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Local government response to urban biodiversity conservation challenges within a global biodiversity hotspot

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Introduction: The post 2020 Global Biodiversity Framework advocates for a whole-of-government and whole-of-society approach to address the global biodiversity crisis, with increasing calls for local governments to play a more active role in biodiversity conservation. We present a local government led examination of tools aimed at increasing biodiversity protection, management, and ecosystem restoration in the City of Durban, located in a global biodiversity hotspot.

Methods: Using analytical frameworks and local government data, we assessed the efficacy of tools applied, and identified barriers and potential enablers to improve conservation outcomes.

Results: We confirmed areas of success in the development of fit-for-purpose town planning tools that have contributed toward avoided loss of biodiversity, and the implementation of tools that have increased the protection of important biodiversity sites. Development of land management and restoration functions have further advanced conservation outcomes through restored ecological processes, and improved management of threats. Despite positive contributions to biodiversity conservation, several challenges persist, including unequal biodiversity protection and investment in relation to local population socio-economic status, cross-sectorial barriers, governance silos, and inadequate incentives for protection and management. Increasing biodiversity conservation on landholdings under traditional and private land tenure represents an important next step for the City. Upscaling of successful management tools, improving financial incentives for landowners, and adopting a more community centered approach to conservation governance, represent key opportunities for the City.

Discussion: We emphasize the important role that a local government can play in contributing toward broader biodiversity goals and identify opportunities and challenges in the development and application of biodiversity conservation tools at the local government scale, through the lenses of governance, equity and justice, and inclusivity.

KEYWORDS

urban biodiversity, conservation expansion, local government, ecological management, Durban

1 Introduction

The world is facing a triple planetary crisis of biodiversity loss, climate change, and pollution (UNEP, 2024). Urbanization represents a key driver of this global polycrisis, intensifying environmental pressures through *inter alia* land-use change and resource consumption (Güneralp et al., 2020; UNEP, 2024), leading to increased attention on the role of cities and local governments in addressing environmental sustainability (Bulkeley et al., 2021). Previous global biodiversity targets have not been met in terms of ecological representation and management effectiveness (Maxwell et al., 2020), and transformative change is required to alter negative trajectories (Gupta et al., 2024). Effective and integrated governance arrangements, including the role of cities and local government, feature prominently in several globally relevant policies. This is particularly evident in the expression of urban-focused sustainable development goals, particularly SDG 11 of the 2030 Agenda for Sustainable Development that aims to *Make cities and human settlements inclusive, resilient and sustainable* (UNGA, 2015); the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services *possible actions and pathways to achieve transformative change* (IPBES, 2019); and Target 12 of the post 2020 Global Biodiversity Framework that aims to *Enhance Green Spaces and Urban Planning for Human Well-Being and Biodiversity* (UN, 2022). Similarly, the importance of biodiversity protection in enabling climate change adaptation represents a central element of the GBF with clear links to urban areas (Targets 8, 11, and 12; UN, 2022).

This call to action is particularly relevant to those cities that are within biodiversity priority areas, as failure to effectively deal with the threats of urbanization in these areas will increase extinction rates and directly impact ambitious global biodiversity goals (McDonald et al., 2018). Average population densities within global biodiversity hotspots have also increased at twice the rate relative to the rest of the world for the period of 1995-2015 (Cunningham and Beazley, 2018), further emphasizing the need for urgent intervention. The majority of future population growth is anticipated to occur in the Global South, emphasizing that the urban world is increasingly a "southern urban World" (Shackleton et al., 2021). Future urban growth within Sub-Saharan Africa represents a particular threat to biodiversity, and without careful planning will lead to significant biodiversity losses (Simkin et al., 2022).

Rarely have cities and their local governments been acknowledged as significant contributors to actively increasing the conservation area estate, and, thereby, contributing toward broader conservation targets (Soanes et al., 2019). There are various reasons for this, such as governance mandates for biodiversity typically positioned at provincial/regional and national government levels (Nilon et al., 2017), but at the core is the idea that urban is the antithesis of natural, and should be avoided due to potential direct and indirect threat of transformation (Soanes and Lentini, 2019). This is often reflected in conservation planning approaches, and subsequent polices and protected area expansion strategies, which typically promote the selection of larger vegetation units at the expense of fragmented patches (Tulloch et al., 2016). The problem with avoiding cities, and particularly those within biodiversity hotspots, is that these areas often harbor significant threatened biodiversity (Ives et al., 2016). Contrary to traditional conservation planning approaches, the importance of small habitat patches to global conservation efforts has been shown to be so important that failure to incorporate these areas in conservation area expansion strategies will result in significant biodiversity loss (Wintle et al., 2019). This calls for increased focus on conservation of remnant critical biodiversity areas and the promotion of ecological connectivity between patches (Wintle et al., 2019). It is also clear that realizing conservation opportunities will be essential to build resilience in response to the global polycrisis, and to achieve area-based targets (Pörtner et al., 2022; UN, 2022; UNEP, 2024), Furthermore, the avoidance of urban areas for achieving biodiversity outcomes does not adequately account for direct local benefit associated with access to biodiversity, and value derived from avoided service delivery costs (IPBES, 2019; Bulkeley et al., 2021).

Biodiversity conservation in fragmented urban landscapes is not limited to land protection, but requires management interventions to ensure ecological processes are maintained (e.g., fire management in grassland systems) and that additional threats to biodiversity are adequately addressed (e.g., combatting invasive alien species and preventing over-exploitation of natural resources; Ramalho et al., 2014). Despite these challenges, urban areas often represent ideal settings for conservation activities in terms of conserving biodiversity, while allowing people to actively engage with nature (Soanes and Lentini, 2019), with all the benefits that brings (Tomita et al., 2017). Cities and local government are also defined by a service delivery mandate (e.g., land-use planning, water supply, sanitation, stormwater control), and, given the strong relationship between biodiversity and the supply of ecosystem services and human wellbeing (Elmqvist et al., 2013; IPBES, 2019; Gupta et al., 2024), should represent a central component of local government planning.

This is particularly relevant to developing cities, where investment in, and protection of, urban green infrastructure offers opportunities to aid in cost-effective service delivery and contribute to the alleviation of the socio-economic challenges facing these cities (Lindley et al., 2018). The loss of these critical services represents a particular challenge to cities of the Global South where citizens are often directly reliant on ecosystems services to meet basic needs (Shackleton, 2021). Compounded by structural spatial and economic inequities, the continual loss of these critical services increases the vulnerability of these citizens (Kumar and Yashiro, 2014; Davoren and Shackleton, 2021). The now almost certain inevitability of exceeding global warming of 1.5°C above the pre-industrial level means that cities will increasingly be subjected to climate change impacts, with impacts being disproportionally associated with cities of the Global South (IPCC, 2023). Increasing coastal storms, droughts, extreme heat and flooding will require adaptation, and generate losses and damages; but, again due to the inherent inequalities and inequities faced by the Global South, the capacity to address these issues is limited (Sitas et al., 2021). Ensuring the protection of biodiversity, and the associated urban regulating ecosystem services, within cities of the Global South, represent critical pathways to improving resilience (Pauleit et al., 2021).

Local government's role in contributing toward biodiversity outcomes and sustainability is receiving increasing global attention

(McDonald et al., 2018; Acuto et al., 2020). Effectiveness of biodiversity mainstreaming has differed substantially across cities (Shih et al., 2020) emphasizing the significant implementation gap that persists in conservation planning and environmental governance (Knight et al., 2008; Ferraro and Failler, 2024). Additionally, the contextual differences of cities from the Global South (Shackleton et al., 2021) has led researchers to call for more active participation in academic literature from cities of the Global South toward a more relevant Global South urban agenda (Nagendra et al., 2018; Shackleton et al., 2021). The research gap is evident across the urban biodiversity and governance space (Nagendra et al., 2018; McDonald et al., 2020; du Toit et al., 2021; Rega-Brodsky et al., 2022). Understanding unique Global South perspectives is essential so as to avoid past mistakes and develop a transformative pathway that promotes sustainability and equity (Lwasa et al., 2018).

The purpose of this research is to determine, using the City of Durban (South Africa) as a case study, the role a local government can play in contributing toward improved biodiversity outcomes. Through new case-study research, the research contributes to addressing the global policy to local implementation gap (Nilon et al., 2017; Shih et al., 2020), research-implementation gap (Knight et al., 2008; Ferraro and Failler, 2024), and the Global South research gap (Nagendra et al., 2018; McDonald et al., 2020; du Toit et al., 2021). The City of Durban, administered by the eThekwini Municipality, located in middle of the Maputaland-Pondoland-Albany biodiversity hotspot (Boon et al., 2016), has been actively involved in the protection, management and restoration of biodiversity for the past four decades (eThekwini Municipality, 2007, 2024b; McLean et al., 2020). This longstanding engagement provides an opportunity to analyze and develop a deeper understanding of these interventions, their efficacy in contributing toward broader biodiversity goals, and contributions to addressing the aforementioned gaps in understanding.

This paper, through an analysis of tools applied by the City of Durban and its partners to protect and manage biodiversity, aims to:

- Illustrate how a local government can contribute to broader conservation goals;
- Assess the efficacy of the tools applied in biodiversity protection, management, and restoration; and
- Identify priority future action and enablers required to improve conservation outcomes.

To address these questions, we used analytical frameworks to assess the tools applied in the protection of biodiversity features, and the tools applied in the management and restoration of these areas. These frameworks are supported and supplemented by additional local level data.

2 Methods

2.1 Location and context

The 2,566 km^2 City of Durban is administered by the eThekwini Municipality in the province of KwaZulu-Natal (KZN), South Africa (McLean et al., 2020). The variety of landforms and climatic conditions in the eThekwini Municipal Area (EMA), as well as its unique biogeographical position, in the center of the Maputaland-Pondoland-Albany global biodiversity hotpot (Mittermeier et al., 2005), has resulted in a wide range of terrestrial and aquatic ecosystems that are home to a rich diversity of organisms (Boon et al., 2016).

With 4.1 million people, Durban is the third largest metropolitan by population in South Africa, representing more than a third of the provincial population in an area that is <3% of the provincial total (eThekwini Municipality, 2022). The result is that Durban's rich natural environment has been under significant pressure and negatively impacted over the past 150 years, initially by extensive agriculture, and then, increasingly, by rapid urbanization, resulting in the cover of the original vegetation types being reduced by approximately two-thirds (Boon et al., 2016). Rates of loss of natural habitat are particularly high in KwaZulu-Natal, averaging 1.2% per annum between 1994 and 2011, and likely to be substantially higher in the more densely populated Durban (Jewitt et al., 2015). The municipality accommodates a variety of land uses, with 32% of the municipal area considered to be urban (e.g., residential, commercial and industrial) located largely to the East and along the major national transport routes (N2 and N3 highways; eThekwini Municipality, 2022). Approximately 68% of the municipality is classified as rural, although this does include pockets of dense settlement, and commercial farms (~10% of the rural area) located mainly in the western hinterland (eThekwini Municipality, 2022). Much of this rural landscape falls within traditional authority areas (hereafter referred to TAAs) administered by the Ingonyama Trust Board, that is held in trust for the Zulu people with the Zulu King as the sole trustee (Nel, 2021). This creates a unique and complex dual governance system, where the municipality is responsible for land-use planning and management in terms of the land-use scheme for the entire area, but only has formal authority in non-TAAs (eThekwini Municipality, 2022).

The socio-economic context of Durban, with a high degree inequality (Gini co-efficient = 0.62) and more than a third of the population living below the poverty line (eThekwini Municipality, 2022), further exacerbates pressure, through growing informality and reliance on reducing natural resources (eThekwini Municipality, 2020). In addition, the availability of land to support development is limited by, *inter alia*, the steep topography that characterizes the City, placing additional pressure on threatened habitats types (e.g., grassland systems) that are typically associated with the flatter, more 'developable' areas (eThekwini Municipality, 2020).

2.2 Approach

Insights detailed in the paper are based on 40 years of experience in the field of local government biodiversity conservation. This case study, and the associated analytical frameworks, have been used to generate understanding of local impacts and outcomes, and this understanding is then generalized beyond the local. This approach is supported by literature

(Flyvbjerg, 2011; Tsang, 2014; Steinberg, 2015), with process tracing representing an important approach in providing evidence to support assertions, with theoretical implications that may extend beyond the boundaries of the case study, and being comparable to large N-methodologies in generalizability (Steinberg, 2015). Further enhancing the generalizability of Durban as a case study is that it shares several similarities with other cities of the Global South relating to: presence of high biodiversity, governance (i.e., decentralized and dual-governance complexity), socio-economic and development pressures, and opportunities for nature-based solutions in response to climate-linked natural disasters (Shackleton et al., 2021). Two analytical frameworks were produced for the: (1) biodiversity protection tools; and (2) management and restoration tools applied to protect and manage important biodiversity areas. These two frameworks, through thematic and content analyses, identified: (1) key policies/legislation enabling the tool (2) how the tool was applied; (3) outcome in terms of protection and management; (4) strengths of the respective tools; (5) weaknesses of the respective tools; and (6) next steps required for improvement and opportunities to scale these tools.

A third analytical framework, based on comparative and content analysis, was applied across all the tools assessed and categorized in term of: (1) impact on policy and practice-tool ranking based on measurable biodiversity conservation outcomes and operational continuity; (2) contribution to socio-economic development- tool ranking based on success in creating green jobs, supporting local economies, and fostering community involvement; and (3) suitability for implementation within TAAs-tool ranking based on measurable outcomes with operational continuity. Based on this assessment each tool was ranked in terms of performance relative to the three criteria (Green/High = 5, Orange/Moderate = 3, Red/Low = 1), and represented graphically. Total cumulative scores for the three criteria were calculated to contrast the effectiveness of the current toolset.

Datasets that were used in highlighting the impact and relative success of these tools have been drawn from various municipal GIS databases and reporting tools, including: (1) Durban's State of Biodiversity reporting (eThekwini Municipality, 2024a); (2) Durban's Systematic Conservation Assessment (McLean et al., 2020); (3) Durban's Strategic Environmental Assessment (eThekwini Municipality, 2020); and (4) the Biodiversity Management Department's environmental information network, viz: development applications; conservation areas; land acquisition; environmental zones (eThekwini Municipality, 2023a).

3 Results

3.1 Biodiversity protection

Table 1 provides an analysis of the tools applied in biodiversity protection using the analytical frameworks. The patterns are summarized below. The results for this section are further discussed based on biodiversity outcome and land tenure, and include: (1) Avoided biodiversity loss through spatial and land-use planning; (2) Increasing the conservation estate through traditional tools; (3) Formal protection of privately owned land; and (4) Formal protection within traditional authority areas.

3.1.1 Avoided biodiversity loss through spatial and land-use planning

Avoided loss through mainstreaming biodiversity considerations into spatial and land use-planning initiatives represents possibly the most significant positive impact regarding biodiversity protection in Durban. Central to this effort has been the Durban Metropolitan Open Space System (D'MOSS), integrated within the City's Spatial Development Framework since 2002 and within land-use planning schemes since 2010. The influence of D'MOSS is evident in three areas, viz: (1) mandated assessment of potential biodiversity impacts from proposed developments; (2) integration of biodiversity priorities within strategic spatial planning products and processes; and (3) the requirement for horizontal engagement across municipal functions (Table 1).

Influence at the individual property level is evident by the number of applications received for assessment (Table 1), and, critically, ensures assessment of developments that do not meet the spatial thresholds for assessment under national and provincial impact assessment processes. Avoided biodiversity loss outcomes, through conditions outlined in the approval of land-use planning applications, have been achieved through reduced development footprints, outright rejection of inappropriate development, or reconfiguration of development footprints (McLean et al., 2024). Of concern, however, is the relative ineffectiveness of D'MOSS within TAAs, where it is largely ignored in the allocation and development of land (based on customary law in terms of the Traditional and Khoi-San Leadership Act, 2019 Act No. 3 of 2019), an illustration of the land-use planning and management challenges posed by the dual governance system. That only 7% of the total applications received fell within TAAs, despite rapid land-use change in some of these areas, emphasizes a governance gap. This disparity in the implementation of D'MOSS regulations represents a significant threat to biodiversity, in that 55% of D'MOSS, including some of the most critical and connected areas, fall within TAAs (Figure 1).

D'MOSS, as a primary planning layer in spatial planning processes, enables engagement with other municipal functions (e.g., Housing, Water and Sanitation, Roads) to address the implications of potential land-use changes (Table 1). A key component of avoided loss in the City is messaging around development constraints due to the presence of important biodiversity features. The development of sustainability thresholds in the first phase of Durban's Strategic Environmental Assessment (eThekwini Municipality, 2020) represents the most recent advancement in this area (Table 1), and highlights the very high exceedance of sustainability thresholds for terrestrial and aquatic systems (eThekwini Municipality, 2020), which is in line with recent global findings (Gupta et al., 2024).

Although horizontal integration of biodiversity considerations has been advanced through these tools, translation of spatial planning products to property level conservation outcomes requires further attention (Table 1). The Cato Ridge Local Area Plan and Draft Land Use Management Scheme Process (eThekwini Municipality, 2018) represented the most significant process at this scale from a conservation and City planning perspective. This area includes much of the remaining threatened grassland systems in Durban, a key area of focus in terms conservation area expansion programmes, but has also been earmarked for use as a logistics hub and industrial production zone in support

TABLE 1 Analytical framework describing the local government tools used in the protection of biodiversity within Durban.

Tools applied	Policy environment	Contribution to biodiversity protection	Outcome	Strengths	Weaknesses	Next steps/opportunities
Durban metropolitan open space system	Municipal planning is a function assigned to municipalities (RSA Constitution: Section 156, schedule 4B). The Spatial Planning and Land Use Management Act no. 16 of 2013 (SPLUMA), and eThekwini Municipality Spatial Planning and Land Use Management Bylaw, 2016 provide the legal context for implementation.	As a result of the inclusion of D'MOSS in the municipality's scheme provisions as a development assessment overlay, any planning application for a site included in or immediately adjacent to D'MOSS must be assessed and approved by the Biodiversity Management Department.	The entire system is 95,000 ha, and includes threatened ecosystems, critical biodiversity areas, and other features of potential significance in terms of biodiversity, and the delivery of ecosystem services. Over 17,000 applications received and assessed over the period 2007–2018 (McLean et al., 2024). 358 ha of registered conservation servitudes.	Ensures that environmental considerations are considered during development assessment processes. Acts as a safety net for development processes that may not 'trigger' assessment based on national environmental legislation thresholds.	Limited effectiveness within traditional authority areas (TAAs).	Integration with national development assessment products and processes to ensure an additional level of oversight from national and provincial conservation authorities. Work toward an integrated land-use planning approach within TAAs, with greater adherence to municipal planning schemes. Registration of outstanding conservation servitudes.
Strategic environmental assessment	The spatial planning and land use management Act no. 16 of 2013 (SPLUMA), and Local Government: Municipal Planning and Performance Management Regulations (2001), promulgated in terms of the Municipal Systems Act (Act No. 32 of 2000), provides the legal framework for strategic analysis of Strategic Development Frameworks (SDF)*.	The tool analyses the City's environmental performance at the most strategic spatial planning level and provides an analysis of the City's performance relative to conservation targets and avoided biodiversity loss.	The most comprehensive review of the state of Durban's natural systems to date. Highlighting the significant challenge in meeting conservation targets for the City.	Analysis of the SDF promotes engagement across several municipal line functions with competing spatial ambitions. Opportunity to engage with City leadership regarding the state of biodiversity within Durban.	Current product has yet to integrate future socio-economic considerations in the assessment of strategic environmental impact.	Phase two of the SEA will require the development of socio-economic scenarios that will be used to determine possible implications for the achievement of established sustainability thresholds in Durban and which will be used to assess options for future urban form and development trajectories.
Lower order spatial planning	First stage of implementation of the Integrated Development Plan (IDP)* and SDF. The Spatial Planning and Land Use Management Act (no. 16 of 2013) required that municipalities have 'wall to wall' coverage of the municipal area with a land use management system (i.e., municipal land-use scheme).	As the bridge between strategic planning and land-use schemes these processes provide opportunity to refine information, and, in some cases, reinforce protection of natural assets.	Refinement of environmental layers that inform land-use planning, and particularly the inclusion of important conservation worthy areas as primary land-uses in newly formed schemes.	Provides a platform for line functions with often competing spatial plans to engage in detailed collaborative planning in administratively defined areas. Opportunities to ensure that biodiversity information is confirmed through more detailed studies.	Translation of these planning products into land-use schemes can lack the land-use controls required for biodiversity protection.	Limited opportunities to change primary land-use due to the presence of already existing wall-to-wall schemes; however, significant opportunity to undertake conservation planning at a precinct level and promote conservation area expansion at a practical level.

(Continued)

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TABLE 1 (Continued)

Tools applied	Policy environment	Contribution to biodiversity protection	Outcome	Strengths	Weaknesses	Next steps/opportunities
Conservation zone	A conservation zone is land (other than publicly owned land) dedicated to the conservation and management of natural areas of land and/or water for the ecosystem services that the areas provide, biodiversity that they support, and/or their landscape, historic or scientific interest values.	Introduces land-use controls on private land parcels that prevents transformation of the natural asset. Intended to be applied on privately owned land, and envisioned primarily for split zoning of properties, where the environmental feature is protected while the remaining area has a development type land-use.	This tool has been sparingly used since the initial large-scale split-zoning of properties surrounding key areas in the Outer West Planning Region. Ultimately this process was rescinded due to a procedural error in the advertising of the scheme amendment.	Provides clear land-use direction on private land via split-zoning of property. Cost effective in comparison to servitudes, and less reliant on landowners for implementation.	Large-scale split zoning remains untested.	A tool with significant promise as a split zone can protect remaining environmental features on individual properties and remove ambiguity regarding available developable footprints. A cost-effective alternative to servitudes (as the landowner would not be required to incur land surveying costs) that may have been required as a result of a development assessment process, but never implemented.
Environmental conservation reserve	Publicly owned land dedicated to the conservation and management of natural areas of land and/or water for the ecosystem services that the areas provide and the biodiversity which they support.	Applied to state owned land that has typically been purchased by the municipality.	1,959 ha have been rezoned to ECR.	Provides additional protection to public sites. Internally controlled process.	Not suitable for nature reserves where there are areas designated for use other than strict conservation (e.g., administrative areas).	Continual rezoning of areas acquired for conservation purposes. Rezoning of conservation worthy sites that are currently zoned as Public Open Space.
Land acquisition	The only annual capital budget item aimed at securing biodiversity in support of Programme 3 of Plan 1 of the IDP which outlines the requirement for ensuring long term sustainability of Durban's natural resource base. Sites acquired are intended to be proclaimed as nature reserves or protected environments in terms of National Environmental Management: Protected Areas Act (No. 57 of 2003).	Targeted implementation tool with a particular emphasis on conserving threatened habitats and/or supporting the expansion of existing conservation areas. Transfer of property purchased for conservation purposes from private individuals with possible development aspirations to a local government department.	750 ha of important conservation areas purchased predominantly in support of existing conservation areas or targeted threatened habitats.	Provides immediate definitive protection of the biodiversity asset. Ability to target strategic land parcels important for effective conservation area expansion. Limited parties involved in implementation.	Limited capital budget available. Process has historically relied on a willing seller to proceed.	Move to a three-year approval cycle for property acquisition, and expropriation with compensation as the preferred tool, allows for shorter Supply Chain Management processes, and the ability to take advantage of municipal capital savings.

(Continued)

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TABLE 1 (Continued)

Tools applied	Policy environment	Contribution to biodiversity protection	Outcome	Strengths	Weaknesses	Next steps/opportunities
Nature reserve proclamation	National Environmental Management: Protected Areas Act (No. 57 of 2003).	The conservation gold standard, providing the greatest level of protection to natural assets. Addressing the disjuncture of municipal nature reserves with NEMPAA was priority for the Department, resulting in a joint project with Ezemvelo KZN Wildlife and the City's Natural Resources Division (NRD) who are directly mandated to undertake management of these reserves.	11 nature reserves proclaimed in terms of NEMPA since 2015.	Highest level of protection available. Opportunities to secure more resources due to status.	The initial pilot has taken considerable time to reach completion. Distribution of Protected Areas reinforces spatial socio-economic inequality.	Primary tool that will be used in consolidating the outcomes of other processes (e.g., land acquired or zoned for conservation purposes). Proclamation of protected areas in poorer areas of the City.
Biodiversity stewardship	EThekwini Municipality Biodiversity Stewardship Policy (2017) is strongly informed by national and provincial approaches to biodiversity stewardship.	The primary tool used for TAAs, and relies on the development of partnerships with traditional leaders within key biodiversity areas.	Five letters of support from key TAAs.	Preferred approach to conservation area expansions at a national and provincial level, primarily due to the cost-effective nature of the intervention. Empowers landowners to protect and manage land, which reduces the strain on government resources.	Lack of suitable financial incentives to 'sell' the concept to landowners. Arrangements within TAAs are complicated by existing governance arrangements where authority would be required from traditional leaders and the Ingonyama Trust Board.	The development of objectives that provide significant economic opportunities is critical for the success of this intervention. Partnerships with key line functions within the City will be important.
Environmental rates certificates	The eThekwini Rates Policy (eThekwini Municipality 2008), provides for landowners to apply for an environmental rates certificate.	Conditions for the certificate, and associated rates rebate, include formal protection of the feature via an appropriate zone or servitude and evidence of a management plan.	While there have been a few certificates issued, the lack of clarity on how environmental features are factored into the determination of property rates has been a limiting factor.	In theory, the incentive-based approach provides an ideal solution to promote landowners taking responsibility for driving biodiversity protection and management.	Lack of clarity regarding the approach to rating of properties with environmental features means that it is difficult to effectively implement this project currently.	Greater clarity is required in terms of rating of properties with important environmental features, and linked to this, a requirement to change the rating policy to incentivize landowners to protect these areas

*An Integrated Development Pan (IDP) is a key City strategy that informs and guides all service delivery and development in the municipality. A Spatial Development Framework (SDF) guides the overall spatial distribution of current and future land uses in line with the objectives of the IDP.

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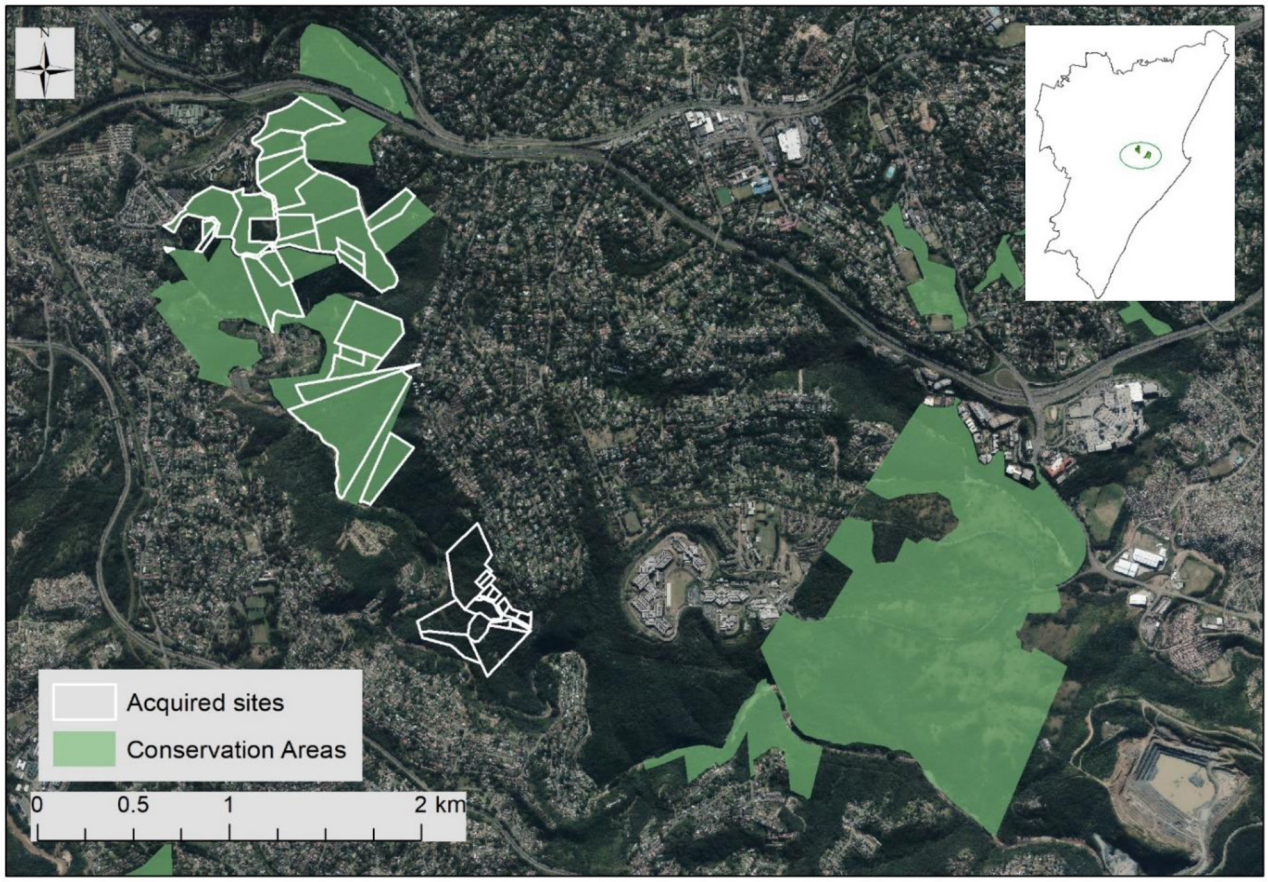

FIGURE 1
Conservation area expansion through targeted land acquisition within the Paradise Valley—Roosefontein corridor to promote connectivity between the conservation areas and the protection of biodiversity features. Green areas with white outlines indicate land that has been acquired and proclaimed as part of the nature reserve, while areas with only white outlines indicates land that has been acquired for conservation purposes and has yet to be formally proclaimed as part of the nature reserve. Inset indicates the proximity of these sites within the eThekwini Municipality.

of port development plans (eThekwini Municipality, 2018). Through detailed engagement with sectors, and refinement of habitat mapping data, important conservation areas were assigned a proposed conservation zone, representing an important an important conservation outcome (McLean et al., 2024). The translation of the draft scheme through the approved Outer West Scheme has, however, provided a level of ambiguity as these areas have been grouped into a 'Land-Use Management Holding Area' (eThekwiniMunicipality, 2023). The zone does list conservation as a primary use, however, there are no precluded activities, and all other land-uses are available via special consent, thereby hindering opportunities to advance and ensure conservation outcomes (eThekwini Municipality, 2023b).

Improving the translation of hierarchical and broad-scale spatial plans to definite land-uses, development of socio-economic scenarios to assess ecological thresholds against options for future urban form, and developing a more integrated land-use planning system in TAAs, represent opportunities to further avoided loss outcomes using spatial planning tools (Table 1). To compliment these horizontal integration interventions, additional benefit can be delivered by focusing on vertical integration opportunities created by national policy advancements. Greater alignment of threatened vegetation mapping across government scales represents an important opportunity to improve avoided loss outcomes in Durban (Table 1), particularly for threatened vegetation types that have more stringent requirements in environmental assessment processes (Botts et al., 2020).

3.1.2 Increasing the conservation estate through traditional tools

Several proactive tools have been tested and applied in an attempt to increase formal biodiversity protection within Durban, which currently represents 7.16% of D'MOSS or 2.73% of the total municipal area (eThekwini Municipality, 2024a). There have been notable achievements with certain tools, including the land acquisition project which has contributed to the protection of Critically Endangered KwaZulu-Natal Sandstone Sourveld grassland (Table 1), where more of the habitat has been conserved through local government interventions

than by national and provincial biodiversity authorities (Boon et al., 2016). A major emphasis of the programme, particularly during its first decade, was acquiring sites near existing conservation areas. A total of 133 (79%) of the acquired sites were situated within 2 km of an existing conservation areas, with the ultimate intention of proclaiming many of the sites to enlarge an existing nature reserve. Figure 2 shows the important contribution made by the land acquisition programme in consolidating the now proclaimed Paradise Valley Nature Reserve, and the progress made in securing the ecological corridor between the Paradise Valley and Roosefontein Nature Reserves.

The identification of sites for acquisition has been based on several important objectives, with protection of intact and threatened ecosystems representing a particular focus. A total of 128 (76%) of the acquired properties contain vegetation types considered to be threatened (Vulnerable, Endangered or Critically Endangered), with the protection of Least Threatened vegetation types (e.g., Eastern Scarp Forest) more typically associated with the expansion or consolidation of existing conservation areas (e.g., toward the protection of ecological corridors as per Figure 1).

Durban has also been successful over the past decade in enhancing biodiversity protection through traditional protected area expansion and the proclamation of nature reserves (Table 1), which has improved the legal protection of sites, demonstrating that this type of protection can be effectively led by organizations aside from provincial and national conservation authorities. The current distribution of proclaimed nature reserves relative to the percentage of households with no or low income [categorized as per (Statistics South Africa, 2015)], a symptom of past apartheid planning, illustrates the greater access that wealthier communities have to proclaimed nature reserves and all the benefits associated with the services that these areas provide (Figure 2). These reserves, many of which have only recently been proclaimed, are largely associated with the older established suburbs of Durban.

Supporting the land acquisition programmes, and in alignment with local government's core mandate of land-use planning, has been the design of fit-for-purpose land use zones in Durban. The Environmental Conservation Reserve (ECR) has, to date, largely been used to provide appropriate protection for land owned by the municipality for conservation purposes (Table 1). Historic Public Open Space (POS) zoning attached to many of the municipal nature reserve sites was considered particularly problematic as permitted activities were not compatible with conservation objectives. ECR has largely addressed this issue, however, smaller sites of conservation significance still have POS as the underlying zoning. In addition, amalgamation of several local councils into a metropolitan municipality (EMB, 1999) led to several historical land-use zones with land-uses seemingly consistent with conservation objectives (e.g., Bush Reserve and River Reserve). The ECR zone provides a vehicle to consolidate and address these inconsistencies, while increasing the conservation estate and highlighting sites that may be included in municipal land management programmes.

3.1.3 Formal protection of privately owned land

Given the limited budget to undertake acquisition focused protected area expansion, and that 38% by area of threatened vegetation types within Durban is under private ownership (McLean et al., in review), additional tools have been tested to improve the conservation status of certain sites. In comparison to the more traditional approaches to conservation area expansion, tools intended to be applied on private land have, to date, not contributed significantly to the overall conservation estate (Table 1).

The roll out of a conservation servitude is one such tool that has been applied to certain land-parcels through conditions resulting from development assessment processes, where the remaining biodiversity feature is protected by the registration of a servitude against the title deed. There are at least 358 ha of registered conservation servitudes, however, this figure should be greater as there are several servitudes that have not been registered despite being a condition of development permission, and this will need to be addressed through administrative action. A downside of conservation servitude registration, and a possible explanation for the lack of implementation, is the financial burden associated with surveying and registration of the servitude against the property title deed. An option to mitigate this issue is through the rezoning of these areas to Conservation Zone, which is a process that can be implemented through local government processes, and, thereby, reduce the reliance on third parties.

The underutilization of the Conservation Zone presents a key opportunity for the City and future conservation area expansion (Table 1). In 2010, the eThekwini Municipality's Biodiversity Management Department (BMD, then Environmental Planning and Climate Protection Department) initiated a split zoning process of 1,800 properties along the Kloof/Waterfall Escarpment, including grasslands and forests of conservation value. This ambitious amendment received numerous comments and objections, and was eventually rescinded due to a procedural error in the advertising of the land-use scheme amendment. Split zoning on private land, introducing a conservation zone, is crucial for municipal land use planning as it allows for long-term environmental protection while promoting development, without government capital expenditure (Table 1). The rezoning along the Kloof escarpment was a bold move to integrate D'MOSS intentions into individual cadasters. This process should be reinitiated as it clarifies land-use planning, ensures environmental protection, and potentially allows for inclusion in large-scale municipal land management programs. Given many D'MOSS areas are undevelopable, this approach could increase the conservation estate with minimal impact on landowners' development aspirations. Based on the level of public resistance to the previous process, focused engagements with affected landowners will be necessary to gain support. Key messages should address: (1) actual vs. perceived impact on development rights as many of these properties are either biophysically constrained or contain threatened vegetation that would limit further development (McLean et al., in review); and (2) landowners' management responsibilities, particularly regarding invasive alien plant control and fire management, and the potential for management support for these obligations.

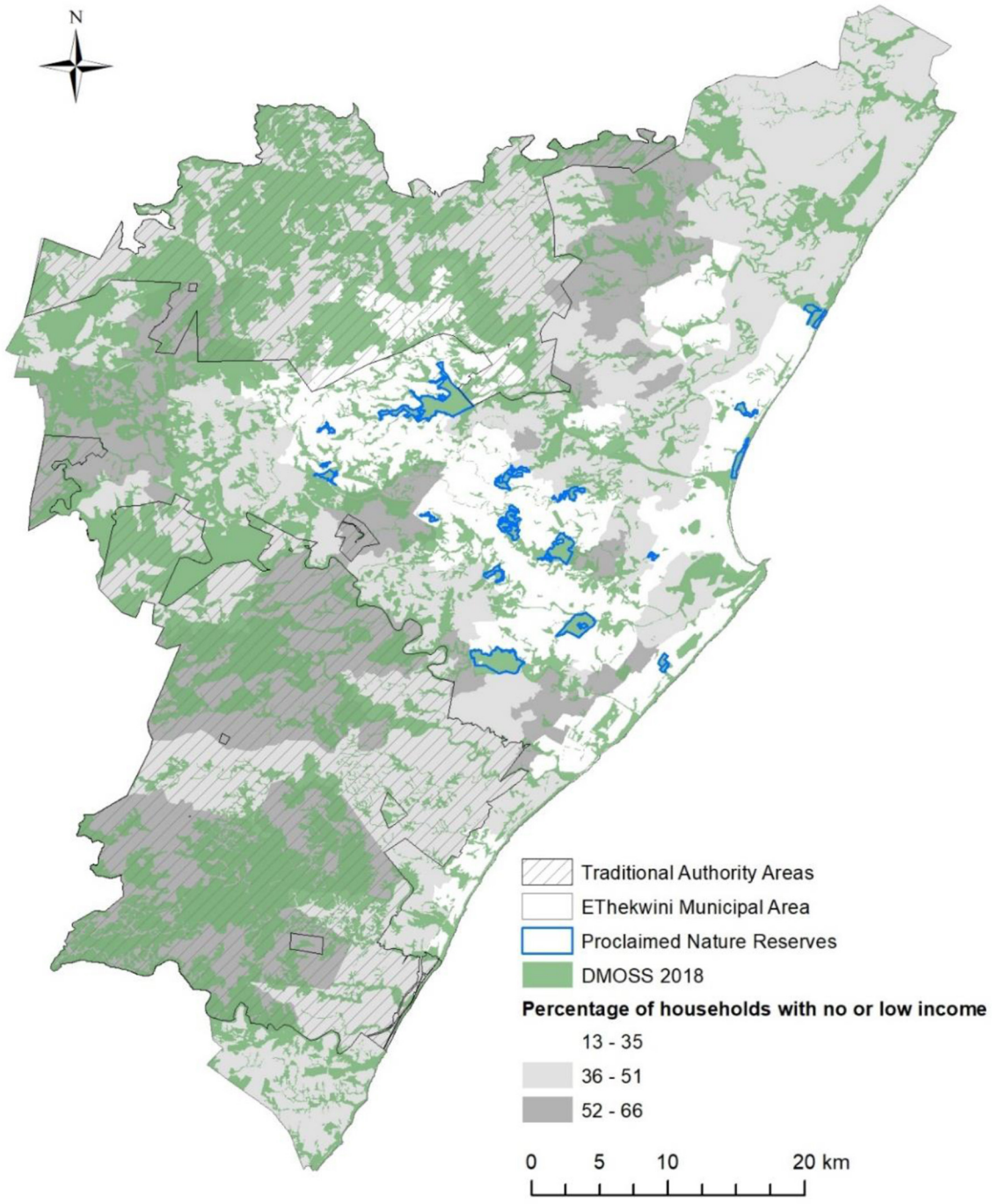

FIGURE 2
Distribution of proclaimed nature reserves relative to the percentage of households that have no/low household income (Statistics South Africa, 2015), and the distribution of traditional authority areas and the Durban Metropolitan Open Space System (Data sources: Statistics South Africa, eThekwini Municipality's GIS repository).

A key tool that was envisioned to incentivize the protection of private land is Environmental Rates Certificates which provide the potential for landowners with key biodiversity features on their land, subject to meeting protection and management conditions, to receive a rebate on property taxes (or property rates; Table 1). Unfortunately, there have to date been few certificates issued, which can be attributed to several issues relating to rating of properties with environmental features. Firstly, to promote development, the City's Real Estate (RE) Department, responsible for City wide property valuations and rates calculations, attaches substantial rates values to 'vacant land.' Promotion of development in this way clearly conflicts with the stated aims relating to environmentally sustainability and calls for a more nuanced approach to rating of vacant land with important environmental features. Secondly, in

more recent years RE has started to apply discounts to certain D'MOSS areas as part of the City-wide valuation processes. This is certainly a benefit to landowners. An unintended consequence of this intervention, however, has been the impact on the number of rates certificates received, as landowners are no longer incentivized to institute formal protection and management of the site. Given that D'MOSS covers more than a third of the municipal area, the potential loss of rates revenue may be significant, and in the absence of long-term protection, possibly unjustified. This represents an opportunity for cross sectoral collaboration between BMD and RE toward the development of a more just rating system that scale incentives based on conservation outcomes. Finally, the budget allocated to environmental rates certificates limits the number of applications that can be received, and the application of a flat percentage discount does not account for site variability in management costs and/or avoided costs associated with conservation outcomes. This would seemingly represent an opportunity for policy advancement toward a more nuanced tool that is responsive to these site differences.

3.1.4 Formal protection within traditional authority areas

Biodiversity conservation within TAAs represents a significant governance challenge, highlighted by the lack of conservation areas and the limited impact of spatial and land-use planning tools (Table 1 and Figure 1). To address this, the BMD (then EPCPD) established a biodiversity stewardship function in 2012, focusing on TAAs, and using the biodiversity stewardship model (SANBI, 2018) as a guide to implement work in Durban. Biodiversity stewardship is recognized for its cost-effectiveness and has become the primary tool for meeting biodiversity targets in South Africa (Cumming et al., 2015). Key to this model are incentives for landowners, such as financial rebates and management support (Barendse et al., 2016; Rawat, 2017).

In TAAs, land title is held by the state, which limits financial incentives tied to ownership. Supporting incentives from municipalities include management activities like invasive species control and grassland burning. These incentives have been sparingly provided due to municipal requirements for site protection to ensure investment security. This raises questions about what constitutes 'protected' status, and the value of partial stewardship agreements (Table 1).

Even with management support, significant biodiversity protection in TAAs is unlikely without suitable financial benefits for local communities. Durban is consistently marketed as a tourism destination, and the value that natural assets provide to this sector are conservatively valued at R2.4 billion pa (~$183 million USD equivalents, based on ZAR 13.1:1 USD, as of 30 June 2017; Turpie et al., 2017), and, predictably, highlights the value of beaches as a major contributor to this sector. At face value the opportunities provided by several of the larger connected natural areas offer significant nature based/cultural tourism opportunities aimed at both local and international tourists. Realizing this potential within TAAs requires top-down support, business plan development, and partnerships with the private sector. Many TAAs projects align with the City's strategic goals for limiting urban sprawl and upper catchment protection (Sim et al., 2016), suggesting a coordinated municipal approach could promote conservation-focused projects with municipal planning co-benefits.

3.2 Ecosystem management and ecological restoration tools

Table 2 provides an analysis of the tools applied in ecosystem management and ecological restoration using an analytical framework. The patterns are summarized below and grouped thematically to include: (1) Managing the increasing municipal conservation estate; (2) Management of established protected areas; (3) The role of active citizenship in conservation management; and (4) Active restoration activities.

3.2.1 Managing the increasing municipal conservation estate

To compliment the increasing protection of land, the introduction of large-scale poverty alleviation programmes aimed at the control of invasive alien plants (IAPs) on these sites, and reintroduction of fire management as an ecological process, have been fundamental to conservation of these areas (Boon et al., 2016). While there are several pieces of legislation that address aspects of IAPs, the introduction of the National Environmental Management: Biodiversity Act [Act 10 of 2004; including the Alien and Invasive Species Regulations (DFFE, 2020)], brought the issue to the forefront for all spheres of government, requiring these institutions to, *inter alia*, prepare plans for, and report on, the eradication of IAPs. The Working for Ecosystems programme was initiated in 2006, following funding from the National Environmental Department, and was subsequently handed over to the municipal Treasury unit following a requirement from the National Auditor General for the municipality to undertake the legal obligations associated with the control of IAPs within the municipal area (as per NEMBA). This was significant in that IAP control was included for the first time as a line item within the municipality's operational budget. The targeted purchasing of threatened grassland systems also revealed a notable management void, viz. the lack of controlled burning, a critical process for the maintenance of grassland (Boon et al., 2016), but also required by law (Table 2). The appointment of Working on Fire (another large-scale poverty alleviation programme, now under the banner of the Fire and Invasive Species programme) in 2009, represented a significant moment for conservation in the City, in that highly threatened grassland systems could be managed through controlled burning, preventing the loss of these critical ecosystems to bush encroachment (Boon et al., 2016). The introduction of fire management into BMD operations has the added benefit of addressing the requirements of the National Veld and Forest Fire Act (Act 101 of 1998) that places a responsibility on landowners to maintain properties appropriately to avoid uncontrolled fires. Job creation (with a focus on women, youth, and persons with disabilities), and training in IAP control, are central components of both the programmes, the former being particularly important in attaining political support for funding allocation.

TABLE 2 Analytical framework describing the major management and ecological restoration tools aimed at enhancing biodiversity within Durban.

Tools applied	Policy environment	Contribution to management	Outcome	Strengths	Weaknesses	Next steps/opportunities
Working for ecosystems	Following the introduction of the National Environmental Management: Biodiversity Act (NEMBA) (Act 10 of 2004) and funding received by the National Environmental Department, the programme was initiated in 2006.	Public employment programme, with a focus on empowering previously marginalized groups, aimed at the control of Invasive Alien Plants (IAPs) within important biodiversity areas and key catchment areas.	2018/19–2022/23 financial year ranges: 0–3,282 ha invasive alien plants (IAP) control. 0–13,987 person days (33–63% youth and 31–36% female employment). 0–776 training person days. Total budget 0–R13.7m ($876,519, based on, ZAR15.63:1 USD, average exchange rate 2018–2023).	Inclusion of IAPs control within the City's operational budgets. Working across land tenure types within priority sites. Job creation and upliftment.	Dependent on available funding, and complicated supply chain management processes.	Linked strongly to protected areas expansion, the model may provide the necessary tool to support management of newly formed protected areas, particularly within TAAs.
Fire and Invasive Species Control Programme (including Working on Fire)	In line with the requirements of NEMBA and the National Veld and Forest Fire Act (Act 101 of 1998) the project was initiated in 2009, primarily to manage the increasing conservation estate and grassland systems.	Public employment programme, with a focus on training individuals and small business support to undertake IAP control and apply fire management within priority municipal owned sites, and ad hoc support to other important sites.	2018/19–2022/23 financial year ranges: 28–500 ha IAP control. 162–417 ha of grassland burning. 2970–11283 person days (22–27% female employment). 0–443 training person days. Total budget R3 m–R13.6m ($191,938–$876,519, based on, ZAR15.63:1 USD, average exchange rate 2018–2023).	The reinstatement of fire as an ecological process within urban grassland systems. Emphasis on bush encroachment control and IAP control in support of grassland conservation.	Dependent on available funding, and complicated supply chain management processes.	Scaling will continue to be in line with the increase in the protection of grassland systems (e.g., outcomes of land acquisition programmes). Extension of fire management service to important grassland systems across tenure types.

(Continued)

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TABLE 2 (Continued)

Tools applied	Policy environment	Contribution to management	Outcome	Strengths	Weaknesses	Next steps/opportunities
Giba Gorge special rating area	The Giba Gorge Environmental Precinct (GGEP) is classified as Special Rating Area under Section 22 of the Municipal Property Rates Act [No. 6 of 2004] and associated Special Rating Area Policy (2020).	GGEP is the first to utilize this legislated tool for environmental management purposes. Funds for management activities are raised from private landowners (through an additional levy over and above their property taxes) and a contribution from the Municipality, which owns a significant portion of land in the Gorge. These funds are then directed to a Section 21 company that undertakes conservation management activities.	In total, the project conserves over 200 ha of Critically Endangered KwaZulu–Natal Sandstone Sourveld Grassland and old growth Eastern Scarp Forest in a major urban hub of Durban.	A cost-effective model in comparison to traditional protected areas. Direct community involvement resulting in greater local support.	Lacking the organization structures that are present within established conservation authorities, and, therefore, reliant on committed individuals.	A cost-effective model that can be used to drive community involvement and ownership. May require creativity and the identification of co-benefits to rollout to other areas with differing socio-economic contexts.
Protected area management	National Environmental Management: Protected Areas Act (No. 57 of 2003)	Typically, this work is associated with a mature organizational setting focused on implementing a management plan for the Protected Area (PA). It is usually carried out by staff members stationed at the PA.	Poor outcomes in terms of Management Effectiveness of proclaimed municipal nature reserves relative to other provincial reserves. Large number of vacant posts.	Established organization with staff that directly underate the work and therefore less reliant on project-based funding. Ability to deal with threats beyond IAPs (e.g., poaching).	Several PAs operate without an approved management plan. Generally, a lack of community involvement in the management of the reserves.	Completion of management plans for all proclaimed nature reserves. Actively partnering with local community groups (e.g., conservancies).
Conservancies	Voluntary conservation organization with limited legal requirements in comparison to other models. Registration with KZN Conservancies Association and Ezemvelo KZN Wildlife is required.	39 active conservancies, many of which have a focus on ecosystem rehabilitation.	Across all conservancy activities in 2021, 18,399 volunteer hours were undertaken and over $639,000 contributed, of which 61% of this value was related to environmental rehabilitation (e.g., IAP control).	Community driven, resulting in greater local support for conservation. Volunteer focus means that it is often cost effective.	Limited legal standing. Over reliance on individuals.	Integration of various government programmes and models with conservancies into a more co-ordinated conservation strategy.
Reforestation programme	Initiated in response to climate mitigation and adaptation requirements associated with the hosting of mega events viz., the 2010 FIFA™ World Cup and United Nations Framework Convention on Climate Change COP17/CMP7 held in 2011.	Focus on mitigation, adaptation and driving biodiversity protection, enhancement, and job creation. 'Treeprenuer' model, created by a local NGO, used in promoting reforestation of locally indigenous forest species within the buffer zone of the Buffelsdraai Landfill, Paradise Valley and Inanda Mountain scarp forest.	2018/19–2022/23 financial year ranges: Trees planted (ha) 53–185. Reforestation budget was R7.4-—10. 6 million ($473,448–$678,182, based on, ZAR15.63:1 USD, average exchange rate 2018–2023). 213–329 active 'Treeprenuers.' 8,920–15,323 green job person days created.	An ecosystem-based approach, with multiple co-benefits for biodiversity and local community upliftment. Inanda Mountain reforestation project represents the most significant investment within TAAs to date.	Significant financial investment.	Active restoration of threatened systems such as grasslands and coastal forest will need to be implemented for the City to make significant progress in meeting conservation targets. More broadly this will be an important opportunity to scale, addressing socio-economic challenges and improving urban sustainability.

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Although both these programmes have been successful in adding an ecological management arm to conservation area expansion, there is a clear need to increase activities within TAAs. In addition, a concerning aspect of the programme has been the delays associated with lengthy and complicated supply chain management processes which govern the procurement of services by public entities. Over the past 5 years, implementation has been delayed by 2 years by these processes, resulting in limited fire management for two fire seasons. In the absence of alternatives, this represents a critical risk to previous IAP management investments, ecological functioning, and financial liability to the City because of uncontrolled fires.

3.2.2 Management of established protected areas

Most formal protected areas with the City are state owned and managed. Ezemvelo KZN Wildlife, the provincial conservation authority, manages six nature reserves in the City, while eThekwini Municipality manages 11 proclaimed nature reserves. The ownership and management of these latter reserves has typically been the responsibility of the Natural Resources Division of the City. As the BMD continues to increase the conservation estate through proactive protected area expansion tools, the risk of biodiversity management decision-making silos is increasingly apparent with two separate structures undertaking conservation area management. To drive coordinated, effective and resource efficient biodiversity protection and management, this governance arrangement will need to be analyzed and addressed.

In addition, while there has been success in attaining adequate protection status for many of the reserves, the rollout of supporting approved management plans, as required by the National Environmental Management: Protected Areas Act (No. 57 of 2003; NEMPA), has been slow. The completion of these documents is vital to ensure effective management of these areas and address developing governance challenges. State funding is, however, rarely consistent and/or guaranteed, and there is limited community involvement (e.g., conservancies, active advisory forums, or 'Friends of' groups) in the management of municipal PAs. Addressing this shortcoming would seem a natural progression that would build a level of resilience into the system.

3.2.3 The role of active citizenship in conservation management

A conservancy represents a voluntary group of landowners and other interested and affected parties that cooperatively manage natural resources in an environmentally sustainable manner and have been registered as a conservancy with the relevant provincial conservation authority (SANBI, 2018). In total there are 39 active conservancies within Durban, ranging in size, areas of focus, and effectiveness (KZNCA, 2021). Many of the conservancies, including the largest and most active conservancy, Kloof Conservancy, and the first urban Conservancy in South Africa, the Everton Conservancy, focus considerable resources on the management of threatened ecosystems (KZNCA, 2021; Table 2). These management activities are supported by the BMD through the provisioning of herbicide, training, and assistance with fire management. Importantly, many of these conservancies undertake management activities on state owned land in addition to their own private properties. As a predominantly volunteer based system, conservancies lack the legislative standing afforded to other management models; however they represent a mechanism for ensuring local support for projects, undertake cost-effective management, and represent a valuable and important addition to biodiversity conservation activities of government. As is the case with the distribution of protected areas, conservancies tend to be associated with more affluent areas of the City, and the logical next step is ensuring the establishment of additional conservancies within previously disadvantaged areas of high conservation value.

Although not a conservancy, the Giba Gorge Environmental Precinct (GGEP) provides an important case study of how public-private partnerships, driven by active citizenship, can work in Durban. The Municipal Property Rates Act (2004) makes provision for the formation of Special Rating Areas (SRAs) for the supply of 'top-up' services to specific areas. The Giba Gorge Environmental Precinct (GGEP) is the first to use this legislated tool for environmental management purposes. GGEP funds conservation management through levies on private landowners and municipal contributions (Table 2). Managed by a not-for-profit company (i.e., Section 21) and a volunteer management committee, GGEP oversees over 200 ha of critically endangered KwaZulu-Natal Sandstone Sourveld Grassland and old-growth Eastern Scarp Forest. This model has demonstrated success through continuous management, job creation, and community involvement, providing a potential template for replication in other areas. A more detailed review is required to fully understand the value of this model in comparison to more traditional protected area approaches. It is, however, anticipated that the model is substantially more cost effective than other municipal protected areas due to, *inter alia*, the savings associated with services provided by the management committee (e.g., financial reporting, human resource services, and construction maintenance), additional savings from service providers as a consequence of Not-for-Profit Organization status, and flexibility to management approaches.

Although GGEP is the only conservation focused SRA, the concept of precinct management has gained momentum in Durban over the past decade. There are currently 11 SRAs and 10 Management Associations within Durban that undertake various public services (e.g., security, cleaning; Layman, 2019). In terms of budget allocation, security services accounts for the greatest proportion of generated funds representing 63% of total budgets (Layman, 2019). Giba Gorge is surrounded by middle/high value properties, with natural physical boundaries, thereby providing ideal conditions for the establishment of a conservation based special rating area. This context is important as there are few similar areas where this model could be directly replicated. Exploring hybrid models where precincts with multiple and complementary objectives (e.g., bush encroachment control, patrolling, and security) may be required in other areas in the City.

There are, however, limits in terms of what areas this model would suit with socio-economic conditions of areas likely to

dictate levels of support and financial viability. What the project does highlight is that if active citizen groups (e.g., conservancies) have a suitable institutional structure, then it is possible for the municipality to enter into partnerships, and provide funding and support services (e.g., fire management, IAP control, and management advice). This is an important mechanism to support conservation work of conservancies and provide a foundation for conservation area expansion across land tenure, including within TAAs. Conservancies represent an important entry point in biodiversity stewardship, and, to date, have not been adequately incorporated within the City's conservation expansion work, as evident by the lack of formal agreement to support a partnership between conservancies and the City. The decentralization of conservation funding may facilitate this, and also allow for greater resilience in biodiversity management systems, an important consideration given the reliance on the large-scale programmes mentioned above.

3.2.4 Active restoration activities

The origins of restoration interventions within Durban are rooted in climate change mitigation and adaptation in response to the hosting of two mega events in the City of Durban viz., the 2010 FIFA™ World Cup, and United Nations Framework Convention on Climate Change's Conference of the Parties, seventeenth session, in 2011 (UNFCCC COP 17; Table 2). A decision was taken upfront to not follow the traditional approach of purchasing carbon credits to offset the carbon footprint of the event, but rather introduce offset principles that responded more appropriately to local issues, with biodiversity protection/enhancement and job creation being key priorities (Diederichs and Roberts, 2016). The flagship reforestation projects, *viz* Buffelsdraai, Paradise Valley, and Inanda reforestation projects, have represented Durban's first venture into largescale active restoration. These programmes have yielded valuable ecological and social outcomes (Table 2), but, equally important, are the substantial costs that have been involved in the establishment and ongoing operations of these projects (Roberts et al., 2012). This reflection is important, in that achieving biodiversity outcomes through habitat protection is more effective than restoration due to *inter alia* financial limitations and time lags (Rey Benayas et al., 2009). The reality is, however, far more complicated when achieving conservation targets within option poor and fragmented landscapes that characterize cities. In this context, active restoration is an essential component of any biodiversity strategy aimed at achieving conservation targets where transformation thresholds have been transgressed (Possingham et al., 2015). Investment in ecosystem restoration also allows for the selection of sites that optimize conservation outcomes, illustrating that both protection and restoration of ecosystems are important as part of broader conservation planning (Possingham et al., 2015). The United Nations Declaration of 2021–2030 as the decade of ecological restoration (UN, 2019) provides an important platform to expand on the ecosystem restoration work, and will likely offer similar opportunities to governments that are able to effectively demonstrate the delivery of restoration projects. Identifying these opportunities and expanding active restoration projects to threatened vegetation types represents an important next stage in the evolution of this function.

3.3 Effectiveness of tools applied

Table 3 categorizes the respective tools in terms of impact on policy and practice, contribution to socio-economic development and suitability for traditional authority land. The contexts that led to the development/implementation illustrates the City's proactive stance taken in attempting to advance biodiversity conservation outcomes. This is evident in number of tools applied within the land-use and spatial planning field, but particularly in the development and application of tools outside of local government's core mandate of land-use planning.

Figure 3 presents the cumulative scores of each tool against the three criteria presented in Table 3. The total score for 'positive impact on policy and practice' was 48 (Figure 3). D'MOSS, Land Acquisition, Giba Gorge Special Rating Area, and the Reforestation Programme all scored highly (Table 3). Common across these tools is that they have resulted in measurable biodiversity conservation outcomes, there has been direct oversight by a single department, and the tools have operated continuously since their inception. The FISC and WFE programmes have been critical to conservation action within the municipality, however, gaps in operations prevented a higher rating.

The total score for 'contribution to socio-economic development' was 45 (Figure 3). Tools such as WFE, FISC, GGEP and the reforestation programme all scored highly (Table 3). These tools have been successful in creating green jobs, supporting local economies, and fostering community involvement. The number of vacant positions within the department responsible for municipal nature reserve management prevented a higher score for protected area management.

The total score for 'Suitability for Traditional Authority Areas' was 23 (Figure 3), reflecting the challenges in implementing conservation tools within these areas. Biodiversity Stewardship, WFE, Conservancies, and the Reforestation Programme were the highest scoring tools, with scores of 3. Investment security and lack of suitable financial incentives prevented scaling and higher scores for these tools. The low scores across the land-use planning tools reflects the current lack of planning integration across this land tenure type.

The Conservation Zone and Environmental Rates Certificates categorized as 'low' across the categories due to the relative ineffectiveness of the interventions to date (Table 3 and Figure 3). This represents a challenge for the City as these tools were designed specifically for private landholdings, creating risk to conservation outcomes in these areas. Across the tools, stronger governance represented an important factor in terms of increased tool effectiveness. Addressing internal municipal governance barriers in the land-use and spatial planning tools (e.g., translation of lower order spatial planning products and rezoning of legacy zones to ECR), and vertical integration of spatial information (associated with D'MOSS) into national biodiversity plans should represent key areas of focus. Similarly, the fragmented nature of the land management governance system, and associated procurement

TABLE 3 Integration analysis of tools applied. (1) Positive impact on policy and practice—measurable biodiversity conservation outcomes and operational continuity; (2) Contribution to socio-economic development—successful in creating green jobs, supporting local economies, and fostering community involvement; and (3) Suitability for Traditional Authority Areas (TAAs)—applied in TAAs with measurable outcomes with operational continuity. Categorization of the tools applied (high, moderate, or low) in response to policy and practice, socio-economic development, and suitability for TAAs. Future potential of tools and opportunities to improve outcomes.

Tool	Context for development/use of tool	Assessment of tool performance	Positive impact on policy and practice	Contribution to Socio-economic development	Suitability for traditional authority areas	Future potential of tool and opportunities to improve outcomes
Durban metropolitan open space system	Evolved significantly over four decades. Intended to act as a development control layer to minimize the impact of development on the natural resource base, by assessing potential impacts of proposed developments.	Represents a critical component of land-use decision making, informed by ecological data, and contributes toward avoided loss in development assessment processes. Limited impact, however, within Traditional Authority Areas.				Given the complexities of the dual governance system additional work is required to improve impact, through: (1) Improved governance relationships between the ITB and the eThekwini Municipality; (2) improved vertical integration of D'MOSS elements (e.g., Critical Biodiversity Areas and Threatened Vegetation Types) within national spatial planning products leading to more stringent environmental assessment process for threatened biodiversity. There is a need to undertake a climate change risk analysis of D'MOSS and the associated Systematic Conservation Assessment.
Strategic environmental assessment	A legislative requirement that assesses environmental performance against current and future spatial development.	The most comprehensive and inclusive assessment, to date, of Durban's natural resource base, and, critically, the development of sustainability thresholds. The lack of completion of a socio-economic analysis against these thresholds represents a gap that compromises effectiveness.				Completion of the second socio-economic phase of the SEA that will enable decision makers to balance future planning against environmental thresholds.

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TABLE 3 (Continued)

Tool	Context for development/use of tool	Assessment of tool performance	Positive impact on policy and practice	Contribution to Socio-economic development	Suitability for traditional authority areas	Future potential of tool and opportunities to improve outcomes
Lower order spatial planning	A bridge between strategic planning and the land-use schemes allowing for more detailed spatial planning for specific areas, and across sectors with often competing spatial priorities. Seen as an opportunity to further embed protection of environmental assets.	While this process has resulted in successes in entrenching D'MOSS and, in some cases, the identification of areas for greater protection, the translation of these plans into land-use schemes is not definitive enough to ensure protection.				Addressing the translation of intended land-uses into appropriate conservation zones. Working with TAAs, through processes such as the Rural Development Strategy to advance biodiversity mainstreaming and utilize this platform to promote appropriate nature-based planning.
Conservation zone	The zone was developed following an acknowledged gap in the availability of suitable zone types for the protection of biodiversity features on private land.	Largely ineffective to date following an initially unsuccessful roll-out of the tool in the outer west planning region.				This tool needs to be reinitiated as a mechanism to protect remaining biodiversity features on private land. Central to this roll-out may be a greater focus on communication with landowners and targeted project sites.
Environmental conservation reserve	The zone was developed following an acknowledged gap in the availability of suitable zone types for the protection of biodiversity features on public land, and particularly the Public Open Space Zone that did not adequately address this shortcoming.	This zone has been effectively applied to newly acquired land for conservation purposes, and to provide municipal areas intended to be proclaimed as nature reserves with suitable interim protection. This zone has, however, not been effectively rolled out across state land with complementary land-uses.				Opportunities to improve conservation outcomes include: (1) targeting of State-owned land with biodiversity features for split zoning; and (2) rezoning legacy zones (associated with passive land-uses) that would contribute to the conservation estate.
Land acquisition	Developed to purchase targeted sites of considerable conservation importance.	A successful project that has contributed to the protection of threatened ecosystems and expansion of conservation areas. Only limited by available budget.				Budget availability is likely to remain a limiting factor in scaling this intervention. The inclusion of land cost an initial filter during prioritization may contribute to increasing the impact of this tool.

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TABLE 3 (Continued)

Tool	Context for development/use of tool	Assessment of tool performance	Positive impact on policy and practice	Contribution to Socio-economic development	Suitability for traditional authority areas	Future potential of tool and opportunities to improve outcomes
Nature reserve proclamation	This tool was originally used to provide adequate protection to municipal areas that were named Nature Reserve but, lacked the formal status in terms of NEMPAA.	The project has been successful in elevating the conservation status of several existing municipal 'Nature Reserves,' and the proclamation of additional sites secured through land acquisition. Currently an imbalance in the distribution of proclaimed areas between socio-economic groupings.				This tool represents the end point of protection initiatives. Current governance challenges impacting traditional authority areas will need to be overcome to allow the application of this tool in TAAs.
Biodiversity stewardship	In the absence of appropriate tools for TAAs, the biodiversity stewardship programme was initiated to promote biodiversity protection in these areas.	Signed agreements with five traditional authorities committing to working with the BMD, but no formal protection of areas to date. Avoided loss through detailed engagements with TAAs is difficult to measure.				Two core issues will need to be addressed to improve outcomes in TAAs through biodiversity stewardship: (1) incentivization and investment in these areas to promote conservation aligned land-uses; and (2) Fostering a more integrated governance system that may require partnerships with third parties to advance such initiatives.
Environmental rates certificates	Designed to promote protection and management of remaining biodiversity features on private land through a rebate of property rates.	Limited success due to: ambiguity in the contributions of remaining land toward overall rates of a property, discounts already applied to land with D'MOSS present, and limited available budget assigned to rebates.				The value of this tool in its current form is questionable. To address this issue, clarity on the rating of land with D'MOSS present will be required. Incentivization should be analyzed through a lens of protection and management of biodiversity features across properties.
Working for ecosystems	Developed in response to national legislation and associated funding compelling municipalities to meet obligations in the control of invasive alien plants (IAPs).	The project has been successful in providing a key management activity to strategic biodiversity areas, including traditional authority areas, while contributing to the creation of green jobs and associated political support. Procurement related delays in the programme have, however, impacted outcomes.				Addressing risks to operational continuity represents the most important factor that requires addressing. In the absence of changes to the current procurement system, decentralization of funding to conservancies, active citizen groups and NGOs may represent an alternative. In addition, there is a need for increased investment within TAAs to foster greater outcomes in these areas.

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TABLE 3 (Continued)

Tool	Context for development/use of tool	Assessment of tool performance	Positive impact on policy and practice	Contribution to Socio-economic development	Suitability for traditional authority areas	Future potential of tool and opportunities to improve outcomes
Fire and invasive species control programme	Developed in response for the need to manage acquired sites, and particularly the need for fire management of grassland systems.	The project has been successful in providing IAP and fire management to key sites, while contributing to the creation of green jobs and associated political support. Procurement related delays in the programme have, however, impacted outcomes. Support to TAAs has also been limited due to lack of security of investment.				Addressing risks to operational continuity represents the most important factor that requires addressing. In the absence of changes to the current procurement system, decentralization of funding may represent an alternative. In addition, there is a need for increased investment within TAAs to foster greater outcomes in these areas.
Giba Gorge special rating area	A pilot project designed to create a management model for the protection and management of public and private land as a single system. Governed by the local community, with support from the municipality.	The project has been successfully implemented for 15 years providing continuous management to a key area within the municipality, creating long-term green jobs and community involvement.				Opportunities to replicate this tool at scale may be limited by contextual factors such as socio-economic conditions and the advantage of distinct natural boundaries. Hybrid Special Ratings Areas (e.g., security and conservation) may represent an opportunity to advance this work area.
Protected area management	Most the City's nature reserves are managed by the Natural Resources Division. Most of these reserves are in the older more established suburbs of the City.	Although providing a management vehicle for the critical areas, several nature reserves have performed poorly when assessed against reserves across the province. The large number of vacancies across the function prevented a higher scoring in contribution to socio-economic development.				Addressing the current governance fragmentation in terms of management and scientific capacity should represent a key focus area for the City.

(Continued)

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TABLE 3 (Continued)

Tool	Context for development/use of tool	Assessment of tool performance	Positive impact on policy and practice	Contribution to Socio-economic development	Suitability for traditional authority areas	Future potential of tool and opportunities to improve outcomes
Conservancies	These voluntary groups of active citizens have developed largely independently of municipal conservation initiatives, and act across land tenure types.	An undervalued contributor to broader conservation goals within the municipality. These groups continue to generate funding, contributing resources and manage several important areas within the City. The lack of legislative standing and continuity of operations prevents higher scores across metrics.				Inclusion of conservancies within the broader conservation strategy of the City is essential in the promotion of inclusive and cost-effective conservation management. Formalizing the relationship with the City, testing project funding through these agreements, and motivating for the development of projects within TAAs represent important goals to advance conservation outcomes.
Reforestation programme	Largely opportunistic in nature, this programme developed as climate mitigation and adaptation responses to the hosting of global mega events.	Successful programmes that have led to important biodiversity outcomes and sustainable job creation. The programme has involved significant resourcing, but, importantly, has been applied within TAAs.				Availability of suitable sites and the significant financial investment required to initiate projects of this nature are likely to represent limiting factors in scaling. These projects do, however, represent opportunities to address current imbalance in the allocation of resources and funding within poorer areas of the City.
Additional tools to be considered						Conservation Bank, and Payment for Ecosystems Services models.

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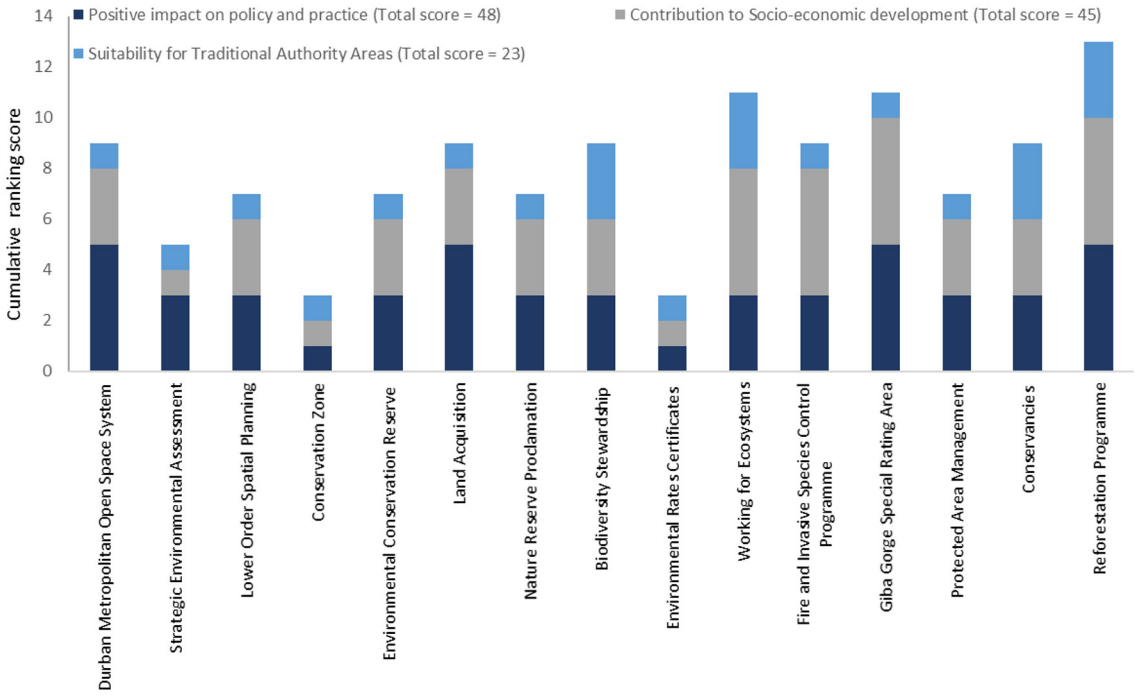

FIGURE 3
Combined score for each tool applied in terms of positive impact on policy and practice, contribution to socio-economic development, and suitability for traditional authority areas. Scoring for each criterion were based on the assessment provided in Table 3 (Green/High = 5, Orange/Moderate = 3, Red/Low = 1). A cumulative score of all tools for each criterion is also provided.

support, requires attention. Service level agreements between the two municipal department actively involved in land management, and a similar agreement with conservancies, are short-term interventions that could be considered to improve the effectiveness of the management system.

These findings emphasize the need for Durban to expand the current toolset. Initial exploratory work on the potential for conservation banking (Macfarlane et al., 2015) and payment for ecosystem service models (INR, 2020) have been undertaken, but not implemented. Conservation banking models (INR, 2020) remain relatively untested in a South African context, however, reference to its use in the recently completed National Biodiversity Offset Guideline (DFFE, 2023a) may provide the policy environment to advance this work area. Critically, this guideline may help address inconsistencies in the application of biodiversity offsets within Durban (Nkosi, 2021) and the country (Brownlie et al., 2017). Given that the majority of land-use applications potentially impacting D'MOSS fall outside of provincial and national environmental assessment processes, the development of a local offset policy may be required (McLean et al., 2024).

4 Discussion

This paper provides evidence of how Durban and its partners have deeply engaged in urban biodiversity conservation, applying, and adapting various tools to expand the conservation estate, curb biodiversity loss, restore ecosystems and address urbanization-related threats. Notable successes include avoided biodiversity loss through land-use planning, increased protection of threatened ecosystems, proclaimed protected areas, and poverty alleviation programmes aimed at restoring key ecological processes. Despite these achievements, challenges remain. These include unequal protection and investment in relation to socio-economic status and apartheid era segregated spatial planning, horizontal governance barriers impacting the effectiveness of tools, and inadequate incentives for private and traditional land protection. To advance biodiversity outcomes, these barriers will need to be overcome, and existing tools scaled, refined, and integrated to advance urban sustainability, and ensure equitable societal benefits. This paper provides a case study on how a local government can contribute to the *Whole-of-government and whole-of-society* approach described in the Kunming-Montreal Global Biodiversity Framework (UN, 2022), while supporting the increasing recognition that local governments are well-positioned to drive transformative change in biodiversity governance (Kok, 2022). In addition, this research contributes case study research toward addressing the global policy to local implementation gap (Nilon et al., 2017; Shih et al., 2020), research-implementation gap (Knight et al., 2008; Ferraro and Failler, 2024), and Global South research gap (Nagendra et al., 2018; McDonald et al., 2020; du Toit et al., 2021). To enhance conservation outcomes, issues of the role of governance, promotion of equity and justice, and social inclusion are explored further in this discussion.

4.1 Role of governance in biodiversity outcomes

This research emphasizes the need for local government to take an active role in advancing biodiversity outcomes, and is particularly relevant to cities in biodiversity priority areas, where provincial or national spheres of conservation governance may avoid urban areas in expansion programmes (Soanes and Lentini, 2019). Despite highly threatened biodiversity, conservation expansion has been almost exclusively undertaken by the municipality over the past decades. At a state level, this situation is likely to remain unchanged due to the limited capacity for provincial conservation authorities to contribute significantly to the 30 × 30 area-based biodiversity conservation expansion targets (DFFE, 2023b), further emphasizing of the importance of local government playing a leading role.

While there have been successes, only 7% of D'MOSS is protected, indicating a need to increase protection levels to ensure biodiversity persistence. In comparison, The City of Cape Town (CoCT) has conserved 65% of the 85,000 ha BioNet (D'MOSS equivalent; City of Cape Town, 2022). There are contextual factors that explain the discrepancies, such as the presence of Table Mountain National Park in the City (proclaimed in 1998), significant provincial and national support from conservation authorities due to the level of endemism and threat status of vegetation types in the CoCT, early international funding, and the absence of the dual governance system within Durban (Rebelo et al., 2011; Holmes et al., 2012; Boon et al., 2016; Bux et al., 2021).

There are key differences in approach between the two cities, including the presence of time-bound protected area expansion targets within strategic planning documents for the CoCT (City of Cape Town, 2022). While conservation targets are used to inform the development of D'MOSS (McLean et al., 2020) and the selection of sites for further protection (e.g., land acquisition), conservation targets are more commonly used in articulating ecological thresholds linked to spatial and land-use planning (McLean et al., 2024). In a review of 135 plans from 40 cities, the goals for nature conservation were often present within plans for cities, however, quantitative targets for conservation action were less frequently articulated, and, thereby, risking the success of such plans (Nilon et al., 2017). The inclusion of annual area-based biodiversity conservation targets represents an important lesson for Durban to take forward in advancing conservation area expansion, but these need to be informed by data that indicate what opportunities are realistically achievable, and over what period (McLean et al., in review).

Durban has, however, invested significant resources in advancing the mainstreaming of biodiversity through integration of D'MOSS within the hierarchy of spatial and land-use planning products, and addressing biodiversity concerns through development assessment processes (Bux et al., 2021; McLean et al., 2024). The advancement of this policy and legislative environment, and investment in scientific institutional capacity, have contributed to protection through avoided loss (McLean et al., 2024), which represents a critical part of biodiversity mainstreaming, but for which it is inherently difficult to measure actual impact (Manuel et al., 2016). It is important to reflect on the divergence of the these cities from many other Global South local governments where severe capacity constraints hamper progress in advancing biodiversity outcomes (Wilhelm-Rechmann and Cowling, 2013; Shih et al., 2020; du Toit et al., 2021; McLean et al., 2024). An important enabler toward improved scientific capacity in Durban has been the successful partnership with a local academic institution (McLean et al., 2024). This support (in different forms) has been constant over the duration of the City's biodiversity work, and has evolved into the Durban Research and Action Partnership (DRAP) that focuses on transdisciplinary research (Cockburn et al., 2016). The development of similar partnerships for cities, particularly those of the Global South, is recommended to enhance the generation of actionable science and scientific capacity. Particularly relevant to biodiverse, resources constrained cities of the Global South, the development of a fine-scale habitat map offers a cost-effective option to provide foundational data that can immediately interact with urban spatial planning and land-use management systems (Nilon et al., 2017; McLean et al., 2024). These types of foundational data, facilitated by advancements and applicability of information and communication technology (Shobande and Ogbeifun, 2022), represent an entry point to support under capacitated local governments, in line with Target 20 of the GBF that aims to *Strengthen Capacity-Building, Technology Transfer, and Scientific and Technical Cooperation for Biodiversity* (UN, 2022).

Advancing biodiversity outcomes will require addressing vertical governance barriers (Huang et al., 2018), viz the integration of local biodiversity information into national spatial planning products that offer additional legislative protection (McLean et al., 2024). Furthermore, ineffective translation of strategic planning products to property level land-use schemes that would result in improved biodiversity outcomes represents an emerging planning-implementation gap that requires attention (Knight et al., 2008; zu Ermgassen et al., 2022; Ferraro and Failler, 2024). The limited impact of land-use and spatial planning tools in TAAs calls for an integrated approach to planning that can effectively combine customary law-based land allocation and formal municipal planning. A previously promoted hybrid planning system offers innovative support options including the deployment of planners to assist traditional authorities in land-use decision making (Sim et al., 2018), and shares several similarities with the recommended approach toward indigenous conservation areas from across the world (Tran et al., 2020). Central to this is the recognition of agency, and empowering community-led conservation programmes to create quality governance structures (Dawson et al., 2021). The development of an EThekwini Traditional Rural Spatial Development Framework and Land Use Management Plan (eThekwini Municipality, 2024b) represents an important first step in promoting effective dual governance by attempting to integrate planning priorities of municipal and traditional authorities into a consolidated planning instrument (eThekwini Municipality, 2024b). Understanding the implementation of this process and outcomes represents an important opportunity for future research, including: (1) Understanding the willingness of Ingonyama Trust Board and individual traditional authorities to support such a process; (2) the ability of local government to deploy resources to support planning; and (3) effectiveness of interventions.

The variety of tools tested and applied highlights the complexity of local environmental governance and the absence of a singular solution for achieving conservation targets (Lemos and Agrawal, 2006; Gurney et al., 2021). Rezoning of land represents an important component of local governments' response to biodiversity protection in many countries (Bruggeman et al., 2015; Gurran et al., 2015; Barut et al., 2016; Hansen et al., 2022), and similarly reflected in the design of fit-for-purpose land use zones in Durban, which has allowed for appropriate protection of public land. Conservation Development (CDs) ordinances in the United States share a number of similarities with the underutilized Conservation zone, including: the avoiding of key biodiversity features in development design and the promotion of a more concentrated development or 'density bonus' on the developable sections of the property (Reed et al., 2014). CDs have been shown to offer significant potential conservation area expansion options as demonstrated in counties of Colorado, where the majority of CDs occurred immediately adjacent to protected areas (Mockrin et al., 2017). Like Durban, the development of suitable incentives and appropriate management of CDs remain barriers to successful scaling (Reed et al., 2014). The uncertainty surrounding the Environmental Rates Certificate poses a problem for incentivizing private landowners. Property tax relaxation is a key incentive for conservation agencies, offering financial benefits to landowners, and is less costly than traditional land acquisition (Schuster et al., 2018). The GBF highlights the significant conservation financing gap that exists globally, with the majority of this gap attributed to harmful incentives (Chausson et al., 2023). The current relationship between biodiversity and property taxes suggest a similar situation, with vacant land being taxed at a rate higher that other land-uses. This calls for a comprehensive review of the rates policy, and engagement with the Municipal Real Estate Unit over the effective rating of properties, and research into the value of potential property rates generation vs. avoided ecosystem services loss.

The control of invasive species and maintenance of ecological processes are essential components of managing for biodiversity in urban areas (Aronson et al., 2017), but the social outcomes (e.g., job creation) is what has allowed for political support and scaling for these programmes (van Wilgen and Wannenburgh, 2016). The relative success of the poverty alleviation programmes as a management arm to the increasing conservation estate risks the development of governance silos, with both the BMD and NRD responsible for different conservation areas. Governance silos are considered a major barrier to implementation of conservation plans (Powell, 2010) and inhibit sustainability within cities (South African Cities Network, 2021). In addition, the lack of techno-scientific capacity and resources are consistently highlighted as barriers to local biodiversity conservation outcomes (Shih et al., 2020). This is particularly urgent when considering that four of Durban's Nature Reserves were listed among the lowest scoring reserves in terms of biodiversity management indicators in the *State of Provincial Reserves in South Africa* (Patel et al., 2023). The same report highlighted capacity and skills as the most frequently identified challenge facing provincial reserves (Patel et al., 2023) and, given that much of the scientific and IAP budget sits within the BMD (McLean et al., 2024), the need for a closer working relationship is clear. Similarly, field rangers from NRD are designated to undertake certain enforcement action on municipal owned sites that staff from BMD are unable to do. Addressing these governance silos through a service level agreement represents a critical next step for the future of biodiversity conservation in the City. Improved coordination in the management of protected and conservation areas is central in addressing skill gaps and enhancing the efficient use of resources (O'Connell et al., 2019).

Horizontal barriers to effective management extend beyond governance silos and include aspects of the legislated (Republic of South Africa (RSA), 2003) procurement processes. Non-compliance with, or inefficient implementation of the current public procurement processes can severely stifle effective service delivery (Matebese-Notshulwana, 2021). This has led to calls for an overhaul that adopts approaches in line with the private sector (Manyathi et al., 2021). Inefficient implementation of processes can severely hamper conservation outcomes in Municipalities (Brooks, 2017), especially for high budget, conservation related public tenders. Particularly relevant to the large-scale poverty alleviation programmes is the development of long-term supplier relationships that would promote continuity in operations (Manyathi et al., 2021).

4.2 Equity and justice in biodiversity outcomes

The large-scale poverty alleviation and reforestation programmes operating within the City represent important interventions that address core socio-economic issues in addition to achieving conservation outcomes. The spatial distribution of the protected area network in relation to household income has, however, emphasized the level of spatial inequality or 'green apartheid' (Venter et al., 2020) that persists across race and income geographies in post-apartheid cities (Anderson et al., 2020; Giombini and Thorn, 2022). Income related spatial inequalities in access to protected areas, biodiversity and urban green spaces, or 'the luxury effect' (Hope et al., 2008), however, represents a more systemic problem across cities in both the developed and developing world (Leong et al., 2018; Sharifi et al., 2021; Wu and Kim, 2021; Sims et al., 2022; Aznarez et al., 2023). This emphasizes the need, and in line with the GBF, for equity and justice to represent key concerns for biodiversity planning and management. Similarly, South Africa's recently gazetted Climate Change Act (Act No. 22 of 2024) seeks to enable the just transition *…toward a low-carbon, climate-resilient economy and society and ecologically sustainable economies and societies…* (Republic of South Africa (RSA), 2024). The convergence and complementarity of actions required to advance equity and justice in both biodiversity and climate change outcomes offers an important framing for future action in the City. Active restoration is receiving increasing recognition as an important contributor to achieving global biodiversity goals and climate resilience (Strassburg et al., 2020), and, as demonstrated in this paper, represents one of the most effective mechanisms for advancing biodiversity outcomes in terms of policy and practice contribution, socio-economic development and application within TAAs. Critically, active restoration, provides an option to not only to meet broader biodiversity objectives, but can also be used as a tool to address societal issues of spatial inequality in access to usable green spaces, creation of green jobs,

and sustainable urban planning (Rawat, 2017; Raymond et al., 2017).

Most remaining natural areas, outside of protected and conservation areas, are located in low-income areas, necessitating City-wide action to address this issue by "*reframing conservation action through the lens of reconciliation and redress*" (Armitage et al., 2020). This will require appropriate investment, of both financial and professional capacity, and particularly the development of suitable models that can promote effective conservation outcomes in TAAs. Importantly, the natural environment in TAAs is integral to the area's social and economic fabric, making community-owned conservation areas essential, moving away from exclusionary protected areas (McCann et al., 2015). A review of over 600 protected areas in 34 developing countries found that multi-use protected areas with tourism improved socio-economic and wellbeing metrics for nearby communities, while tourism alone did not (Naidoo et al., 2019). Furthermore, exclusionary protected areas have the potential to aggravate poverty levels and levels of inequality in communities within protected areas (Ma et al., 2019). The Kuznets curve hypothesis, applied in several developing countries and contexts (Shobande and Ogbeifun, 2023, 2024), postulates that environmental degradation is greatest under early stages of economic development, before decreasing as economic conditions mature (Dinda, 2004). This further emphasizes the need to intentionally factor in prevailing economic conditions in project design. Fostering these necessary socio-economic conditions toward conservation outcomes will require environmental professionals to challenge conventional local government approaches to conservation area expansion, particularly within TAAs, through the promotion of an adaptive, pluralistic approach to conservation (Gavin et al., 2018).

4.3 Inclusivity

The idea of 'inclusive conservation' has been introduced as a framework to address and integrate equity considerations in biodiversity conservation and protected area management strategies (Raymond et al., 2022). Inclusivity in the achievement of biodiversity goals features prominently within the GBF, more so than previous global strategies (e.g., Aichi Targets), and includes recognition of the importance of indigenous peoples and communities through inter alia Target 22, that aims to *Ensure Participation in Decision-Making and Access to Justice and Information Related to Biodiversity for all* (Watson et al., 2023). In terms of conservation outcomes, the current bottom-up approach of the Biodiversity Stewardship Programme and conservancies needs to be supplemented by coordinated City level support. In Australian cities, top-down organizational support was viewed as a key enabler in advancing indigenous community support for urban biodiversity conservation (Taylor et al., 2022). Achieving this integrated approach will require a reframing the value of these open spaces from conservation priorities to valuable green infrastructure that offers significant economic savings and social outcomes, but requiring investment to maintain (Gulati and Scholtz, 2020). This approach offers considerable potential in TAAs for empowered inclusion.

Overlaid on this complex governance challenge is the possibility that local government may not be best placed to lead stewardship projects within TAAs, due to political dynamics and often contested authority between traditional leadership and local government (Ramolobe, 2023). The most advanced example of conservation area expansion within TAAs to date relates to the proposed Sobonakhona Protected Environment, led by the Endangered Wildlife Trust, a conservation NGO, that is in the process of being proclaimed under Biodiversity Stewardship (Acker, 2022). Actively partnering with NGOs and the private sector in TAAs may represent an important opportunity to advance conservation outcomes, as demonstrated in the examples of indigenous land conservation from other countries (Schlick, 2011; Snyman and Spenceley, 2019; Zimmerman et al., 2020).

Building resilience in conservation governance systems is critical to mitigate operational issues and scale conservation outcomes (Holley and Sofronova, 2017), and in this regard the role of active citizenship toward the development of a mosaic governance system is important. Mosaic governance is defined as *the diversity of processes that may facilitate existing active citizenship and stimulate its upscaling through a mix of governance modes and policy interventions tailored to the socio-ecological context of urban landscapes* (Buijs et al., 2019), with several examples of successful implementation in other cities (Buijs et al., 2024; Dobšinská and Daško, 2024). The GGEP and several conservancies' projects serve as important examples of mosaic governance in Durban. Mobilizing the diversity of active citizens required to scale interventions, however, requires partnerships with civil society, often through NGOs that are able to effectively bridge the gap with local governments (KimDung et al., 2016; Buijs et al., 2019). Importantly in the case of GGEP, it has demonstrated that decentralization of conservation funding can be a viable option to compliment centrally controlled management systems (Atisa et al., 2021). While decentralized governance funding arrangements can be effective in certain situations, these need to be supported by increased monitoring of management effectiveness (Sayer and Margules, 2017). A comparative study that analyses the budget efficiency, biodiversity, and socio-economic outcomes for different governance models (e.g., conservancies, large-scale poverty alleviation programmes, Special Rating Areas, and traditional protected areas) is recommended.

4.4 Conclusion

This paper sheds light on the important role a local government can and must play in addressing the biodiversity crisis in line with the GBF's *whole-of-government, whole-of-society approach* (UN, 2022). Through the generation of actionable knowledge it is hoped that this research will: (1) Assist other local governments, particularly those of the Global South, with identifying critical investment areas to advance biodiversity mainstreaming; (2) provide insights for national governments in terms of opportunities to use local government mechanisms to mitigate biodiversity loss and contribute to area-based conservation expansion; and (3) provide the basis to guide further conservation work in Durban. Contextual differences may prevent direct replication of all tools in other resource constrained cities of the Global South, however,

lessons from this research provide important learnings. Land-use planning creativity, identification of socio-economic co-benefits in project design, and urban sustainability co-benefits identified in this research, may offer cost-effective methods for resource constrained cities to advance biodiversity mainstreaming.

Many areas considered conserved in this paper will not be proclaimed as formal protected areas, but could be considered for potential recognition as other effective area-based conservation measures (OECMs) (CBD, 2018; DFFE, 2023c). An important component of OECMs is the recognition of managed areas that sustain biodiversity irrespective of their primary objective, thereby offering an opportunity to increase equity in conservation decision making and the range of actors involved (Gurney et al., 2021). OECMs represent an important vehicle to increase the conservation estate in key biodiversity areas (Donald et al., 2019), and offer opportunities to recognize a diverse range of actors (including previously marginalized groups), improve governance, and attract conservation financing (Marnewick et al., 2021).

The City of Durban has demonstrated the important role that cities, and particular cities within biodiversity hotspots, can play in contributing toward broader conservation efforts. Progress has been made over the past four decades, but in the face of rapid urbanization and with only a relatively small proportion of D'MOSS formally protected and managed, the need to scale these interventions is apparent. Tools will undoubtedly need to evolve to respond to changing contexts (Gavin et al., 2018), and new tools will be required to cope with the significant biodiversity loss associated with an increasingly likely 1.5°C overshoot (IPCC, 2022). Given the relative importance of land under traditional authority and private control, the development of an integrated and community-centered conservation area expansion strategy through the OECM lens for the City of Durban is recommended. This will require, as a foundation, a critical assessment of future opportunities to maximize effectiveness of the toolset available at the local government level, with an emphasis on co-benefits that will support the City's service delivery mandate (McLean et al., in review).

Data availability statement

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

Author contributions

CM: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. DR: Conceptualization, Methodology, Supervision, Writing – review & editing. RS: Conceptualization, Methodology, Supervision, Writing – review & editing.

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CM is employed by the eThekwini Municipality. DR was employed by the eThekwini Municipality up until her retirement at the end of January 2024.

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

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The author(s) declare that no Gen AI was used in the creation of this manuscript.

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References

Acker, C. (2022). *A case study for wetland restoration towards socio-ecological appreciation of natural resources in KwaZulu-Natal (South Africa)* (MSc thesis). University of South Africa, Pretoria, South Africa.

Acuto, M., Kosovac, A., Pejic, D., and Jones, T. L. (2020). The city as actor in UN frameworks: formalizing 'urban agency' in the international system? *Territory Polit. Governance* 11, 519–536. doi: 10.1080/21622671.2020.1860810

Anderson, P., Charles-Dominique, T., Ernstson, H., Andersson, E., Goodness, J., and Elmqvist, T. (2020). Post-apartheid ecologies in the City of Cape Town: an examination of plant functional traits in relation to urban gradients. *Landsc. Urban Plan.* 193:103662. doi: 10.1016/j.landurbplan.2019.103662

Armitage, D., Mbatha, P., Muhl, E. K., Rice, W., and Sowman, M. (2020). Governance principles for community-centered conservation in the post-2020 global biodiversity framework. *Conserv. Sci. Pract.* 2, 1–18. doi: 10.1111/csp2.160

Aronson, M. F. J., Lepczyk, C. A., Evans, K. L., Goddard, M. A., Lerman, S. B., MacIvor, J. S., et al. (2017). Biodiversity in the city: key challenges for urban green space management. *Front. Ecol. Environ.* 15, 189–196. doi: 10.1002/fee.1480

Atisa, G., Zemrani, A., and Weiss, M. (2021). Decentralized governments: local empowerment and sustainable development challenges in Africa. *Environ. Dev. Sustain.* 23, 3349–3367. doi: 10.1007/s10668-020-00722-0

Aznarez, C., Svenning, J. C., Pacheco, J. P., Have Kallesøe, F., Baró, F., and Pascual, U. (2023). Luxury and legacy effects on urban biodiversity, vegetation cover and ecosystem services. *NPJ Urban Sustain.* 3:47. doi: 10.1038/s42949-023-00128-7

Barendse, J., Roux, D., Currie, B., Wilson, N., and Fabricius, C. (2016). A broader view of stewardship to achieve conservation and sustainability goals in South Africa. *S. Afr. J. Sci.* 112, 1–15. doi: 10.17159/sajs.2016/20150359

Barut, M., Raar, J., and Azim, M. I. (2016). Biodiversity and local government: a reporting and accountability perspective. *Manag. Audit. J.* 31, 197–227. doi: 10.1108/MAJ-08-2014-1082

Boon, R., Cockburn, J., Douwes, E., Govender, N., Ground, L., McLean, C., et al. (2016). Managing a threatened savanna ecosystem (KwaZuluNatal Sandstone Sourveld) in an urban biodiversity hotspot: Durban, South Africa. *Bothalia* 46, 1–12. doi: 10.4102/abc.v46i2.2112

Botts, E. A., Skowno, A., Driver, A., Holness, S., Maze, K., Smith, T., et al. (2020). More than just a (red) list: over a decade of using South Africa's threatened ecosystems in policy and practice. *Biol. Conserv.* 246:108559. doi: 10.1016/j.biocon.2020.108559

Brooks, M. (2017). The legality of centralised public procurement in South Africa. *Afr. Public Procure. Law J.* 3, 42–71. doi: 10.14803/3-1-18

Brownlie, S., von Hase, A., Botha, M., Manuel, J., Balmforth, Z., and Jenner, N. (2017). Biodiversity offsets in South Africa–challenges and potential solutions. *Impact Assess. Proj. Apprais.* 35, 248–256. doi: 10.1080/14615517.2017.1322810

Bruggeman, D., Meyfroidt, P., and Lambin, E. F. (2015). Production forests as a conservation tool: effectiveness of Cameroon's land use zoning policy. *Land Use Policy* 42, 151–164. doi: 10.1016/j.landusepol.2014.07.012

Buijs, A., Hansen, R., Van der Jagt, S., Ambrose-Oji, B., Elands, B., Lorance Rall, E., et al. (2019). Mosaic governance for urban green infrastructure: upscaling active citizenship from a local government perspective. *Urban For. Urban Green.* 40, 53–62. doi: 10.1016/j.ufug.2018.06.011

Buijs, A. E., Gulsrud, N. M., Rodela, R., Diduck, A. P., van der Jagt, A. P. N., and Raymond, C. M. (2024). Advancing environmental justice in cities through the Mosaic Governance of nature-based solutions. *Cities* 147:104799. doi: 10.1016/j.cities.2024.104799

Bulkeley, H., Kok, M., and Xie, L. (2021). *Realising the Urban Opportunity: Cities and the Post-2020 Biodiversity Governance*. The Hague: PBL Netherlands Environmental Assessment Agency.

Bux, Q., Anderson, P., and O'Farrell, P. J. (2021). Understanding the local biodiversity and open space strategies in two south african cities. *Ecol. Soc.* 26:4. doi: 10.5751/ES-12498-260304

CBD (2018). *Decision Adopted by the Conference of the Parties to the Convention on Biological*. Available online at: https://www.cbd.int/doc/decisions/cop-14/cop-14-dec-08-en.pdf (accessed April 6, 2024).

Chausson, A., Welden, E. A., Melanidis, M. S., Gray, E., Hirons, M., and Seddon, N. (2023). Going beyond market-based mechanisms to finance nature-based solutions and foster sustainable futures. *PLoS Clim.* 2:e0000169. doi: 10.1371/journal.pclm.0000169

City of Cape Town (2022). *City of Cape Town State of the Environment 2022*. Available online at: https://www.capetown.gov.za/document-centre (accessed February 26, 2024).

Cockburn, J., Rouget, M., Slotow, R., Roberts, D., Boon, R., Douwes, E., et al. (2016). How to build science-action partnerships for local land-use planning and management: lessons from Durban, South Africa. *Ecol. Soc.* 21:28. doi: 10.5751/ES-08109-210128

Cumming, T. L., Driver, A., Pillay, P., Martindale, G., Purnell, K., McCann, K., et al. (2015). *The Business Case for Biodiversity Stewardship*. Pretoria: South African National Biodiversity Institute.

Cunningham, C., and Beazley, K. F. (2018). Changes in human population density and protected areas in terrestrial global biodiversity hotspots, 1995-2015. *Land* 7, 1–20. doi: 10.3390/land7040136

Davoren, E., and Shackleton, C. M. (2021). "Urban ecosystem disservices in the Global South," in *Cities and Nature*, eds. C. M. Shackleton, S. S. Cilliers, E. Davoren, and M. J. du Toit (Cham: Springer), 265–292. doi: 10.1007/978-3-030-67650-6_11

Dawson, N. M., Coolsaet, B., Sterling, E. J., Loveridge, R., Gross-Camp, N. D., Wongbusarakum, S., et al. (2021). The role of indigenous peoples and local communities in effective and equitable conservation. *Ecol. Soc.* 26:19. doi: 10.5751/ES-12625-260319

DFFE (2020). *National Environmental Management: Biodiversity Act, 2004 (Act no. 10 of 2004) Alien and invasive Species Lists, 2020*. Pretoria: DFFE.

DFFE (2023a). *National Biodiversity Offset Guideline*. Pretoria: DFFE. Available online at: www.gpwonline.co.za (accessed April 6, 2024).

DFFE (2023b). *Synthesis Workshop Outputs 30x30 Implementation Workshop*. Pretoria: DFFE.

DFFE (2023c). *White Paper on the Conservation and Sustainable Use of South Africa's Biodiversity* (Pretoria: DFFE), 1–42.

Diederichs, N., and Roberts, D. (2016). Climate protection in mega-event greening: the 2010 FIFA™ World Cup and COP17/CMP7 experiences in Durban, South Africa. *Clim. Dev.* 8, 376–384. doi: 10.1080/17565529.2015.1085361

Dinda, S. (2004). Environmental Kuznets curve hypothesis: a survey. *Ecol. Econ.* 49, 431–455. doi: 10.1016/j.ecolecon.2004.02.011

Dobšinská, Z., and Daško, M. (2024). Mosaic governance models in the creation of environmental policies in Slovakian cities. *Sociológia* 56, 93–119. doi: 10.31577/sociologia.2024.56.2.4

Donald, P. F., Buchanan, G. M., Balmford, A., Bingham, H., Couturier, A. R., de la Rosa, G. E., et al. (2019). The prevalence, characteristics and effectiveness of Aichi Target 11′s "other effective area-based conservation measures" (OECMs) in Key Biodiversity Areas. *Conserv. Lett.* 12:e12659. doi: 10.1111/conl.12659

du Toit, M. J., Shackleton, C. M., Cilliers, S. S., and Davoren, E. (2021). Advancing urban ecology in the Global South: emerging themes and future research directions. *Cities Nat. Part F* 337, 433–461. doi: 10.1007/978-3-030-67650-6_17

Elmqvist, T., Fragkias, M., Goodness, J., Güneralp, B., Marcotullio, P. J., McDonald, R. I., et al. (2013). *Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities: A Global Assessment*. Cham: Springer. doi: 10.1007/978-94-007-7088-1

EMB (1999). *Durban Metropolitan Open Space Management Framework Plan*. Durban.

eThekwini Municipality (2007). *Local Action for Biodiversity Report*: *Durban*. Durban: eThekwini Municipality.

eThekwini Municipality (2018). *Cato Ridge Local Area Plan Review, Functional Area Plans and Draft Scheme*. Durban: eThekwini Municipality.

eThekwini Municipality (2020). *Durban Strategic Environmental Assessment: Environmental Analysis Phase*. Durban: eThekwini Municipality.

eThekwini Municipality (2022). *Final SDF 2022-2023*. Durban: eThekwini Municipality.

eThekwini Municipality (2023a). *Environmental Information Network*. Durban: eThekwini Municipality.

eThekwini Municipality (2023b). *Ethekwini Municipal Land Use Scheme : Outer West Sub-Scheme*. Durban: eThekwini Municipality.

eThekwini Municipality (2024a). *Durban's State of Biodiversity Report 2022/2023*. Durban: eThekwini Municipality.

eThekwini Municipality (2024b). *Ethekwini Traditional Rural Spatial Framework and Land Use Management*. Durban: eThekwini Municipality.

Ferraro, G., and Failler, P. (2024). Understanding the "implementation gap" to improve biodiversity governance: an interdisciplinary literature review. *J. Sustain. Res.* 6:e240009. doi: 10.20900/jsr20240009

Flyvbjerg, B. (2011). Five misunderstandings about case-study research. *Qual. Res. Pract.* 12, 390–404. doi: 10.4135/9781848608191.d33

Gavin, M. C., McCarter, J., Berkes, F., Mead, A. T. P., Sterling, E. J., Tang, R., et al. (2018). Effective biodiversity conservation requires dynamic, pluralistic, partnership-based approaches. *Sustainability* 10:1846. doi: 10.3390/su10061846

Giombini, V., and Thorn, J. P. R. (2022). "Urban green spaces in a post-apartheid city: challenges and opportunities for nature-based solutions," in *Human-Nature Interactions*, eds. I. Misiune, D. Depellegrin, and L.Egarter Vigl (Cham: Springer), 207–219. doi: 10.1007/978-3-031-01980-7_17

Gulati, M., and Scholtz, L. (2020). *The Case for Investment in Green Infrastructure in African Cities*. Available online at: https://wwfafrica.awsassets.panda.org/downloads/green_infrastructure_in_african_cities.pdf (accessed April 6, 2024).

Güneralp, B., Reba, M., Hales, B. U., Wentz, E. A., and Seto, K. C. (2020). Trends in urban land expansion, density, and land transitions from 1970 to 2010: a global synthesis. *Environ. Res. Lett.* 15:044015. doi: 10.1088/1748-9326/ab6669

Gupta, J., Bai, X., Liverman, D. M., Rockström, J., Qin, D., Stewart-koster, B., et al. (2024). A just world on a safe planet : a Lancet Planetary Health – Earth Commission report on Earth-system boundaries, translations, and transformations. *Lancet Planetary Health Commission* 8, e813–e873. doi: 10.1016/S2542-5196(24)00042-1

Gurney, G. G., Darling, E. S., Ahmadia, G. N., Agostini, V. N., Ban, N. C., Blythe, J., et al. (2021). Biodiversity needs every tool in the box: use OECMs. *Nature* 595, 646–649. doi: 10.1038/d41586-021-02041-4

Gurran, N., Gilbert, C., and Phibbs, P. (2015). Sustainable development control? Zoning and land use regulations for urban form, biodiversity conservation and green design in Australia. *J. Environ. Plan. Manag.* 58, 1877–1902. doi: 10.1080/09640568.2014.967386

Hansen, R., Buizer, M., Buijs, A., Pauleit, S., Mattijssen, T., Fors, H., et al. (2022). Transformative or piecemeal? Changes in green space planning and governance in eleven European cities. *Eur. Plan. Stud.* 31, 2401–2424. doi: 10.1080/09654313.2022.2139594

Holley, C., and Sofronova, E. (2017). "New environmental governance: adaptation, resilience and law," in *Risk, Resilience, Inequality and Environmental Law*, ed. B. Hutter (Edward Elgar Publishing), 129–146. doi: 10.4337/9781785363801.00016

Holmes, P. M., Rebelo, A. G., Dorse, C., and Wood, J. (2012). Can Cape Town's unique biodiversity be saved? Balancing conservation imperatives and development needs. *Ecol. Soc.* 17:28. doi: 10.5751/ES-04552-170228

Hope, D., Gries, C., Zhu, W., Fagan, W. F., Redman, C. L., Grimm, N. B., et al. (2008). Socioeconomics drive urban plant diversity. *Urban Ecol. An Int. Perspect. Interact. Between Humans Nat.* 100, 339–347. doi: 10.1007/978-0-387-73412-5_21

Huang, C. W., McDonald, R. I., and Seto, K. C. (2018). The importance of land governance for biodiversity conservation in an era of global urban expansion. *Landsc. Urban Plan.* 173, 44–50. doi: 10.1016/j.landurbplan.2018.01.011

INR (2020). *Scoping a Water Fund for the Greater Ethekwini Metropolitan Area, Kwa- Zulu Natal*. Durban.

IPBES (2019). *Summary for Policymakers of the Global Assessment Report on Biodiversity and Ecosystem Services*. Available online at: https://zenodo.org/record/3553579#.YfmYTerMI2w (accessed September 2, 2024).

IPCC (2022). *Fact Sheet - Biodiversity* (Geneva: IPCC), 2–4.

IPCC (2023). "Technical summary," in *Climate Change 2022 – Impacts, Adaptation and Vulnerability*, eds. H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, et al. (Cambridge: Cambridge University Press), 37–118. doi: 10.1017/9781009325844.002

Ives, C. D., Lentini, P. E., Threlfall, C. G., Ikin, K., Shanahan, D. F., Garrard, G. E., et al. (2016). Cities are hotspots for threatened species. *Glob. Ecol. Biogeogr.* 25, 117–126. doi: 10.1111/geb.12404

Jewitt, D., Goodman, P. S., Erasmus, B. F. N., O'Connor, T. G., and Witkowski, E. T. F. (2015). Systematic land-cover change in KwaZulu-Natal, South Africa: implications for biodiversity. *S. Afr. J. Sci.* 111, 1–9. doi: 10.17159/sajs.2015/20150019

KimDung, N., Bush, S. R., and Mol, A. P. J. (2016). NGOs as bridging organizations in managing nature protection in Vietnam. *J. Environ. Dev.* 25, 191–218. doi: 10.1177/1070496516642499

Knight, A. T., Cowling, R. M., Rouget, M., Balmford, A., Lombard, A. T., and Campbell, B. M. (2008). Knowing but not doing: selecting priority conservation areas and the research-implementation gap. *Conserv. Biol.* 22, 610–617. doi: 10.1111/j.1523-1739.2008.00914.x

Kok, M. T. J. (2022). *Transforming Biodiversity Governance*. Cambridge: Cambridge University Press.

Kumar, P., and Yashiro, M. (2014). The marginal poor and their dependence on ecosystem services: evidence from South Asia and Sub-Saharan Africa. *Marginality Addressing the Nexus of Poverty, Exclusion and Ecology*, eds. J. von Braun and F. Gatzweiler (Dordrecht: Springer), 169–180. doi: 10.1007/978-94-007-7061-4_11

KZNCA (2021). *KZN Conservancies Association Annual Report 2021*. Durban. Available online at: https://www.nampower.com.na/Media.aspx?m=Annual$+$Reports (accessed April 5, 2024).

Layman, A. (2019). *Precinct Management in eThekwini*. Durban: International Precinct Management Symposium.

Lemos, M. C., and Agrawal, A. (2006). Environmental governance. *Annu. Rev. Environ. Resour.* 31, 297–325. doi: 10.1146/annurev.energy.31.042605.135621

Leong, M., Dunn, R. R., and Trautwein, M. D. (2018). Biodiversity and socioeconomics in the city: a review of the luxury effect. *Biol. Lett.* 14:20180082. doi: 10.1098/rsbl.2018.0082

Lindley, S., Pauleit, S., Yeshitela, K., Cilliers, S., and Shackleton, C. (2018). Rethinking urban green infrastructure and ecosystem services from the perspective of sub-Saharan African cities. *Landsc. Urban Plan.* 180, 328–338. doi: 10.1016/j.landurbplan.2018.08.016

Lwasa, S., Buyana, K., Kasaija, P., and Mutyaba, J. (2018). Scenarios for adaptation and mitigation in urban Africa under 1.5 C global warming. *Curr. Opin. Environ. Sustain.* 30, 52–58. doi: 10.1016/j.cosust.2018.02.012

Ma, B., Cai, Z., Zheng, J., and Wen, Y. (2019). Conservation, ecotourism, poverty, and income inequality – a case study of nature reserves in Qinling, China. *World Dev.* 115, 236–244. doi: 10.1016/j.worlddev.2018.11.017

Macfarlane, D., van Deventer, R., and von Hase, A. (2015). *Exploring the Opportunity to Pilot a Conservation Banking Schemei in the eThekwini Municipality Deliverable 2: Review of Local Context and Associated Constraints and Opportunities for Piloting a Conservation Report No: EP74-02*. Durban: eThekwini Municipality.

Manuel, J., Maze, K., Driver, M., Stephens, A., Botts, E., Parker, A., et al. (2016). "Key Ingredients, Challenges and Lessons from Biodiversity Mainstreaming in South Africa: People, Products, Process," in *OECD Environment Working Papers, No. 107* (Paris: OECD Publishing). doi: 10.1787/5jlzgj1s4h5h-en

Manyathi, S., Burger, A. P. J., and Moritmer, N. L. (2021). Public sector procurement: a private sector procurement perspective for improved service delivery. *Afr. Public Serv. Deliv. Perform. Rev.* 9:11. doi: 10.4102/apsdpr.v9i1.521

Marnewick, D., Stevens, C. M. D., Jonas, H., Antrobus-wuth, R., Wilson, N., and Theron, N. (2021). Assessing the extent and contribution of oecms in south africa. *Parks* 27, 57–70. doi: 10.2305/IUCN.CH.2021.PARKS-27-1DM.en

Matebese-Notshulwana, K. (2021). "Weak procurement practices and the challenges of service delivery in South Africa BT," in *Public Procurement, Corruption and the Crisis of Governance in Africa*, eds. N. Dorasamy and O. Fagbadebo (Cham: Springer International Publishing), 93–111. doi: 10.1007/978-3-030-63857-3_6

Maxwell, S. L., Cazalis, V., Dudley, N., Hoffmann, M., Rodrigues, A. S. L., Stolton, S., et al. (2020). Area-based conservation in the twenty-first century. *Nature* 586, 217–227. doi: 10.1038/s41586-020-2773-z

McCann, K., Kloppers, R., and Venter, A. (2015). "Using biodiversity stewardship as a means to secure the natural wild values on communal land in South Africa," in *Watson, Alan; Carver, Stephen; Krenova, Zdenka; McBride, Brooke, comps. Science and Stewardship to Protect and Sustain Wilderness Values: Tenth World Wilderness Congress Symposium, 2013, 4-10 October, Salamanca, Spain. Proceedings RMRS-P-74* (Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Research Station), 133–140.

McDonald, R. I., Colbert, M., Hamann, M., Simkin, R., and Walsh, B. (2018). *Nature in the Urban Century: A Global Assessment of Where and How to Conserve Nature for Biodiversity and Human Wellbeing*. The Nature Conservancy, Future Earth, Stockholm Resilience Centre. Available online at: https://www.nature.org/en-us/what-we-do/our-insights/perspectives/nature-in-the-urban-century/ (accessed April 6, 2024).

McDonald, R. I., Mansur, A. V., Ascensão, F., Colbert, M., Crossman, K., Elmqvist, T., et al. (2020). Research gaps in knowledge of the impact of urban growth on biodiversity. *Nat. Sustain.* 3, 16–24. doi: 10.1038/s41893-019-0436-6

McLean, C. T., Ground, L., Boon, R., Roberts, D. C., Govender, N., and McInnes, A. (2020). *Durban's Systematic Conservation Assessment*. Durban: EThekwini Municipality.

McLean, C. T., Roberts, D. C., and Slotow, R. (2024). The evolution of open space planning within a developing, biodiverse city (Durban, South Africa). *Sustainability* 16:3073. doi: 10.3390/su16073073

McLean, C. T., Roberts, D. C., and Slotow, R. (in review). *Identifying Opportunities for Terrestrial Area-Based Conservation within an Urban Global Biodiversity Hotspot* (Durban), 1–25.

Mittermeier, R. A., Gil, P. R., Hoffmann, M., Pilgrim, J., Brooks, T., Mittermeier, C. G., et al. (2005). *Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions: Conservation International*. Sierra Madre: Cemex, 315.

Mockrin, M. H., Reed, S. E., Pejchar, L., and Jessica, S. (2017). Balancing housing growth and land conservation: conservation development preserves private lands near protected areas. *Landsc. Urban Plan.* 157, 598–607. doi: 10.1016/j.landurbplan.2016.09.015

Nagendra, H., Bai, X., Brondizio, E. S., and Lwasa, S. (2018). The urban south and the predicament of global sustainability. *Nat. Sustain.* 1, 341–349. doi: 10.1038/s41893-018-0101-5

Naidoo, R., Gerkey, D., Hole, D., Pfaff, A., Ellis, A. M., Golden, C. D., et al. (2019). Evaluating the impacts of protected areas on human well-being across the developing world. *Sci. Adv.* 5:eaav3006. doi: 10.1126/sciadv.aav3006

Nel, A. (2021). Biodiversity Economy and conservation territorialization: a pyrrhic strategy in Kwazulu-Natal. *J. Polit. Ecol.* 28, 1–19. doi: 10.2458/jpe.4744

Nilon, C. H., Aronson, M. F. J., Cilliers, S. S., Dobbs, C., Frazee, L. J., Goddard, M. A., et al. (2017). Planning for the future of urban biodiversity: a global review of city-scale initiatives. *Bioscience* 67, 332–342. doi: 10.1093/biosci/bix012

Nkosi, S. B. (2021). *Learning from biodiversity offsets implementation within eThekwini Municipality (Durban)* (MSc Thesis). North-West University, Potchefstroom, South Africa.

O'Connell, M. J., Nasirwa, O., Carter, M., Farmer, K. H., Appleton, M., Arinaitwe, J., et al. (2019). Capacity building for conservation: problems and potential solutions for sub-Saharan Africa. *Oryx* 53, 273–283. doi: 10.1017/S0030605317000291

Patel, T., Cowan, O., Little, I., Friedmann, Y., and Blackmore, A. (2023). *The State of Provincial Reserves in South Africa, Challenges and Recommendations*. Available online at: https://ewt.org.za/resources/cpsu-programme/ (accessed January 4, 2024).

Pauleit, S., Vasquéz, A., Maruthaveeran, S., Liu, L., and Cilliers, S. S. (2021). "Urban green infrastructure in the Global South," in *Cities and Nature*, eds. C. M. Shackleton, S. S. Cilliers, E. Davoren, and M. J. du Toit (Cham: Springer), 107–143. doi: 10.1007/978-3-030-67650-6_5

Pörtner, H.-O., Roberts, D. C., Poloczanska, E. S., Mintenbeck, K., Tignor, M., Alegría, A., et al. (2022). *Summary for Policymakers*. Cambridge: Cambridge University Press.

Possingham, H. P., Bode, M., and Klein, C. J. (2015). Optimal conservation outcomes require both restoration and protection. *PLoS Biol.* 13:e1002052. doi: 10.1371/journal.pbio.1002052

Powell, R. B. (2010). "Developing institutions to overcome governance barriers to ecoregional conservation," in *Landscape-scale Conservation Planning*, eds. S. Trombulak, and R. Baldwin (Cham: Springer), 53–66. doi: 10.1007/978-90-481-9575-6_4

Ramalho, C. E., Laliberté, E., Poot, P., and Hobbs, R. J. (2014). Complex effects of fragmentation on remnant woodland plant communities of a rapidly urbanizing biodiversity hotspot. *Ecology* 95, 2466–2478. doi: 10.1890/13-1239.1

Ramolobe, K. S. (2023). The dynamics of traditional leaders' relationship with municipal councillors and service delivery. *J. Local Gov. Res. Innov.* 4:95. doi: 10.4102/jolgri.v4i0.95

Rawat, Y. S. (2017). Sustainable biodiversity stewardship and inclusive development in South Africa: a novel package for a sustainable future. *Curr. Opin. Environ. Sustain.* 24, 89–95. doi: 10.1016/j.cosust.2017.03.003

Raymond, C. M., Cebrián-Piqueras, M. A., Andersson, E., Andrade, R., Schnell, A. A., Battioni Romanelli, B., et al. (2022). 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

Raymond, C. M., Frantzeskaki, N., Kabisch, N., Berry, P., Breil, M., Nita, M. R., et al. (2017). A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. *Environ. Sci. Policy* 77, 15–24. doi: 10.1016/j.envsci.2017.07.008

Rebelo, A. G., Holmes, P. M., Dorse, C., and Wood, J. (2011). Impacts of urbanization in a biodiversity hotspot: conservation challenges in Metropolitan Cape Town. *South Afr. J. Bot.* 77, 20–35. doi: 10.1016/j.sajb.2010.04.006

Reed, S. E., Hilty, J. A., and Theobald, D. M. (2014). Guidelines and incentives for conservation development in local land-use regulations. *Conserv. Biol.* 28, 258–268. doi: 10.1111/cobi.12136

Rega-Brodsky, C. C., Aronson, M. F. J., Piana, M. R., Carpenter, E. S., Hahs, A. K., Herrera-Montes, A., et al. (2022). Urban biodiversity: state of the science and future directions. *Urban Ecosyst.* 25, 1083–1096. doi: 10.1007/s11252-022-01207-w

Republic of South Africa (RSA). (2003). *Municipal Finance Management Act, 56 of 2003*. Pretoria: Government Printer.

Republic of South Africa (RSA). (2024). *Climate Change Act, 2024 (Act No. 22 of 2024)*. Government Gazette No. 50966, 23 July 2024. Available at: https://www.gov.za/documents/acts/climate-change-act-22-2024-english-tshivenda-23-jul-2024 (accessed October 6, 2024).

Rey Benayas, J. M., Newton, A. C., Diaz, A., and Bullock, J. M. (2009). Enhancement of biodiversity and ecosystem services by ecological restoration: a meta-analysis. *Science* 325, 1121–1124. doi: 10.1126/science.1172460

Roberts, D., Boon, R., Diederichs, N., Douwes, E., Govender, N., Mcinnes, A., et al. (2012). Exploring ecosystem-based adaptation in Durban, South Africa: "learning-by-doing" at the local government coal face. *Environ. Urban.* 24, 167–195. doi: 10.1177/0956247811431412

SANBI (2018). *Biodiversity Stewardship Guideline*. Pretoria: SANBI.

Sayer, J., and Margules, C. (2017). Biodiversity in locally managed lands. *Land* 6:41. doi: 10.3390/land6020041

Schlick, K. (2011). *Biodiversity conservation governance on the Tibetan Plateau: cross-scale linkages and bridging organizations* (MSc thesis). University of Wellington, Wellington, New Zealand.

Schuster, R., Law, E. A., Rodewald, A. D., Martin, T. G., Wilson, K. A., Watts, M., et al. (2018). Tax shifting and incentives for biodiversity conservation on private lands. *Conserv. Lett.* 11:e12377. doi: 10.1111/conl.12377

Shackleton, C. M. (2021). Ecosystem provisioning services in Global South cities. *Cities Nat. Part F* 337, 203–226. doi: 10.1007/978-3-030-67650-6_8

Shackleton, C. M., Cilliers, S. S., du Toit, M. J., and Davoren, E. (2021). "The Need for an Urban Ecology of the Global South BT," in *Urban Ecology in the Global South*, eds. C. M. Shackleton, S. S. Cilliers, E. Davoren, and M. J. du Toit (Cham: Springer International Publishing), 1–26. doi: 10.1007/978-3-030-67650-6_1

Sharifi, F., Nygaard, A., Stone, W. M., and Levin, I. (2021). Accessing green space in Melbourne: measuring inequity and household mobility. *Landsc. Urban Plan.* 207:104004. doi: 10.1016/j.landurbplan.2020.104004

Shih, W. Y., Mabon, L., and Puppim de Oliveira, J. A. (2020). Assessing governance challenges of local biodiversity and ecosystem services: barriers identified by the expert community. *Land Use Policy* 91:104291. doi: 10.1016/j.landusepol.2019.104291

Shobande, O. A., and Ogbeifun, L. (2022). Has information and communication technology improved environmental quality in the OECD?—a dynamic panel analysis. *Int. J. Sustain. Dev. World Ecol.* 29, 39–49. doi: 10.1080/13504509.2021.1909172

Shobande, O. A., and Ogbeifun, L. (2023). An empirical analysis of Fishery Kuznets curve hypothesis: evidence from OECD countries. *J. Dev. Areas* 57, 1–16. doi: 10.1353/jda.2023.0019

Shobande, O. A., and Ogbeifun, L. (2024). Emergence of forest environmental Kuznets curve in Africa: some new evidences. *J. Dev. Areas* 58, 131–147. doi: 10.1353/jda.2024.a931319

Sim, V., Sutherland, C., Buthelezi, S., and Khumalo, D. (2018). Possibilities for a hybrid approach to planning and governance at the interface of the administrative and traditional authority systems in Durban. *Urban Forum* 29, 351–368. doi: 10.1007/s12132-018-9355-2

Sim, V., Sutherland, C., and Scott, D. (2016). Pushing the boundaries - urban edge challenges in eThekwini Municipality. *South Afr. Geogr. J.* 98, 37–60. doi: 10.1080/03736245.2015.1052840

Simkin, R. D., Seto, K. C., McDonald, R. I., and Jetz, W. (2022). Biodiversity impacts and conservation implications of urban land expansion projected to 2050. *Proc. Natl. Acad. Sci. U.S.A.* 119, 1–10. doi: 10.1073/pnas.2117297119

Sims, K. R. E., Lee, L. G., Estrella-Luna, N., Lurie, M. R., and Thompson, J. R. (2022). Environmental justice criteria for new land protection can inform efforts to address disparities in access to nearby open space. *Environ. Res. Lett.* 17:64014. doi: 10.1088/1748-9326/ac6313

Sitas, N., Selomane, O., Hamann, M., and Gajjar, S. P. (Sp.). (2021). Towards equitable urban resilience in the Global South within a context of planning and management. *Cities Nat. Part F* 337, 325–345. doi: 10.1007/978-3-030-67650-6_13

Snyman, S., and Spenceley, A. (2019). *Private Sector Tourism in Conservation Areas in Africa*. Oxfordshire: CABI. doi: 10.1079/9781786393555.0000

Soanes, K., and Lentini, P. E. (2019). When cities are the last chance for saving species. *Front. Ecol. Environ.* 17, 225–231. doi: 10.1002/fee.2032

Soanes, K., Sievers, M., Chee, Y. E., Williams, N. S. G., Bhardwaj, M., Marshall, A. J., et al. (2019). Correcting common misconceptions to inspire conservation action in urban environments. *Conserv. Biol.* 33, 300–306. doi: 10.1111/cobi.13193

South African Cities Network (2021). *State of South African Cities*. Johannesburg: South African Cities Network.

Statistics South Africa (2015). *Census 2011: Income Dynamics and Poverty Status of Households in South Africa*. Statistics South Africa, 1–68. Available online at: http://www.statssa.gov.za/publications/Report-03-10-10/Report-03-10-102014.pdf (accessed August 3, 2024).

Steinberg, P. F. (2015). Can we generalize from case studies? *Glob. Environ. Polit.* 15, 152–175. doi: 10.1162/GLEP_a_00316

Strassburg, B. B. N., Iribarrem, A., Beyer, H. L., Cordeiro, C. L., Crouzeilles, R., Jakovac, C. C., et al. (2020). Global priority areas for ecosystem restoration. *Nature* 586, 724–729. doi: 10.1038/s41586-020-2784-9

Taylor, L., Maller, C. J., Soanes, K., Ramalho, C. E., Aiyer, A., Parris, K. M., et al. (2022). Enablers and challenges when engaging local communities for urban biodiversity conservation in Australian cities. *Sustain. Sci.* 17, 779–792. doi: 10.1007/s11625-021-01012-y

Tomita, A., Vandormael, A. M., Cuadros, D., Di Minin, E., Heikinheimo, V., Tanser, F., et al. (2017). Green environment and incident depression in South Africa: a geospatial analysis and mental health implications in a resource-limited setting. *Lancet Planet. Heal.* 1, e152–e162. doi: 10.1016/S2542-5196(17)30063-3

Tran, T. C., Ban, N. C., and Bhattacharyya, J. (2020). A review of successes, challenges, and lessons from Indigenous protected and conserved areas. *Biol. Conserv.* 241:108271. doi: 10.1016/j.biocon.2019.108271

Tsang, E. W. K. (2014). Generalizing from research findings: the merits of case studies. *Int. J. Manag. Rev.* 16, 369–383. doi: 10.1111/ijmr.12024

Tulloch, A. I. T., Barnes, M. D., Ringma, J., Fuller, R. A., and Watson, J. E. M. (2016). Understanding the importance of small patches of habitat for conservation. *J. Appl. Ecol.* 53, 418–429. doi: 10.1111/1365-2664.12547

Turpie, J., Letley, G., Chyrstal, R., Corbella, S., and Stretch, D. (2017). *A Spatial Valuation of the Natural and Semi-Natural Open Space Areas in eThekwini Municipality*. Washington, DC: World Bank. doi: 10.1596/26765

UN (2019). *United Nations Decade on Ecosystem Restoration (2021–2030)*. Resolution adopted by the General Assembly on 1 March 2019. Un 03519, 1–6. Available online at: undocs.org/A/RES/73/284%0Ahttps://digitallibrary.un.org/record/3794317?ln=en (accessed October 9, 2024).

UN (2022). *Decision Adopted by the Conference of the Parties to the Convention on Biological Diversity 15/5*, 1–23. Available online at: https://www.cbd.int/conferences/post20202CBD/WG8J/11/7,CBD/SBSTTA/23/9,CBD/SBSTTA/24/12andCBD/SBI/3/21,respectively (accessed August 24, 2023).

UNEP (2024). *Global Resources Outlook 2024: Bend the Trend - Pathways to a Liveable Planet as Resource Use Spikes*. Available online at: https://www.unep.org/resources/Global-Resource-Outlook-2024 (accessed August 25, 2024).

UNGA (2015). *Transforming Our World: the 2030 Agenda for Sustainable Development*. New York: UNGA.

van Wilgen, B. W., and Wannenburgh, A. (2016). Co-facilitating invasive species control, water conservation and poverty relief: achievements and challenges in South Africa's Working for Water programme. *Curr. Opin. Environ. Sustain.* 19, 7–17. doi: 10.1016/j.cosust.2015.08.012

Venter, Z. S., Shackleton, C. M., Van Staden, F., Selomane, O., and Masterson, V. A. (2020). Green apartheid: urban green infrastructure remains unequally distributed across income and race geographies in South Africa. *Landsc. Urban Plan.* 203:103889. doi: 10.1016/j.landurbplan.2020.103889

Watson, J. E. M., Venegas-Li, R., Grantham, H., Dudley, N., Stolton, S., Rao, M., et al. (2023). Priorities for protected area expansion so nations can meet their Kunming-Montreal Global Biodiversity Framework commitments. *Integr. Conserv.* 2, 140–155. doi: 10.1002/inc3.24

Wilhelm-Rechmann, A., and Cowling, R. M. (2013). Local land-use planning and the role of conservation: an example analysing opportunities. *South Afr. J. Sci.* 109, 1–6. doi: 10.1590/sajs.2013/20120026

Wintle, B. A., Kujala, H., Whitehead, A., Cameron, A., Veloz, S., Kukkala, A., et al. (2019). Global synthesis of conservation studies reveals the importance of small habitat patches for biodiversity. *Proc. Natl. Acad. Sci. U.S.A.* 116, 909–914. doi: 10.1073/pnas.1813051115

Wu, L., and Kim, S. K. (2021). Exploring the equality of accessing urban green spaces: a comparative study of 341 Chinese cities. *Ecol. Indic.* 121:107080. doi: 10.1016/j.ecolind.2020.107080

Zimmerman, B., Schwartzman, S., Jerozolimski, A., Esllei, J., Santini, E., and Hugh, S. (2020). Large scale forest conservation with an indigenous people in the highly threatened Southeastern Amazon of Brazil: the Kayapo. *Encycl. World's Biomes.* 1–5, V3-27–V3-34. doi: 10.1016/B978-0-12-409548-9.11918-9

zu Ermgassen, S., Drewniok, M. P., Bull, J. L., Walker, C. C., Mancini, M., Ryan-Collins, J., et al. (2022). A home for all within planetary boundaries: pathways for meeting England's housing needs without transgressing national climate and biodiversity goals. *Ecol. Econ.* 201:107562. doi: 10.31219/osf.io/5kxce