem-based, and participatory governance frameworks?

Analytical framework

This study is grounded in three interrelated theoretical perspectives: Environmental Justice Theory, Political Ecology, and Resilience Thinking. Together, these frameworks provide an integrated analytical lens for examining how ecosystem services, livelihood pathways, climate variability and governance intersect to shape environmental outcomes and rural well-being in the Amathole Mountains, Eastern Cape.

Environmental justice theory

Environmental Justice Theory extends beyond the equitable distribution of environmental risks and benefits to include questions of access, participation, and recognition. It emphasises not only distributional justice, fair access to resources such as water, grazing land, forests, and tourism-related opportunities, but also procedural justice, which concerns meaningful participation in environmental decision-making processes (Schlosberg 2007; Walker 2012). Recognitional justice

further underscores the importance of acknowledging diverse social identities, knowledge systems, and cultural practices, ensuring that marginalised groups' perspectives are valued and incorporated into environmental governance (Fraser 1998; Schlosberg 2013).

In the South African context, environmental justice is particularly salient because historical inequalities shaped by apartheid continue to influence land tenure systems, access to ecosystem services, and representation within governance structures (Bond 2014; McDonald 2002). Within mountain socio-ecological systems, these injustices manifest through uneven access to ecosystem services that underpin rural livelihoods, thereby shaping differentiated livelihoods, pathways and adaptative capacities. This framework therefore helps to illuminate whose voices are amplified and whose concerns remain marginalised in climate adaptation and resource governance. Building on this focus on fairness and inclusion, political ecology deepens the analysis interrogating the power relations that produce and sustain these inequalities.

Political Ecology

Political Ecology provides a complementary perspective by examining how power relations, historical processes, and political-economic structures shape environmental governance and access to natural resources. It situates environmental change within broader dynamics of state policy, conservation intervention, land reform, and development agendas (Bryant 1998; Robbins 2012). This perspective is especially relevant in rural, post-colonial contexts such as the Eastern Cape, where governance arrangements often reproduce exclusion, marginalisation, and uneven development (Benjaminsen and Svarstad 2021).

At the same time, political ecology foregrounds the agency of local actors, demonstrating how informal institutions, everyday practices, and subtle forms of resistance challenge dominant conservation and development narratives (Scott 2020). In the Amathole Mountains, these dynamics shape how communities negotiate access to ecosystem services and reconfigure livelihood strategies under conditions of climate variability and weak institutional support. While political ecology reveals the structural and historical roots of inequality, it does not fully explain how communities adapt and persist within these constraints, a gap addressed by resilience thinking

Resilience thinking

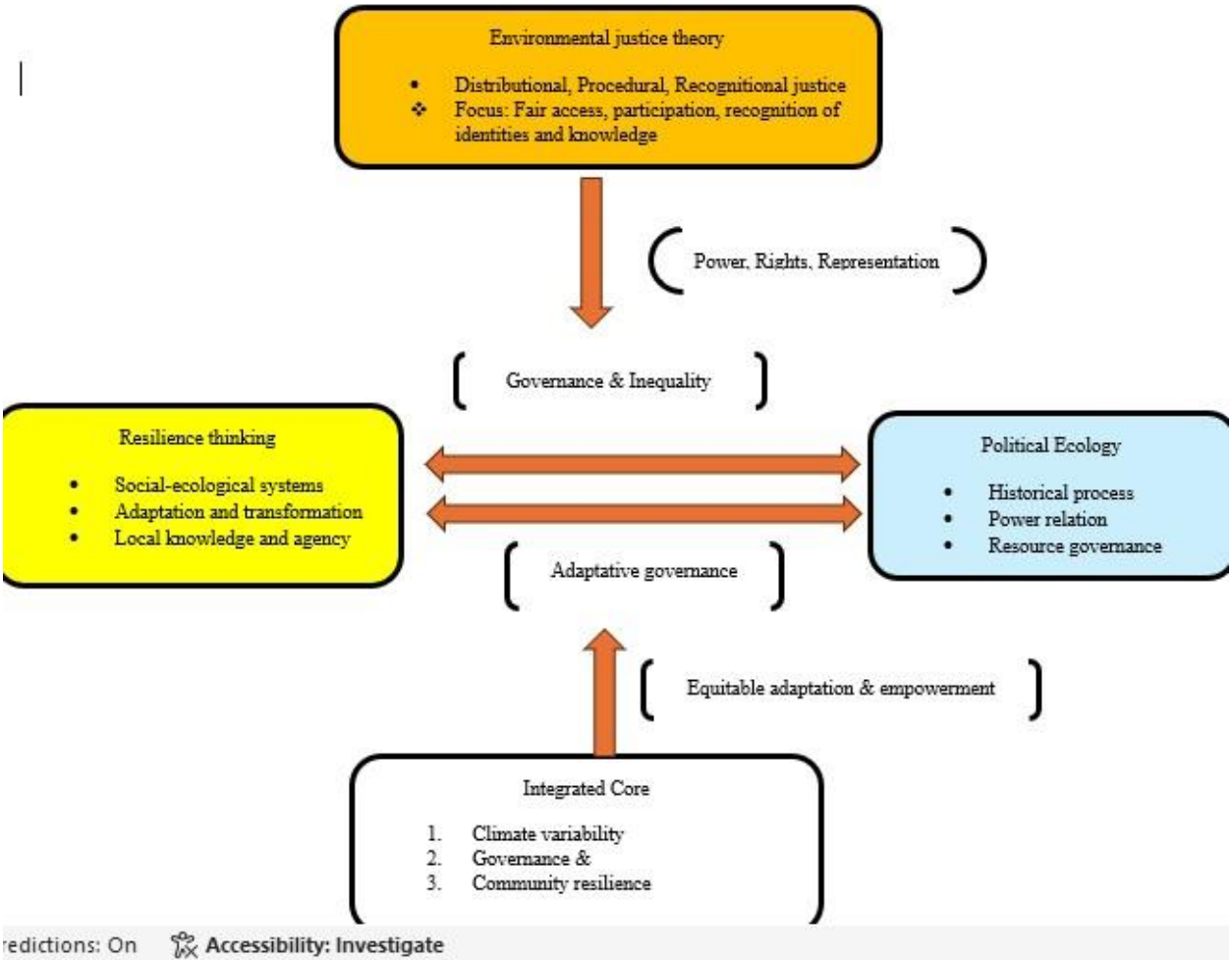
Resilience Thinking emphasises the capacity of social-ecological systems to absorb disturbances, adapt, and where necessary, transform in response to shocks such as climate variability (Folke, et

al. 2010; Walker et al. 2004). This perspective highlights the interconnectedness of people and ecosystems, the centrality of local and indigenous knowledge systems, and the importance of flexible, adaptive governance in sustaining ecosystem services and livelihoods over time (Berkes and Ross 2013).

In this study, resilience is not conceptualised as a purely technical or ecological attribute, but as a socially negotiated process shaped by power relations, justice concerns, and institutional dynamics (Cote and Nightingale 2012). Assessing community resilience therefore involves examining how governance arrangements enable or constrain people's ability to adapt, diversy livelihood pathways and maintain access to critical ecosystem services under changing climatic conditions. The interpretation aligns resilience thinking with the normative concerns of environmental justice and the structural insights of political ecology.

Integrated Analytical lens

By integrating Environmental Justice Theory, Political Ecology, and Resilience Thinking, this study develops a holistic framework for understanding how climate variability, governance structures, and community action jointly shape environmental outcomes, livelihood pathways, and justice claims in the Amathole Mountains. Environmental justice highlights fairness and recognition. Political ecology reveals structural drivers and historical constraints that produce inequality, and resilience thinking illuminates adaptative capacities and communities' responses within dynamic social-ecological systems. Their intersection provides a robust analytical foundation for examining how ecosystem services are governed, accessed, and transformed into livelihood opportunities under conditions of climate stress.



Source: Authors, 2026

Figure 1. Conceptual framework integrating environmental justice, political ecology, and resilience thinking.

This figure illustrates the interconnections among environmental justice, political ecology, and resilience thinking as analytical lenses. Their convergence provides a holistic understanding of climate variability, governance structures, and community responses collectively shaped environmental outcomes, livelihood pathways, and justice claims within the Amathole mountain socio-ecological system.

The overlap between Environmental Justice and Political Ecology highlights how governance arrangement and resource inequalities are produced and maintained through power relations and historical processes (Walker 2012; Benjaminsen and Svarstad 2021). The intersection of Political

Ecology and Resilience thinking emphsasise community innovations, local knowledge and adaptative strategies that emerge within structural constraints (Turner 2014). The overlap between Resilience Thinking and Environmental Justice underscores the need for equitable, inclusive, and empowering adaptation processes that strengthen both social and ecological resilience (Cote and Nightingale 2012; Berkes and Ross 2013).

At the centre, where all three frameworks converge lie an integrated understanding of ecosystem services, livelihood pathways, climate variability, governance, and community resilience. With this conceptual grounding established, the next section outlines the materials and methods used to investigate these dynamics empirically.

Materials and methods

This section describes the study area and outlines the research design, participant recruitment, data collection procedures, and data analysis methods used to investigate stakeholders' perceptions of ecosystem services, climate variability, and governance in the Amathole mountain region.

Description of the study area

The study was conducted in South Africa's Eastern Cape province, located between 30''00'−34''15' S and 22°45'−30'15 E (Afolayan et al. 2014). Within this region, the Raymond Mhlaba local Municipality (RMLM) lies approximately at 32.6086° S, and 26.3854° E and falls within the subtropical high-pressure belt, a global atmospheric system occurring around 30° latitude in both hemispheres (CSIR 2011). The regional climate is influenced by interactions between the Agulhas Bank and subtropical atmospheric circulation systems, producing variable rainfall patterns, shifting wind regimes, sea surface temperature anomalies, and periodic extreme weather events linked to the convergence of the warm Agulhas and cold Benguela currents (Schumann et al.1995; Shannon et al. 2003). The Eastern Cape remains one of South Africa's most socio-economically disadvantaged provinces. Many rural households rely on small-scale agriculture and rural resource use, while peri-urban populations dependent largely on low-wage labour (Statistics South Africa 2017). These structural conditions increase vulnerability to climate variability and environmental change, particularly within mountain ecosystems. In the Amathole District Municipality, approximately 59% of residents earn less than R1600 per month, and unemployment reaches

42.8%, with social grants serving as a key poverty-relief mechanism (Ngumbela and Mle, 2019; Statistics South Africa 2017). Combined with increasing climate variability, these conditions place considerable pressure on rural livelihoods and natural resource systems.

The study focused on three communities within the Raymond Mhlaba Local Municipality (RMLM): Hopefield, Hogsback, and Bold Point. These settlements are located within the Amathole Mountains landscape, an area of high ecological and hydrological importance, and socio-economic significance. Two main stakeholders' groups were engaged: (i) rural households residing in Hopefield and Bold Point, and (ii) tourism stakeholders operating in Hogsback "village" involved in local development planning.

RMLM forms part of the Amathole District Municipality (ADM), established following South Africa's municipal restructuring reforms in 2000 (ECSECC 2017). ADM stretches from the Indian Ocean coast to the Amathole Mountains and covers approximately 21,114 km², with an estimated population of 762,037 inhabitants in 2023 (Health Systems Trust. 2024). RMLM itself, was created in 2016 through the merger of the former Nkonkobe and Nxuba municipalities, and spans roughly 6,358 km² with about 156,000 residents (Statistics South Africa 2017). The municipality is predominantly rural, and characterised by dispersed settlements, commercial farms, and small service towns including Alice, Fort Beaufort, and Cathcart.

The Hogsback Mountain range rises to approximately 1,963 m above sea level (a.s.l), and constitutes a significant ecological asset providing water regulation, soil fertility, carbon sequestration, and biodiversity support (Shackleton and Luckert 2015). RMLM typically experiences average summer temperatures of around 26°C, and winter temperatures of approximately 13°C, Rainfall averages approximately 1,000 mm per year in summer and 400 mm per year during winter (Bontsa et al. 2024). Ecologically, the area falls within the Albany Thicket Biome, characterised by dense shrubs, succulents, and forest patches, distributed across elevations between 300 to 700 m above sea level (Carvalho et al. 2022). Although the annual rainfall ranges from 800-1,200 mm, recent decades have seen increasing climate variability, including recurrent droughts, soil erosion, overgrazing and deforestation pressures that threaten agricultural productivity, water security, and biodiversity (Apraku et al. 2019). These environmental pressures present major challenges for local livelihoods and development planning.

A total of 83 participants took part in the study. These included 77 community members (62 household representatives from Hopefield, 12 from Bold Point village, and three from Hogsback) and six key informants: three Hopefield community leaders, one Bold Point leader, and two tourism stakeholders (one from Hogsback Inn Hotel and one Jikane tourism guide). Data were collected through individual interviews and two FGDs given time constraints (Lakens 2022).

Table 1. Participants involved in the study

(Table 1 found here)

Source: Authors, fieldwork 2024

This table summarises the distribution of study participants across the study area, indicating the number of individual interviews and key informant interviews conducted within each community.

Bold Point is a small formal rural settlement about 5 km from Hogsback Inn, while Hopefield is a semi-rural community located over 10 km away. Hopefield features some modern housing, whereas Bold Point is marked by informal dwellings and limited educational facilities. Both communities face significant socio-economic challenges: 65% of residents live below the upper-bound poverty line and unemployment is around 45% (ECSECC 2024). Social grants remain the main source of income for many households (Mthethwa and Wale 2023), while limited employment opportunities increase reliance on natural resources for water, grazing, small-scale agriculture, and livelihoods.

The Amathole Mountain system reflects the intersection of ecological significance, socio-economic vulnerability, and climate sensitivity. Although Hogsback's tourism sector provides some seasonal employment, benefits remain unevenly distributed, and persistent poverty and population pressures continue to drive reliance on natural resources, including subsistence farming and firewood collection (Wondirad and Ewnetu 2019). A lack of diversified livelihoods pushes many young people to seek temporary work in nearby tourist establishments.

Given this dependence on mountain ecosystem resources, these communities form a key interface between environmental sustainability and rural development. The study therefore examined differences in access to and valuation of ecosystem services between upstream tourism stakeholders and downstream rural households, using the Millennium Ecosystem Assessment

(MEA) framework (Reid 2005) to classify and analyse ecosystem services and their perceived importance across stakeholder groups.

Research design

This research adopted a qualitative approach to capture the nuanced experiences, perceptions and lived realities of community members and tourism stakeholders regarding ecosystem services, livelihood pathways, and governance under conditions of climate variability. Guided by an interpretive paradigm, the study aimed to understand how individuals interpret and respond to changing socio-ecological conditions.

A sequential mixed-method design was employed across Hopefield, Hogsback, and Bold Point to examine interactions between ecosystem services, livelihood pathways, climate variability, and governance within the Amathole Mountain landscape. Purposive and snowball sampling techniques were used to recruit participants with relevant knowledge and experience of local environment conditions. In total 83 participants took part in the study, comprising 77in-depth interviews with rural community members, two focus group discussions (FGDs) in Hopefield involving six to ten participants each, and six key informant interviews (KIIs) with tourism resort operators and community leaders.

Community participants represented diverse demographic backgrounds and livelihood experiences. Of the 74 community members interviewed 50 were women and 24 were men. Participants ranged in age from 21 to 76 years and were predominantly Black South Africans, with two white South African participants. Many participants engaged in multiple livelihood strategies, including subsistence farming, informal trade, natural resource use, and tourism-related activities. Approximately 60% had not completed secondary education, reflecting broader structural education challenges within the municipality.

Key informants were selected based on their roles in tourism development, natural resource management, and community leadership within the mountain landscape. Their perspectives provided institutional insights that complemented the lived experiences and enable triangulation across governance and livelihood contexts.

Data collection

Fieldwork was conducted between September and November 2025 through semi-structured interviews and focus group discussions. These methods enabled the collection of detailed qualitative data on participants' perceptions of climate variability, ecosystem services, governance, livelihood strategies, vulnerability, and environmental justice within the Amathole Mountain region. Participants were divided into two targeted groups: (1) rural community members from Hopefield and Bold Point, and (2) tourism stakeholders operating in Hogsback. Participants were selected through purposive sampling based on their knowledge of mountain ecosystems and involvement in resources-based livelihoods. Snowball sampling was then subsequently used to identify additional participants until data saturation was reached. The methods applied follow the qualitative research guidelines outlined by Mack et al. (2005), which emphasise adaptative recruitment strategies and contextual engagement during fieldwork. Community liaison officers familiar with the local context assisted with participant recruitment through referral networks, enhancing, trust and participation. Semi-structured interview guides were used to explore key themes while allowing flexibility for participants to express their experiences in their own words. Interview topics included climate variability, ecosystem service use, environmental governance processes, and livelihood adaptation strategies.

Two FGDs were conducted in Hopefield to gather in-depth insights from local community members who depend on mountain ecosystem services. Each group consisted of six to ten participants aged 18 and older and were organised, into homogeneous sub-groups based on gender and age to promote free expression, as recommended by De Vos (2011). Each FGD lasted between 45 and 60 minutes and was audio recorded. Ethics clearance was obtained from the University of Fort Hare Inter-Faculty Human Research Ethics Committee (IFRED). Written informed consent was obtained from all participants after explaining the study's objectives, potential risks, and their rights to withdraw at any stage without consequence. Confidentiality and anonymity were maintained throughout the research process.

KIIs were conducted with community leaders and tourism stakeholders and lasted between 30 and 45 minutes. Tourism participants provided insights into natural resources use in hogsback, climate related risks, and environmental governance processes related to tourism activities. Some interviews and FGDs were conducted in isiXhosa and later translated into English. To preserve

meaning and tone while ensuring clarity, translations were lightly edited for grammar without altering participants' intended meaning. Transcription was conducted verbatim, with minor editing for readability while preserving participants intended meaning.

To examine spatial differences in ecosystem services data were collected along a distance gradient extending approximately 20 km from Hogsback Mountain upstream. This approach enabled comparison between upstream tourism stakeholders and downstream rural households. Data validation occurred through group sharing and discussion of emerging themes, allowing participants to confirm or challenge preliminary interpretations.

Data analysis

All interview and FGDs transcripts were organized and stored in labelled digital folders to ensure confidentiality. Pseudonyms were assigned to participants to protect anonymity. The data were manually coded following an iterative thematic analysis process (Saldana 2009). This process involved repeated readings of transcripts, coding, and categorisation of key themes related to ecosystem services, livelihood pathways, governance dynamics, environmental justice, and community resilience. Both inductive and deductive coding were applied. Inductive coding allowed themes to emerge directly from participants' narratives, while deductive coding was guided by research questions and conceptual framework of the study. Manual coding enabled close engagement with the data and facilitated the identification of nuanced meanings.

A summary codebook was developed to systematise key themes, and a thematic matrix was constructed to compare patterns across stakeholder groups and locations. This matrix helped identify convergences and divergences in perceptions of ecosystem services, governance processes, and adaptive responses. Coding involved multiple rounds of review and refinement to enhance analytical reliability (Bailey 2008). All identifying information was removed from transcripts prior to analysis.

Findings from the interviews and FGDs are presented through descriptive narratives, supported by direct quotations from participants to provide contextual depth. Quotations are attributed using general identifiers (e.g., "female FGD, Hopefield") to maintain anonymity while reflecting participants' perspectives recorded during fieldwork.

Results

This section presents findings aligned with three objectives: (1) examining how climate variability affects access to key ecosystem services and associated livelihood pathways in the Amathole Mountains ; (2) analysing how governance structures and power relations enable access to these resources and influence environmental justice outcomes, and (3) identifying community and sector-specific adaptation strategies that support resilience..

Climate variability, ecosystem services, and livelihood pathways

Participants consistently reported that climate variability is altering mountain ecosystems and the services they provide. Participants highlighted changes in rainfall patterns, declining water availability, vegetation stress, and shifts in biodiversity. These changes directly affect livelihoods, particularly for households dependent on subsistence agriculture, livestock grazing, wild plant harvesting, and mountain-fed water sources.

Through focus groups and interviews, participants described rainfall as increasingly unpredictable. Seasonal rains that previously arrived in early spring now occur irregularly or are delayed, resulting in shorter growing seasons and declining water availability. Streams and rivers that once flowed throughout the year now dry up earlier during the dry season, reducing water availability for households and agriculture. Water provisioning emerged as a major concern in all three communities. Participants reported that declining rainfall and drying water sources have disrupted farming activities, domestic water supply, and broader ecosystem stability. In Hopefield, drying rivers reduce soil moisture and limit irrigation for household gardens and small-scale farming. This has contributed to declining crop yields for staple crops such as maize, beans, spinach, cabbage, and potatoes. As a female community member stated:

"*The river often dries up now because the rain doesn't come as before"* (Female, FGDs, September 2025).

Another participant in Hopefield emphasised the uncertainty that climate variability introduces into agricultural decision making:

"Sometimes it rains too much, other times there is no rain at all ...farming becomes difficult because we don't know when to plant" (Young male, September 2025)

Participants in Bold Point reported similar challenges. Reduced rainfall has weakened streamflow and increased sedimentation, limiting the reliability of mountain-fed water systems. Many households previously relied on piped water drawn directly from mountain sources, but broken infrastructure and declining streamflow have forced residents to rely on distant streams or purchase water during dry periods. A male participant stated:

"Before, pipes came directly from the mountain, but they broke… now we mostly rely on mountain streams" (Male, September 2025).

Beyond agricultural and domestic water use, climate variability also affects cultural and spiritual practices tied to mountain ecosystem services. Participants described declining availability of traditional herbs used for healing, rituals, and household protection. Several participants in Hopefield and Bold Point explained that these plants are becoming harder to find due to changing rainfall patterns and vegetations shifts. A Hopefield old woman stated:

"Some of the herbs don't grow like before because the rain is not the same… we now look for them higher up the mountain" (Woman, September 2025)

Similar concerns were raised in Bold Point, where the community relies on wild herbs for medicinal purposes and cultural rituals. Participants noted that declining rainfall and vegetation stress have reduced the availability of these plants, disrupting traditional practices that depend on access to specific forest resources.

Climate-related changes were also evident in Hogsback, where tourism and hospitality businesses depend heavily on the mountain landscape. Participants linked declining precipitation and reduced snowfall to falling groundwater levels and reduced spring recharge. Older residents recalled that snow historically contributed to groundwater replenishment and sustained local streams and wetlands. However, snowfall has become less frequent over the past decades. One tourism stakeholder described these changes:

"We get far less snow than when I was a child…. a stream that flowed for 140 years dried for the first time" (KII 1, November 2025)

Changes in vegetation and water availability also affect livestock grazing. Households in Hopefield and Bold Point reported increasing grass shortages prolonged dry spells. Lower-altitude

grazing areas dry earlier in the season, forcing farmers to move animals to higher slopes where moisture remains for longer periods.

Wildlife availability has also declined. Some hunters in Hopefield reported that animals increasingly migrate in search of water and vegetation, reducing access to bushmeat and weakening an important supplementary food source for rural households.

Overall, participants described a broad decline in ecosystem services including water, food, grazing resources, medicinal plants, wildlife, and tourism-related natural amenities. These changes are attributed to erratic rainfall, rising temperatures, prolonged drought conditions, reduced snow cover, and increased fire frequency. Despite these pressures, participants consistently emphasised the central role of mountain ecosystem in sustaining local livelihoods and cultural practices.

Table 2. Summary of key ecosystem services and climate-related impacts across Hopefield, Bold Point, and Hogsback communities.

(Table 2 found here)

Source: Author's own fieldwork (2025)

Firewood collection patterns are also shifting, with distance being one of the main factors influencing harvesting frequency and overall collection declining. Table 2 compares ecosystem services used by rural households and tourism stakeholders across the three study areas, alongside the observed impacts of climate variability on water provisioning, firewood availability, medicinal plants, cultural practices, grazing resources, and tourism-related services.

Governance, access, and environmental justice in mountain ecosystems

While communities across the Amathole Mountains rely heavily on ecosystem services, manty participants reported limited involvement in the governance processes that regulates access to these resources. Across Hopefield and Bold Point, participants described a lack of formal representation in decision-making structures related to land use, water management, and forest resources. Forest areas remain controlled by private tourism operators and forestry companies, restricting access to grazing areas, trails, and other natural resources. A tourism guide explained that a forestry company managing a large portion of the surrounding land has imposed access restrictions that have triggered disputes over resource rights.

"The forestry company managing roughly 55,000 hectares restricts access and we are currently in arbitration to improve access to some of the mountain resources" (KII 2, September 2025)

Participants frequently linked these governance challenges to historical land dispossession and long-standing struggles for recognition and restitution. Several participants emphasised that communities continue to rely on landscapes that were historically part of their ancestral territories but are now managed by commercial forestry or tourism enterprises. In Hopefield, participants described governance processes dominated by powerful actors such as commercial farmers, forestry companies, and tourism businesses, leaving local voices marginalised despite their dependence on these ecosystems for livelihoods.

Water governance emerged as another major concern. Participants reported inconsistent municipal water supply, poor communication during water shortages, and limited coordination between upstream and downstream users. When municipal systems fail, households often rely on rivers, mountain springs, or rainwater storage systems. Downstream communities also reported reduced water flow due to upstream water diversions, further exacerbating existing inequalities in water access.

Land restitution processes were also described as incomplete or delayed. Some communities reported receiving compensation for ancestral land, while others continue to wait for resolution. Participants expressed frustration at the lack of consultation during the transfer of land to forestry companies or tourism estates. One participant reported:

"Some families were paid, but others are still waiting …we are not part of the decision even though this land was ours." (Female, September 2025)

Although Hogsback maintains a tourism-led forum, participants acknowledged that commercial and forestry interests dominate discussions, limiting genuine community representation. One tourism stakeholder (hotel owner) admitted that the forum currently lacks direct community representation but aims to appoint one soon. As stated:

"Currently, our forum does not have direct community representatives, but we are working toward appointing one soon. We maintain regular communication with strong leaders in each community." (KII 1, November 2025)

Table 3: overview of mountain resource governance in the Hogsback area.

(Table 3 found here)

Source: Author's own fieldwork (2025)

Table 3 summarises governance mechanisms, key actors, levels of community inclusion, and major challenges affecting resource access in Hogsback, Hopefield, and Bold Point. It highlights governance gaps, particularly weak community participation and poor institutional coordination. While formal governance mechanism exists in Hogsback, rural communities who depend most directly on ecosystem services remain largely excluded from decision-making processes. This imbalance reinforces environmental injustice by limiting community participation in decisions affecting access to land, water, forests, and other essential resources.

Community resilience, livelihood adaptation, and grassroots responses

Despite growing climate pressures and governance constraints, communities across the Amathole Mountains have developed a range of adaptation strategies. These responses combine local ecological knowledge, household coping mechanisms, and sector-specific innovations.

Rural households in Hopefield and Bold Point rely heavily on ecosystem-based strategies to manage climate risks. In Hopefield, communities frequently draw water from rivers, mountain springs, or storage tanks when the municipal water system fails. As one male participant explained:

"When the taps don't work, we get water from the river or directly from the mountain." (Male participant, September 2025).

Another participant explained the importance of rainwater storage:

"*We use tanks to store water… but when there is no rain, it becomes difficult."* (Female participant, September 2025).

Farmers also attempt to adapt to shifting rainfall patterns by adjusting planting practices and diversifying livelihood activities. Some households supplement agricultural income through activities such as wild honey harvesting and small-scale trading.

Seasonal livestock mobility remains a key adaptation strategy. Farmers move their cattle to higher elevations during prolonged dry periods where pasture remains greener and soil moisture persists for longer periods. This practice was drescribed as follow by a male participant in Hopefield:

"During the drought we move our livestock up to the mountain because the grass stays soft and green even in winter season and we bring them back in December." (Young male Shepherd, September 2025)

In Bold Point, forest resources play an essential role in supporting households' resilience. Firewood remains the primary energy source due to cold mountain temperatures and high electricity costs. A male participant stated.

"We collect firewood in the forest…Eskom electricity is expensive, so firewood is our main energy source." (Male, September 2025)

Participants also reported cooperating with forestry authorities by following guidelines on wood harvesting and tree planting. These informal governance arrangements help regulate access to forest resources while supporting local energy needs.

In contrast, tourism enterprises in Hogsback demonstrate higher adaptive capacity due to greater financial resources and infrastructure. They have invested in diversified water supply systems including springs, artesian wells, dams, and expanded storage tanks. One tourism operator explained:

"We increased water storage… we have an artesian well, several good springs on the farm, and a large dam to store water." (KII 1, November 2025).

Some hotel establishments have also adopted ecological technologies to manage waste more efficiently. As stated,

"We installed a biological digester system so we can recycle wastewater safely and use it for irrigation." (Tourism employee, September 2025)

These investments have largely insulated tourism businesses from water shortages that severely affect surrounding rural communities. During recent droughts, tourism operations were able to maintain water supply through private infrastructure, while nearby households faced severe shortages.

519 Taken together, these findings reveal significant differences in adaptive capacity across sectors.
520 Tourism enterprises rely on capital-intensive technological solutions, while rural households
521 depend on ecosystem resources, mobility, and community-based coping strategies. Despite these
522 differences, participants across all three communities emphasised the critical importance of the
523 mountain ecosystem services as a natural buffer against climate variability and environmental
524 stress.

525

526 ## Discussion

527 Mountain ecosystems play a central role in rural livelihoods and local economies, but are
528 increasingly strained by climate variability, land-use change, and governance challenges. Viewed
529 through ecosystem services, political ecology, and environmental justice perspectives, the findings
530 show how ecological change intersects with historical land dispossession, unequal access, and
531 uneven benefit distribution across mountain communities. Similar dynamics have been
532 documented in rural areas of KwaZulu-Natal and Limpopo provinces, where households remain
533 highly dependent on natural resources amid limited infrastructure and persistent inequalities
534 (Rankoana 2020; Ngwenya et al. 2019).

535 Across Hopefield, Bold Point, and Hogsback, participants demonstrate strong dependence on
536 mountain-based ecosystem services, particularly water, firewood, medicinal plants, grazing land,
537 and wild food. These services underpin different livelihood pathways across the study sites. This
538 finding aligns with ecosystem services literature emphasising the importance of provisioning,
539 cultural, and supporting services, in sustaining rural households in Africa (Booi et al.2022;
540 Bélanger and Pilling 2019). In Hopefield and Bold Point, livelihoods are closely tied to direct-use
541 services such as water, firewood, wild herbs, and grazing resources. This reflects broader evidence
542 that marginalised rural communities disproportionately rely on nature-based subsistence
543 economies", particularly where state infrastructure or formal employment opportunities are limited
544 (Ohonba 2025).

545 In contrast, Hogsback demonstrates a more commercialised relationship with ecosystem services,
546 where nature is primarily utilised for tourism, hospitality, and recreation. Aesthetic and cultural
547 ecosystem services therefore play a central role in the local economy. Similar dynamics have been

observed in other conservation landscapes where natural environments are increasingly commodified for tourism and leisure activities (Do 2019). The contrast between subsistence-based livelihoods in Hopefield and Bold Point and tourism-driven economic activities in Hogsback highlights the multifunctional nature of mountain ecosystems and the competing demands placed on shared environmental resources.

Climate variability further intensifies vulnerability across these livelihood pathways. Participants reported reduced rainfall, drying rivers, vegetation stress, increased wildfire, and declining snowfall in Hogsback. These observations align with studies identifying mountain ecosystems as highly climate-sensitive environments (McBride et al. 2022). In Hopefield and Bold Point, impacts including crop failure, declining medicinal plants, and constrained grazing availability mirror broader African literature showing how rainfall variability threatens food security, livestock production, and traditional knowledge systems (Alotaibi 2023; Zenda 2024).

The tourism economy in Hogsback also faces climate-induced stress, including declining waterfall flow, reduced water availability, and drought-related operational challenges. Research on nature-based tourism similarly demonstrates that tourism activities are highly sensitive to climate-driven changes in biodiversity, hydrology, and scenic quality (Scott 2020). These findings suggest that climate change acts as a livelihood-threat multiplier, intensifying existing socio-economic inequalities across mountain communities rather than affecting all users equally.

Political ecology provides insight into why ecosystem services remain unevenly accessed across the study area. Historical land dispossession, commercial forestry expansion, and the growth of tourism estates influence who controls mountain resources, and who benefits from them. Restricted access to waterfalls, forests, grazing areas, and culturally significant sites illustrate how private ownership and commercial land uses can limit rural access to natural resources. Similar patterns have been documented across Southern Africa where land-use privatisation marginalises local users while privileging commercial actors (Robbins 2012; Sarfo et al. 2022; Mani et al. 2021).

Environmental justice perspectives further reveal how this governance dynamics affect community participation and benefit distribution. Participants from Hopefield and Bold Point reported limited involvement in decision-making processes, weak communication from forestry companies and tourism operators, and inconsistent engagement from municipal authorities. Meanwhile, economic

benefits associated with tourism such as employment infrastructure, and revenue, are concentrated in Hogsback (Bentley 2024). Surrounding rural communities continue to experience water insecurity, restricted access to resources, and declining ecosystem services.

Cultural and ecological dimensions of injustice are also evident. Communities reported declining access to medicinal plants, cultural sites, and traditional harvesting areas, threatening cultural practices and local knowledge systems. Similar concerns have been raised by Cornelius and Van Wyk (2025), who show how emvironmental change can undermine cultural heritage and indigenous ecological knowledge.

These inequalities are further intensified by climate variability. As drought, fires, and ecological stress reduce the availability of mountain resources, competition among communities, tourism enterprises, and forestry companies increases. Political ecology explains these tensions as struggles over scarce resources driven by entrenched power asymmetries, while environmental justice frameworks highlight the unequal distribution of risks and adaptive capacities.

Overall, the findings suggest that the challenges facing Hopefield, Bold Point, and Hogsback are not purely environmental but also institutional and political. Ecosystem services are unevenly accessed, climate impacts are experienced differently, and governance structures often fail to recognise community rights, local knowledge, and cultural practices. Communities such as Hopefield and Bold Point, which rely directly on subsistence ecosystem services, face heightened vulnerability as climate variability undermines water security and food systems. Hogsback, through economically more diversified, also experiences climate-related pressures alongside growing tensions around land use and resource access.

These findings highlight the importance of more inclusive and participatory governance approaches in mountain ecosystems. Integrating ecosystem services, political ecology, and environmental justice perspectives suggests that strengthening resilience requires addressing not only ecological degradation but also land rights, equitable benefit-sharing, and meaningful community participation in environmental decision-making. Such approaches are essential for supporting sustainable livelihoods while ensuring that mountain ecosystems continue to provide critical services for both rural communities and local economies.

Conclusion

The study highlights the central role of mountain ecosystems in sustaining livelihoods, cultural practices and local economies in the Amathole region of South Africa. Across Hopefield, Bold Point, and Hogsback, communities rely heavily on ecosystem services such as water, firewood, medicinal plants, grazing lands, and wild foods. However, these services are increasingly under pressure from climate variability, land-use change, and unequal access to natural resources. Participants reported declining rainfall, reduced snow cover, drying rivers, vegetation stress, and increased fire risk, all of which are altering the availability of ecosystem services. These changes are already affecting agricultural productivity, livestock grazing, cultural practices, and tourism-related activities, highlighting the growing vulnerability of mountain socio-ecological systems.

By integrating ecosystem services, political ecology, and environmental justice perspectives, the study shows that climate-related pressures interact with long-standing governance challenges. Historical land dispossession, restricted access to forests and grazing areas, limited community participation in decision-making, and uneven distribution of tourism and forestry benefits continue to influence how ecosystem services are used. Communities such as Hopefield and Bold Point remain particularly vulnerable because their livelihoods depend largely on direct-use ecosystem services. In contrast, Hogsback, although more economically diversified through tourism, also faces climate-related risks associated with declining water resources and landscapes degradation.

The findings emphasise that strengthening resilience in mountain environments requires more than ecological or technical interventions. It also demands governance reforms that promote equitable resource access, meaningful community participation, and recognition of cultural and livelihoods rights. Climate-responsive and ecosystem-based management strategies that incorporate local knowledge and address social inequalities are essential for sustaining both livelihoods and biodiversity. While grounded in the Amathole Mountains, these insights contribute to broader debates on climate adaptation and environmental governance in mountain regions across sub-Saharan Africa.

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