Policy and legislative responses to climate change impacts on indigenous medicinal plant resources in South Africa. A desktop-based qualitative policy analysis.

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Abstract
Background
Indigenous medicinal plants play a critical role in South Africa's primary healthcare systems, cultural heritage, and biodiversity economy. Climate change poses increasing threats to these resources through altered rainfall patterns, rising temperatures, habitat loss, and increased pressure on harvesting. While South Africa has developed progressive environmental and biodiversity legislation, the extent to which existing policy and legal frameworks respond adequately to climate change impacts on indigenous medicinal plant resources remains insufficiently explored.

Methods
A desktop-based qualitative policy analysis was conducted. Relevant national legislation, policies, strategies, and international agreements ratified by South Africa were systematically reviewed, including environmental management, biodiversity conservation, climate change, and traditional knowledge protection instruments. Data were analysed thematically to assess policy coherence, implementation mechanisms, and alignment with climate adaptation objectives relevant to medicinal plant conservation.

Results
The analysis revealed that South Africa possesses a robust legislative foundation for biodiversity protection, particularly through the National Environmental Management: Biodiversity Act and associated regulations. However, climate change considerations are often addressed indirectly, with limited explicit integration of medicinal plant vulnerability, community-based adaptation, and Indigenous Knowledge Systems. Gaps were identified in policy coordination, implementation capacity, and monitoring of climate-driven impacts on medicinal plant populations.

Conclusion
Although South Africa's policy and legislative frameworks provide a strong basis for biodiversity conservation, they inadequately address the specific and emerging risks posed by climate change to indigenous medicinal plant resources. The absence of targeted adaptation measures and weak integration of traditional knowledge limit the effectiveness of current responses.

Recommendations
The recommendation would be that climate change adaptation strategies explicitly incorporate indigenous medicinal plant conservation, strengthen community participation, and enhance cross-sectoral policy alignment. Integrating Indigenous Knowledge Systems with scientific monitoring can improve resilience and sustainable use of medicinal plant resources under changing climatic conditions.

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Background information

Indigenous medicinal plants form an essential component of South Africa's healthcare system, cultural heritage, and biodiversity economy. A significant proportion of the population relies on traditional medicine for primary healthcare, particularly in rural and peri-urban areas where access to formal medical services is limited. Beyond their medicinal value, these plants contribute to livelihoods, cultural identity, and the preservation of Indigenous Knowledge Systems (IKS). However, the sustainability of indigenous medicinal plant resources is increasingly threatened by environmental pressures, most notably climate change. Climate change in South Africa is manifested through rising temperatures, altered rainfall patterns, prolonged droughts, increased frequency of extreme weather events, and ecosystem shifts. These

changes directly affect plant phenology, distribution, regeneration capacity, and habitat suitability. Medicinal plants are particularly vulnerable because many species are harvested from the wild, often from climatically sensitive ecosystems. Climate-induced stress, combined with overharvesting and land-use change, exacerbates the risk of population decline and local extinction, undermining both biodiversity conservation and traditional healthcare systems.

South Africa has developed a relatively progressive policy and legislative framework aimed at environmental protection, biodiversity conservation, and sustainable development. Key instruments include the Constitution of the Republic of South Africa (1996), the National Environmental Management Act (NEMA), the National Environmental Management: Biodiversity Act (NEMBA), and climate-focused policies such as the National Climate Change Response Policy. In addition, South Africa is a signatory to international agreements including the Convention on Biological Diversity and the Nagoya Protocol, which emphasise conservation, sustainable use, and fair benefit-sharing. Despite this extensive framework, the extent to which these policies explicitly address climate change impacts on indigenous medicinal plant resources remains unclear. Existing legislation often treats medicinal plants within broader biodiversity or conservation categories, with limited attention to their unique socio-cultural importance and climate vulnerability. Furthermore, policy implementation challenges, fragmented governance, and insufficient integration of Indigenous Knowledge Systems weaken the effectiveness of current responses. There is therefore a need for systematic examination of how climate change considerations are incorporated into policies governing medicinal plant conservation and use.

Against this background, the objective of this study was to critically analyse South Africa's policy and legislative frameworks to assess how they address climate change impacts on indigenous medicinal plant resources, identify existing gaps and strengths, and evaluate the extent to which these frameworks support climate-resilient conservation and sustainable use of medicinal plants.

Methodology

Study Setting

This study was conducted within the policy and legislative context of the Republic of South Africa. South Africa is a biodiversity-rich country recognised as one of the world's megadiverse nations, with extensive indigenous medicinal plant resources distributed across diverse biomes, including the Grassland, Savanna, Forest, and Fynbos regions. The country is also highly vulnerable to climate change impacts, including increasing temperatures, prolonged droughts, altered rainfall patterns, and extreme weather events, which pose significant risks to biodiversity and natural resource-dependent communities. The analysis focused on national-level legislation, policy frameworks, and strategic documents governing climate change response, biodiversity conservation, Indigenous Knowledge Systems (IKS), and access and benefit-sharing of biological resources. International agreements ratified by South Africa, including multilateral environmental agreements relevant to climate change and biodiversity, were also reviewed to assess alignment with domestic policy instruments. Document collection and analysis were conducted between January 2025 and April 2025. Policies and legislative instruments published between 1994 (post-democratic legislative reform period) and 2025 were considered to ensure comprehensive coverage of contemporary environmental governance frameworks. The study did not involve fieldwork, as it was based exclusively on desktop analysis of publicly accessible policy and legislative documents.

Study Design

This study adopted a desktop-based qualitative policy analysis design. The design was appropriate for systematically examining existing legislation, policy frameworks, and strategic documents relevant to climate change, biodiversity conservation, and indigenous medicinal plant resources in South Africa. A qualitative approach enabled in-depth interpretation of policy intent, scope, and coherence rather than measurement of outcomes.

Data Sources

Data were obtained exclusively from secondary sources, including national legislation, government policies, strategic plans, regulatory guidelines, and international agreements ratified by South Africa. Key documents reviewed included environmental management legislation, biodiversity and conservation policies, climate change response strategies, and instruments governing traditional knowledge and benefit-sharing. Supplementary sources included peer-reviewed journal articles, policy briefs, and reports from recognised institutions to provide contextual interpretation.

Document Selection Criteria

Documents were included if they:

- Addressed climate change, biodiversity conservation, environmental management, or indigenous medicinal plant use;

- Were officially adopted or endorsed by the South African government or international bodies to which South Africa is a signatory;

- Had relevance to conservation, sustainable use, access, benefit-sharing, or adaptation strategies affecting medicinal plant resources.

Documents that were outdated, duplicated, or lacked relevance to climate change or medicinal plant governance were excluded.

Data Analysis

A thematic content analysis was applied to the selected documents. Relevant text was systematically reviewed, coded, and categorised into thematic areas, including climate change adaptation, biodiversity protection, medicinal plant conservation, Indigenous Knowledge Systems, governance structures, and implementation mechanisms. Themes were compared across documents to assess policy alignment, gaps, and overlaps in addressing climate-related risks to medicinal plant resources.

Ethical Considerations

Ethical clearance was not required for this study, as it relied solely on publicly available policy documents and secondary sources and did not involve human participants, personal data, or confidential information.
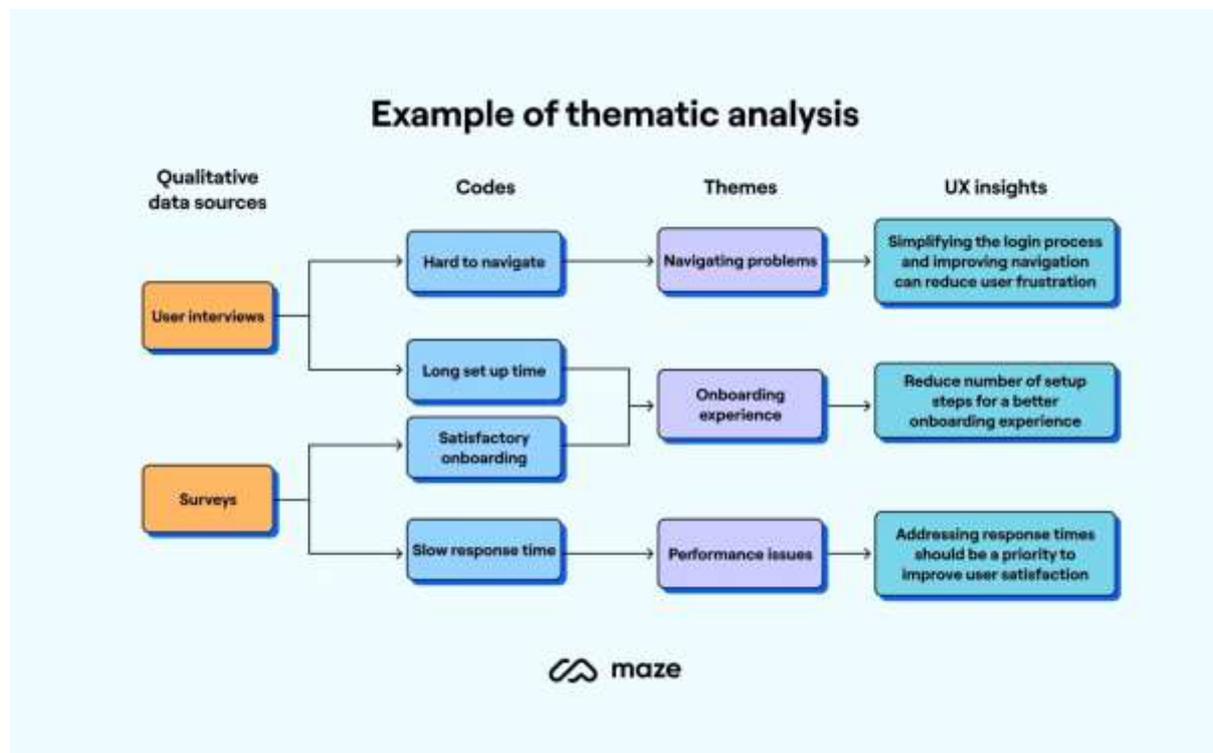
Results

Figure 1: The diagraph represents the examples of thematic analysis.

Panel (a) illustrates the relative emphasis placed on major drivers of biodiversity loss across terrestrial, marine, freshwater, and other ecosystems. Climate change emerges as the most frequently addressed driver across all systems, with particularly high representation in marine ecosystems, where it accounts for over 50% of the articles. Terrestrial systems also show strong emphasis on climate change, followed by habitat change. Freshwater and "other" systems display a more balanced distribution between climate change, invasive species, and habitat change. Habitat change remains a dominant driver in terrestrial ecosystems, reflecting land-use change, deforestation, and agricultural expansion as persistent pressures. Invasive species are most prominently studied in freshwater and other systems, highlighting their disproportionate impact on these environments. In contrast, overexploitation and pollution receive comparatively lower attention overall, although marine systems show a notable emphasis on overexploitation, consistent with fisheries pressure and resource extraction.

Panel (b) demonstrates changes in the proportion of articles addressing different biodiversity drivers over time. Research attention to climate change shows a clear and sustained increase, overtaking all other drivers after approximately 2009 and continuing to rise through 2016. This trend reflects the growing recognition of climate change as a cross-cutting and intensifying threat to biodiversity. Studies on invasive species show moderate growth and stabilization over time, while habitat change maintains a relatively consistent level of attention, indicating its long-standing recognition as a primary driver. Pollution and overexploitation remain persistently underrepresented, with only marginal increases, suggesting potential gaps between ecological impact and research emphasis.

Panel (c) highlights the interconnections between drivers by showing how frequently they are addressed together within the same studies. Climate change has the largest node, indicating the highest number of publications, and is most strongly linked with habitat change and invasive species. This suggests increasing recognition that biodiversity loss is driven by interacting and compounding pressures, rather than isolated factors. In contrast, pollution and overexploitation appear as smaller nodes with weaker connections, indicating they are less frequently studied in combination with other drivers, despite their known ecological significance.
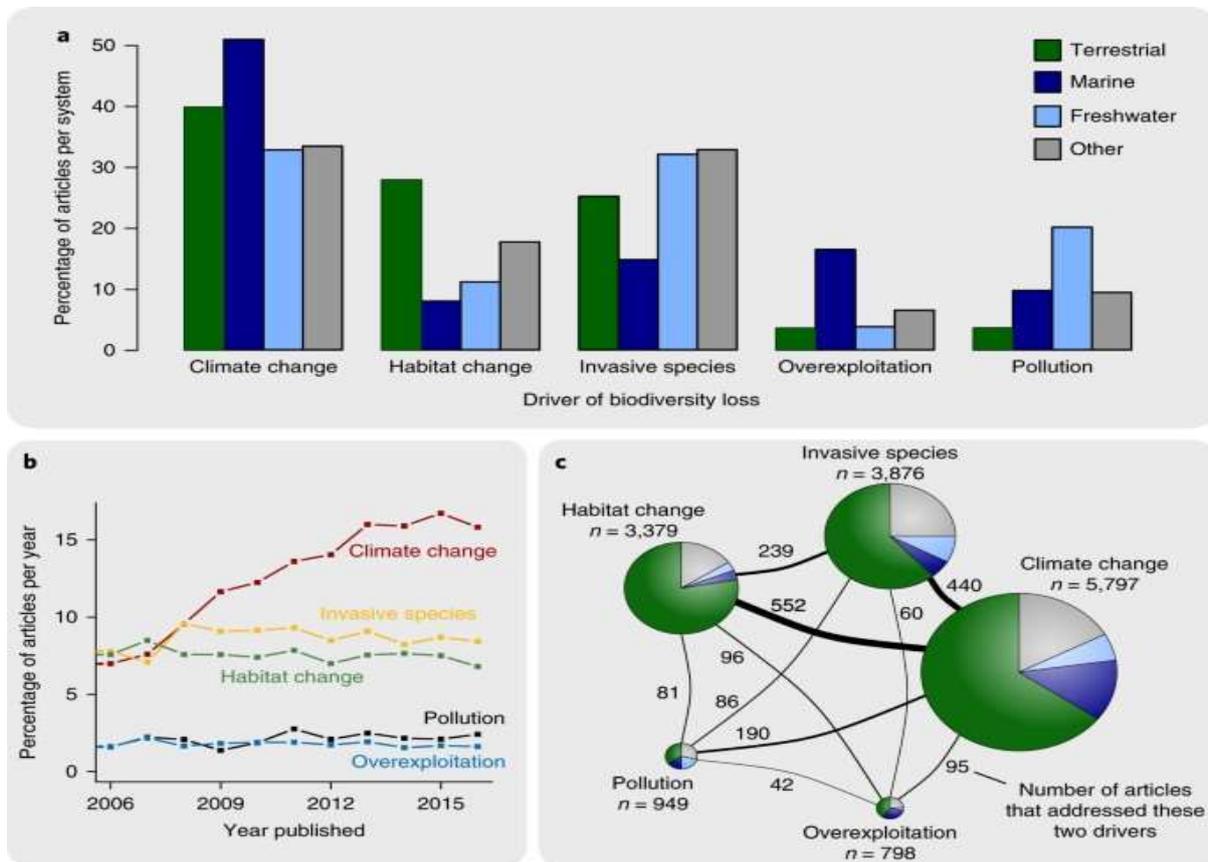
Figure 1: The graphs indicate the analysis of Biodiversity Loss Drivers Across Ecosystems and Time

Figure 2 illustrates the distribution of themes and sub-themes identified in the reviewed studies, highlighting the relative emphasis placed on quality of care, patient factors, and interventions. Intervention-related themes were the most frequently reported, accounting for 44.2% of all coded instances. Within this category, the evaluation of outcomes (n = 75) was the dominant sub-theme, followed by descriptions of treatment approaches (n = 28). This indicates that the majority of studies focused on assessing the effectiveness of interventions and measuring clinical or programmatic outcomes, reflecting a strong outcome-oriented research agenda. Themes related to quality of practice constituted 35.6% of the total and were largely driven by studies examining the quality of practice

(n = 60). In contrast, considerably fewer studies assessed the quality of records (n = 8) or explored access, utilisation, and service provision (n = 6). This imbalance suggests that while clinical practice quality is frequently evaluated, systemic aspects such as documentation quality and service accessibility receive limited attention. Patient-related factors represented 19.7% of the themes identified. Most of these studies focused on characterising patient profiles (n = 38), with fewer examining diagnostic, prognostic, or risk indicators (n = 18). This indicates a moderate level of attention to patient characteristics, though less emphasis is placed on predictive or risk-based analyses.
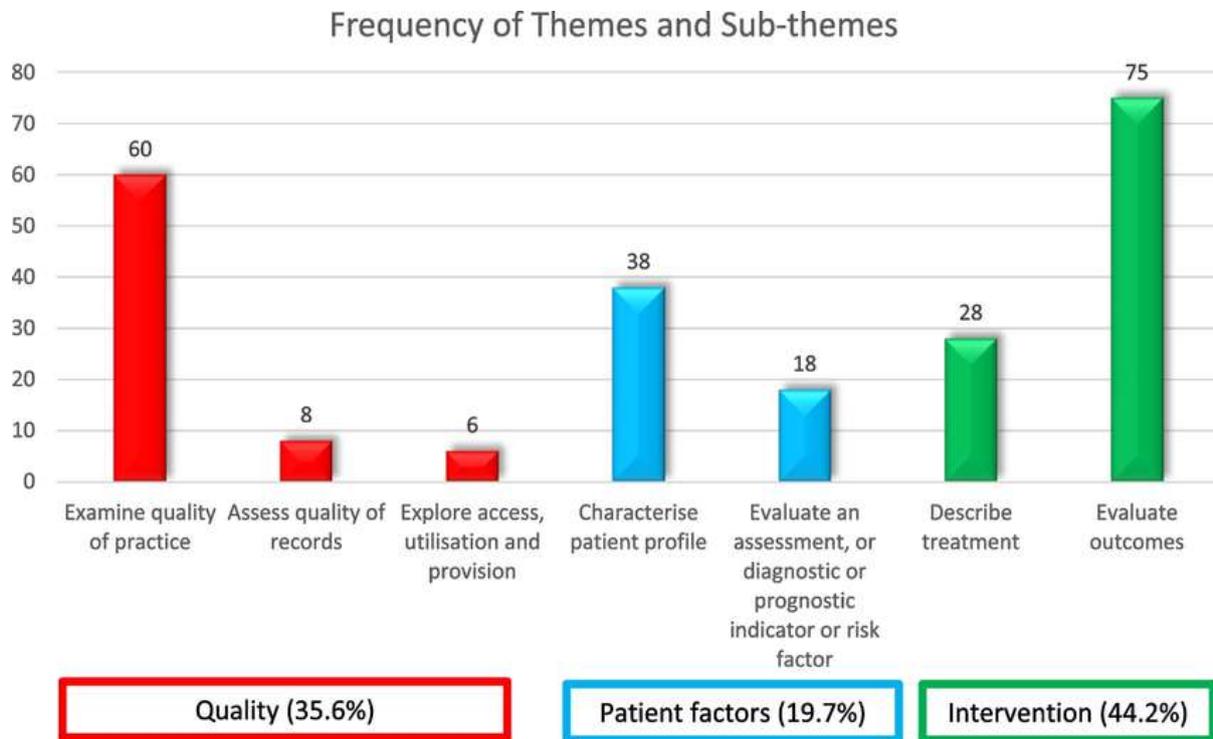
Figure 2: The graph illustrates the distribution of themes and sub-themes identified in the reviewed studies.

Discussion

The results indicate a clear and increasing dominance of climate change as the primary driver of biodiversity loss addressed in scientific research. Across terrestrial, marine, freshwater, and other ecosystems, climate change consistently receives greater attention than other drivers, particularly within marine systems. This trend reflects the growing recognition of climate change as a pervasive and cross-cutting threat that intensifies existing ecological pressures. The sharp rise in climate-focused studies after 2009 aligns with global policy developments, including heightened international climate negotiations and increased funding for climate-related research, suggesting that scientific agendas are strongly influenced by global policy priorities. Habitat change remains a major focus in terrestrial ecosystems, consistent with long-standing concerns regarding land-use change, deforestation, and agricultural expansion. The stable research attention to habitat change over time indicates its continued relevance but also suggests that it may be perceived as a well-established driver rather than an emerging crisis. In contrast, invasive species receive comparatively greater attention in freshwater and other ecosystems, reflecting their significant ecological impacts in systems that are particularly vulnerable to biological invasions. These findings highlight the importance of ecosystem-specific drivers, which may be overlooked when research is dominated by global-scale climate narratives. Despite their well-documented ecological impacts, overexploitation and pollution remain underrepresented across all ecosystem types and over time. The limited research focus on these drivers suggests a disconnect between scientific attention and the cumulative pressures affecting biodiversity, particularly in regions where resource extraction, pollution, and unsustainable harvesting persist. This imbalance may limit the effectiveness of conservation strategies that rely heavily on climate adaptation while neglecting locally manageable stressors. The co-occurrence analysis further demonstrates that biodiversity loss is increasingly understood as the result of interacting drivers rather than isolated threats. The strong links between climate change, habitat change, and invasive species underscore the need for integrated research and policy frameworks. However, the weak integration of pollution and overexploitation into multi-driver analyses suggests that these pressures remain insufficiently embedded within holistic conservation approaches.

Generalizability

The findings are broadly applicable to global biodiversity research trends, as the reviewed literature spans multiple ecosystems and geographic contexts. However, caution is required when extrapolating results to specific local or regional settings, where drivers such as pollution, overharvesting, or land-use change may exert greater influence than climate change alone. The results are most generalizable to research prioritization patterns rather than direct ecological outcomes and should therefore be interpreted within the context of research agenda-setting rather than site-specific conservation dynamics.

Conclusion

The study demonstrates that climate change has become the dominant driver of biodiversity loss addressed in scientific research across ecosystems and over time. While habitat change and invasive species remain important focal areas, overexploitation and pollution receive comparatively limited attention despite their substantial ecological impacts. The increasing co-occurrence of drivers in research reflects a growing recognition of biodiversity loss as a multi-dimensional problem. However, the uneven distribution of research attention highlights critical gaps that may constrain the development of comprehensive conservation strategies.

Limitations of the Study

This study is subject to several limitations. First, the analysis is based on a synthesis of published literature, which may reflect existing research biases rather than the full spectrum of biodiversity loss drivers. The overrepresentation of climate change in the literature may therefore partly result from publication and funding priorities rather than actual ecological dominance. Second, the categorization of drivers relied on how studies framed their focus, which may oversimplify complex, interacting pressures. Third, the temporal scope of the reviewed studies may not capture recent shifts in research emphasis or emerging drivers. Finally, the study does not quantify the actual ecological impact of each driver, but rather assesses patterns in research attention, which may not directly correspond to on-the-ground biodiversity loss.

Recommendations

To strengthen biodiversity conservation outcomes, future research should adopt more balanced, integrative approaches that address multiple interacting drivers of biodiversity loss. Greater emphasis should be placed on underrepresented drivers such as pollution and overexploitation, particularly in regions where these pressures are immediately manageable through policy and regulation. Conservation planning and policy frameworks should move beyond climate-centric strategies and incorporate ecosystem-specific drivers, supported by cross-sectoral collaboration and long-term monitoring. Integrating multi-driver evidence into biodiversity policy and management will be essential for developing effective, resilient, and context-sensitive conservation interventions.

Biography

Dr. Sibonelo Thanda Mbanjwa is a dedicated lecturer in the Department of Nature Conservation at Mangosuthu University of Technology (MUT), South Africa. He holds a Ph.D. in Environmental Science and specializes in biodiversity conservation, sustainable development, and environmental education. Dr. Mbanjwa is deeply committed to community engagement, student mentorship, and the integration of indigenous knowledge systems into conservation practices. His work bridges academia and practical application, empowering students and communities through innovative teaching, research, and outreach initiatives.

Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

Author Contributions

I, the author, contributed to the study conception and design. Material preparation, data collection, and research were performed by Mbanjwa S.T. The first draft was written by Mbanjwa S.T.

Data Availability

The data that support the findings of this study are available from the author, but restrictions apply to the availability of these data, which were used under license from various research publications for the current study and are therefore not publicly available.

Conflict of interest

The author declares no conflict of interest

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