



The Biodiversity, Food Security, and Poverty Nexus in the Musina-Makhado Special Economic Zone of South Africa

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Abstract

Wild-sourced foods are entrenched among African women as a survival resource, with the potential to be expanded. Instead of optimising food security, current linear economic growth models in South Africa favour large environment-degrading projects, such as special economic zones and mining, that increase the gap between the wealthy and poor sectors of society. The contentious Chinese-funded Musina–Makhado Special Economic Zone (MMSEZ) planned for the Limpopo province of South Africa is used as a case study in this paper. The MMSEZ case demonstrates the failure of an Environmental Impact Assessment (EIA) to consider alternative land use suited to a biodiverse economy and existing livelihood strategies. Notably, the availability of a popular edible insect, the mopane worm, was not surveyed at a time when it might have been visible. Despite a local and global interest in insect protein, this opportunity was not considered as a means to improve food security and income streams for local unemployed African women.

Keywords: Biodiversity economy; Environmental Impact Assessment (EIA); food security; mopane worms.

Introduction

Mega developments in Africa, such as mining and special economic zones, are becoming a curse rather than an advantage to the communities living in those areas. South Africa, despite its bounty of mineral resources, remains one of the most inequitable countries in the world. Poverty and food insecurity are on the rise (Sulla, Zikhali and Cuevas 2022) and the middle class is disappearing (van der Watt 2021). This article discusses the multidimensional use of natural resources in Africa and presents a case study of the South African Energy Metallurgical Zone (also referred to as the MMSEZ). A key research question is whether a popular and nutritious edible caterpillar, the mopane worm, and its importance to the women of the Limpopo province of South Africa (Gardiner et al. 2012) was adequately addressed in the preparation and planning of development in this area.

Across the continent, the socio-economic disparity between those exploiting underground mineral resources and those reliant on that area's biodiversity for food security seems unchanged since Cecil John Rhodes proposed the Cape to Cairo railway to 'tame' Africa (Williams 1922). Although Rhodes's project was not realised in its entirety, it proved useful for the transportation of mined products and the building of the South African economy for almost 150 years. Today, South Africa's railroad system has been severely impacted by poor governance, corruption, arson, and vandalism (Hartley, Mills and Soko 2023) even though it is the most affordable mode of transport for commuters and goods (Norton 2022).



Concurrent with the railway “boom and bust” was the exploitation of South Africa’s mineral wealth. Paradoxically, areas that had the richest gold deposits now have the largest mine-affected communities living in squalor. These communities use water and soil polluted with dangerous levels of radiation (Bobbins et al. 2018) caused by uranium, a by-product of the mining (Winde et al. 2019). For example, pursuing food security-related activities, such as fishing, cattle raising, and subsistence farming, comes with inherent hazards in the post-mining landscape of the West Rand, Gauteng province (Raji et al. 2021).

The unintended consequences of mining, such as loss of community and traditional livelihoods and increases in the cost of living, have led to the assertion that the original residents of mine-affected areas were better off before mining took place (Davids and Skinner 2006; Magadzu 2021; Owen, Kemp and Marais 2021). Similarly, in the Limpopo province, Shackleton (2020) found that a community’s farming land; grazing areas; and access to wild-sourced edible insects, fruits and vegetables, fuelwood, reeds, and medicinal plants were sacrificed to develop a platinum mine, but only a few members benefitted from formal employment. Quantification of the natural resources lost to mining resulted in the community receiving an out-of-court settlement in 2019, in addition to the initial compensation provided by the mine. The mine agreed to pay R10 million as a one-time cash payment, divided among mine-affected households. Additionally, R6 million would be used for purchasing land to compensate the community for the natural resources lost to mining. Another R2 million was allocated for community-based, agricultural development, and R25 million was earmarked for a public benefits trust, controlled by the community, for development initiatives (Shackleton 2020).

Foreign Direct Investment (FDI) can be a significant source of economic growth and job creation for African countries, but it also comes with socio-ecological risks (Bradlow 2023; Debongo et al. 2022). To reduce risks arising from FDI, good governance, upholding the rule of law, and compliance monitoring are essential. Research has found that the “resource curse” (Brisman and South 2013) is perpetuated by corrupt rent-seeking practices by individuals or firms, such as bribing government officials in exchange for mining licenses or favourable treatment in regulatory processes (Ogwang, Vanclay and Van Den Assem 2019, Owen, Kemp and Marais 2021). In South Africa, the Zondo Commission—also known as the Commission of Inquiry into State Capture—heard testimony from former government officials and business people describing how the Gupta family, who had close ties to former South African President Jacob Zuma, engaged in corrupt rent-seeking to secure contracts and mining licences (Harper 2022). In particular, the Gupta family’s acquisition of the Optimum Coal Mine—which supplied coal to the national power utility, the Electricity Supply Commission (Eskom)—was a source of controversy (Smit 2019). Eskom had imposed penalties on the Optimum Coal Mine for allegedly supplying inferior quality coal, but they allegedly used political connections to avoid these penalties. Undermining good governance, political interference, and an aging infrastructure has resulted in Eskom being unable to consistently supply electricity for South Africa (Hartley, Mills and Soko 2023). This underscores the importance of promoting transparency, accountability, and fair competition in the economy to ensure the country’s sustainable development is not compromised by corruption. This is particularly challenging in South Africa as many government officials implicated in the Zondo Commission still hold positions of influence (Harper 2022).

Constitutional Rights and Environmental Impact Assessments

A commitment to good governance, adherence to the rule of law, and diligent compliance monitoring are rooted in South Africa’s hard-won struggle for democracy, which was aligned with the pursuit of social and environmental justice. The monumental effort to rid South Africa of its apartheid past culminated in the creation of a national Constitution and a set of laws explicitly aimed at safeguarding social justice (Becker, Wet and Vollenhoven 2015; Jinnah 2022). Of particular significance is the Bill of Rights, enshrined in Section 24 of the Constitution, which unequivocally links social justice to environmental protection, stating that ‘Everyone has the right to an environment that is not harmful to their health or well-being and to have the environment protected, for the benefit of present and future generations through reasonable legislative and other measures’ (Republic of South Africa 1996: 1251). The Environmental Impact Assessment (EIA) process regulated by the *National Environmental Management Act 107 of 1998* (national law) is intended to ensure that development projects do not harm the environment in a way that would compromise the Bill of Rights or cause unnecessary environmental degradation (Hochkirch et al. 2021; Lambrecht, Sowman and Day 2023). The EIA process provides a systematic framework for assessing and managing environmental impacts associated with development projects and preventing social injustice (Pinnock 2023).

The EIA process in South Africa should be managed by an independent Environmental Assessment Practitioner (EAP) (Department of Environmental Affairs and Tourism [DEAT] 2004; Weaver et al., 2008; Sandham, Chabalala and Spaling 2019) registered with the Environmental Assessment Practitioners Association of South Africa (EAPASA). The Department of Forestry, Fisheries and the Environment (DFFE) has appointed EAPASA to oversee EAP registration. Depending on the site location and existing knowledge (Lambrecht, Sowman and Day 2023), other specialists such as botanists, entomologists, or archaeologists may be appointed to survey the site to contribute to a robust evidence-based EIA report. These specialists should

be registered according to chosen disciplines with the South African Council for Natural Scientific Professions (SACNASP), a legislated regulatory body with the tagline ‘Integrity in Science’.

An important component of the EIAs is the public participation process, which uses word-of-mouth, site notices, newspaper advertisements, and onsite announcements to alert interested and affected parties (I&APs) to the proposed development (DEAT 2004). I&APs can contribute place-based knowledge and must be fully aware of the impacts of, and opportunities provided by, the development (Sandham, Chabalala and Spaling 2019). A Comments and Response Report (CRR) showing the inclusion of the I&APs’ perceptions, and the manner in which the EAP would address these, are integrated by the EAP into the final EIA report submission. Specialist reports, such as biodiversity studies and acoustic or traffic surveys, are sometimes commissioned following the I&APs alerting the EAP to their concerns. In this way, I&APs create additional work which not only improves the EIA but also contribute to research on various important topics.

Despite the mandatory EIA process (DEAT 2004; Hochkirch et al. 2021) and contrary to the Constitutional tenet of a healthy environment for all, communities located next to megadevelopments (e.g., mines) often lack basic services, such as health care, while sexually transmitted diseases and gender-based violence are rife (Castañeda Camey et al. 2021; Pretorius and Blaauw 2021; Rubin and Harrison 2015). For example, a 2015 study in Rustenburg, North West province—where platinum group metals are mined—reported that one in four women aged 18 to 49 years had been raped (Médecins Sans Frontières 2016). In response, the humanitarian organisation Médecins Sans Frontières (MSF) established an office to assist rape victims. Furthermore, MSF (2016) found that the mining region exhibited a significant concentration of orphans and vulnerable children, akin to conditions observed in a war zone. Despite the risk of contracting HIV/AIDS, the normalisation of child prostitution as a survival strategy is promoted by adults in the mine-affected community as evidenced by local phrases such as “go phanda”, meaning “go help yourself” (Davids and Skinner 2006), and “blesser”: the term for an older man providing gifts to a schoolgirl in return for sexual acts (van der Watt 2021). Problematic physical and mental health conditions caused by air, soil, and water pollution persist even after mine closures (Bobbins et al. 2018; Lynch and Long 2022). When gold mines on the West Rand closed due to declining profits, informal artisanal miners continued operating with no EIA or concern for health and safety (Magadzu 2021). These opportunistic miners are colloquially called “Zama Zamas”, meaning “hustlers”, as they do not conform to laws or regulations (Jinnah 2022) and threaten local communities with rape and murder (ka Canham 2022). The duty of care should be applied to any greenfield megadevelopment to avoid the inhumane conditions that many women and children in mine-affected communities in South Africa experience.

Food Security

Traditionally, communities in the Vhembe District Municipality of the Limpopo province practice organic farming, agroforestry, and crop diversification, supplemented by food gathering from the wild. Such livelihood strategies are threatened by land clearing to make way for megadevelopments (Castañeda Camey et al. 2021) such as the Musina–Makhado Special Economic Zone (MMSEZ), which will destroy large tracts of wilderness and pollute soil, water, and air (Semenya 2021). Pereira, Cuneo and Twine (2014) found, in another district of Limpopo province where food acquisition had switched from being grown or gathered to being purchased, the diets of the local community had become less nutritious. The ability to grow or gather food freely from the environment for personal use or resale serves as a green safety net for communities in the Limpopo province (Shackleton 2020). A green safety net is the natural capital of an area used to reduce poverty and hunger (Whitmee et al. 2015). Indigenous Knowledge about a place is developed over centuries to provide a backup food source in times of drought, pandemics, and economic uncertainty fueled by inconsistent electricity and global conflict.

Findings from two villages in the Vhembe District Municipality revealed the underestimated role that wild foods play in assisting households during periods of vulnerability (Paumgarten, Locatelli and Witkowski 2018). However, a potential decrease in the availability of wild foods was linked to factors such as land expropriation, land conversion, excessive harvesting, and lower rainfall over time. A Household Food Insecurity Access Scale conducted in 120 households in the Limpopo province found that half of the sample directly collected an edible and nutritious insect, the mopane worm (*Gonimbrasia belina*). The study also found that 80% of the households collecting mopane worms were food insecure and 60% were headed by women (Oppong 2013). The mopane worm crop is a significant source of nutrition for local communities, having three times the protein content of beef and containing essential vitamins: phosphorus, iron, and calcium (Potgieter, Makhado and Potgieter 2012). They can also be stored for several months without refrigeration. This is important in the Vhembe District Municipality where less than 30% of households had access to electricity in 2011 (Haddad and Badham 2017) and load shedding¹ is a growing problem. In addition, they are a cultural delicacy enjoyed during holiday reunions when migrant workers return to visit family in rural Limpopo province.

Mopane worms feed on the extensive tracts of mopane trees (*Colophospermum mopane*) that occur in the Limpopo province (Gardiner et al. 2012) and are threatened when the tree on which they feed is removed for fuel or construction (Makhado et al. 2014). Mopane worms remain a popular edible insect in southern Africa and dried mopane worms and mopane worm health bars can be purchased on Takealot, South Africa's leading online store. These products are manufactured and packaged by a female entrepreneur from Limpopo province who sources mopane worms directly from the community and distributes them to a wider market. She is also researching the production of mopane worm crackers and protein powder to diversify the product (Ndabezitha 2022), but lack of funding has constrained her progress. Food security is not simply about access to food. It also requires addressing issues of social inequality, environmental sustainability, and preventing economic exploitation of vulnerable groups (Brisman and South 2017) through initiatives that support small business development.

Green Crimes

Blatantly ignoring the current and future food security of marginalised communities, such as Indigenous peoples and low-income communities in Africa, through megadevelopments can be labelled as green crime. Lynch and Long (2022: 257) described green criminology as 'the study of green harms, crime, law, and injustice; the causes of those crimes/harms; and the various species or living entities that are the victims of green crimes and harms'. Furthermore 'the global hierarchy of capitalism' differentiates between economically powerful nations and those vulnerable to exploitation (Lynch and Long 2022: 259). Notably, FDI in infrastructure has contributed to increased green crimes on the African continent as roads have improved access to remote areas containing precious timber species and rare animals (Debongo et al. 2022), such as pangolins.

South Africa has excellent environmental legislation and ensuring compliance at the municipal and provincial government levels is key to avoiding green crimes and ensuring social justice. Regrettably, when the government fails to act, responses to green crimes may need resolution through the courts. Unfortunately, a court process in South Africa can be time-consuming and costly. Associated delays allow the criminal activity to persist unchecked during this period, as witnessed in the amaXimba community case in the KwaZulu-Natal province of South Africa (Pinnock 2023).

Approval of the controversial EIA for the foreign-funded MMSEZ—planned for the Limpopo province—has raised several concerns regarding process, national commitment to sustainable development (Carnie 2023; Thompson and Shirinda 2021; Yaowen 2021), and protection of Indigenous women's livelihood strategies (Hlongwane, Slotow and Munyai 2021; Makhado et al. 2009; Opong 2013; Sekonya, McClure and Wynberg 2020; Staff Reporter 2020). The Centre for Environmental Rights maintained from the onset of the EIA that the MMSEZ should have been reviewed at the national level by the DFFE as it has national and international impacts on water security and climate change (Centre for Environmental Rights [CER] 2022). Instead, the administration of the EIA process, environmental authorisation, and subsequent unsuccessful appeals submitted by several organisations were dealt with at the provincial level of government by the Limpopo Department of Economic Development, Environment and Tourism (LEDET). LEDET's authority over the EIA was legally considered to be a conflict of interest as the proponent of the MMSEZ is the Limpopo Economic Development Agency (LEDA), another provincial government entity (CER 2022).

Study Area

During former President Jacob Zuma's tenure (9 May 2009 to 14 February 2018), over 7 000 hectares of predominantly natural savanna in the Vhembe District Municipality of the Limpopo province were earmarked for the MMSEZ (Thompson and Shirinda 2021). The land is mostly used for game and stock farming. It has an average annual precipitation of around 820 mm, falling mostly in summer, with temperatures reaching 35°C and higher during the summer months. Shenzhen Hoi Mor of China, now renamed the South African Energy Metallurgical Base, has invested over US\$3.8 billion in the MMSEZ development (Paulino 2021). Should civil society court action fail to stop the MMSEZ, over 8 000 hectares of wilderness will be changed to a light industrial site in the north, near Musina, and a heavy industrial site in the south, dominated by steel manufacturing at the northern foot of the Soutpansberg mountains (Yaowen 2021).

The proposed MMSEZ raises serious environmental impact concerns due to its location in the Vhembe Biosphere Reserve. The draft Vhembe bioregional plan recognises this as a critical biodiversity area essential for meeting national biodiversity targets (Carnie 2023). The renowned Mapungubwe Cultural Landscape—a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage site—and the Makuleke wetlands—a designated UNESCO Ramsar site—are also located close to the MMSEZ area (Bega 2023). The MMSEZ will be situated mainly within Musina Mopane Bushveld—the most diverse mopane veld type in South Africa—with a conservation target set at 19%, but with only 3% formally protected (Mucina and Rutherford 2006).

Mopane veld is a habitat for mopane worms, collected bi-annually around April and again in December for food and to sell for income (de Swardt, Wigley-Coetsee and O'Connor 2018; Illigner and Nel 2000; Sekonya 2016; Taljaard 2019). Other wild-sourced nutritious foods that will be lost with the development of the MMSEZ include three species of termites, marula (*Scerocarya birrea*), and baobab (*Adansonia digitata*) fruits (Staff Reporter 2020). Geographically, the Vhembe District Municipality borders Botswana, Zimbabwe, and Mozambique, allowing an informal cross-border trade of mopane worms (Makhado 2014; Rebe 1999) and other natural resources. Considering a survey of mopane bushveld near Musina found about 29 000 mopane worms ha⁻¹ in 44% of trees (de Swardt, Wigley-Coetsee and O'Connor 2018), sourcing highly nutritious mopane worms in the study area is significant to current and future food security. This is crucial, given that the area has a high unemployment rate (Hlongwane, Slotow and Munyai 2021; Semenya 2021) and a dependence on government social grants to alleviate poverty (Paumgarten, Locatelli and Witkowski 2018).

Methods

This study undertook a secondary analysis of the 727 pages of the CRR compiled for the public participation section of the EIA (Semenya 2021) and the two invertebrate studies that should have included mopane worms (Greffrath 2019; Singo 2021). Several organisations and groups, including the Wildlife and Environment Society of South Africa (WESSA); World Wide Fund for Nature (WWF); Birdlife South Africa; the Endangered Wildlife Trust; South African National Parks (SANParks); and a group of local biodiversity experts, primarily from the University of Venda and local community groups, submitted comments on biodiversity impacts during the public participation exercise for the MMSEZ (Semenya 2021). The main focus of this study are comments from I&APs related to the traditional, wild-sourced food known as mopane worms, and the response and action taken by the EAP. Many of the comments expressed broad concern about the rich biodiversity that South Africa would sacrifice. However, the WESSA's comments on the initial invertebrate survey (Greffrath 2019) and the recommissioned invertebrate study (Singo 2021) focused mainly on mopane worms, due to the invertebrates' importance in food security. This allowed the CRR and the specialist reports to be compared to independent academic studies on mopane worms and their contribution to the economy. The latest price for mopane worms was obtained during a field trip on 11 March 2023, near a filling station in Sibasa, Limpopo province, where mopane worms and other insects were being sold as food. The dried mopane worms were weighed to determine the price per kilogram and converted to the average monthly US\$ exchange rate. The EAPASA and SACNASP databases were consulted to determine the EAPs' and the specialists' qualifications and registrations, as mandated by law.

Findings

The EIA and two invertebrate studies conducted for the MMSEZ failed to address the widespread use of natural resources by local communities for food, water, fuel, medicine, and cultural practices. During the Covid-19 pandemic, when sampling for the second invertebrate study by Singo (2021) was conducted, nature-based livelihoods from Pretoria northwards to the site of the MMSEZ and beyond to the Zimbabwean border were evident. Roadside hawkers were observed selling bundles of wild-sourced *Artemisia afra*, a traditional remedy for flu (Ramalevha and Thompson 2020). The importance of mopane worms as a nature-based livelihood has been documented in publications from several universities (*Table 1, Appendix*) and mopane worms were mentioned 47 times in the EIA's CRR (Semenya 2021) alerting the EAP to the presence of this traditional food in the study area. The WESSA comments on mopane worms covered points raised by other parties (Semenya 2021) and were, thus, a significant focus point for the study.

Considering 127 women and three men were found camping and bulk collecting mopane worms on a single farm near Musina in the Limpopo province (Taljaard 2019), the public participation process of the EIA should have identified mopane worm users as I&APs. The substantial body of literature documenting the importance of mopane worms as a nutritional food and a source of income (Baiyegunhi and Oponng 2016; Egan et al. 2014; Makhado et al. 2009; Sekonya, McClure and Wynberg 2020; Taljaard 2019) was also excluded from the EIA and the invertebrate reports compiled by Greffrath (2019) and Singo (2021).

A common theme from I&APs in the EIA comments was that no alternatives other than an extensive industrial and manufacturing cluster had been considered by the EAP. Furthermore, WESSA suggested that the MMSEZ would increase poverty and destroy untapped natural resources, such as the mopane worm. Although two biodiversity reports with field sampling of invertebrates (Greffrath 2019, Singo 2021) were commissioned for the MMSEZ, the WESSA and others continued to raise concerns that their comments were being disregarded. The progression of three phases of commentary supplied to the EAP on mopane worms by WESSA from October 2020 to March 2022 shows that these were not professionally addressed (*Table 2, Appendix*). First, general references applicable to southern Africa, such as Red List species, were cited by the specialists commissioned to survey biodiversity. However, no references specific to the biodiversity of the Vhembe District

Municipality, such as mopane worms, were cited. This was despite this deficit being highlighted by the WESSA at a public meeting, in three formal submissions to the LEDET, and in the press (Carnie 2023).

Second, a registered entomologist or zoologist was not commissioned to survey mopane worms and other invertebrates in the area proposed for the MMSEZ EIA. The first fauna and flora report was conducted by a person having SACNASP registration in conservation science. Despite several complaints from I&AP that this first biodiversity report inadequately covered fauna, the EAP did not appoint an entomologist or zoologist to conduct the bat and invertebrate study. The only specialist identified on the bat and invertebrate study was registered by SACNASP in earth science only. Earth science considers the physical constitution of the earth and its atmosphere, not biodiversity. The SACNASP was alerted to this malpractice via a signed affidavit on 31 January 2023 but, as of 12 November 2023, had not provided any feedback.

The WESSA (Table 2; Semanya 2021: 83) and a group of biodiversity specialists who made a submission (Semanya 2021: 262) alerted the EAP that past studies were available to improve the invertebrate study. Unfortunately, none of these studies were included in a reference list or used for planning the timing of the second invertebrate survey. The field sampling was undertaken in May 2021 when the mopane worm would have been pupating underground and not visible.

In addition, the WESSA pointed out in the first round of comments that termite mounds, a common and noticeable feature of the landscape, had been ignored by Greffrath (2019). This error was not corrected in the second study by Singo (2021), even though three species of termite are harvested and traded by women in the Vhembe District Municipality (Netshifhefhe, Kunjuku and Duncan 2018) and one species was available at the Sibasa market in March 2023.

WESSA and the group of biodiversity experts further highlighted the inadequacy of the initial invertebrate study as Greffrath (2019) reported a mere 18 insect and one spider species (Semanya 2021: 273). In stark contrast, the biodiversity experts referred the EAP to an inventory of 113 beetle species recorded in a previous study within the vegetation types that would be disrupted by the MMSEZ. In comparison, Singo (2021: 21) found a paltry four beetle species and a total of 17 insect species. The biodiversity specialists also highlighted that Red List categorisations for invertebrate taxa are undeveloped for the area. They noted the MMSEZ site harboured highly localised beetle endemics such as *Wahlbergiana alternans* and *Microstizopus transvaalensis* and that there could be undescribed spider species on the site (Semanya 2021: 273). The EAP was disingenuous in responding to the biodiversity specialists, writing that ‘additional information obtained from specialist Avifaunal, Invertebrate, Ecological and Biodiversity Offset studies’ would be included in the final submission (Semanya 2021: 261). However, an invertebrate or entomology specialist was never commissioned by the EAP for the MMSEZ. While the Singo (2021) report title specifies ‘bats and invertebrates’, it also includes information on pages 25 to 26 on reptiles and amphibians. This inaccuracy, along with a table on page 22 that indiscriminately combines insects, spiders, millipedes, and centipedes, raises questions about the author’s taxonomic understanding and attention to detail.

Finally, the alternative for using the area to stimulate the bioeconomy of the Vhembe District Municipality was ignored in the EIA, even though many researchers have documented the economic significance of mopane worms (Table 2). None of these findings were considered in the EIA, suggesting the EAP had a bias towards the MMSEZ going ahead. Makhado et al. (2009) found that, during the 2004/5 season in Limpopo province, one person reported an annual selling turnover of US\$2 980.63. Additionally, 16 000 metric tonnes of mopane worms were traded annually in South Africa in informal markets at a value of US\$59 million (Potgieter, Makhado and Potgieter 2012). In over two decades, the price of mopane worms has increased from US\$5.42 per kilogram (Rebe 1999) to US\$14.60 (record in Sibasa in March 2023) and, with the use of online marketing, to US\$31 per kilogram. This trend demonstrates the potential to expand product development and marketing.

Discussion

The risk of prejudicing the rights of vulnerable sectors of society associated with FDI can only be mitigated if EAPs, specialists, and state officials base decisions on the best available knowledge from both scientific research and Indigenous Knowledge. The Department of Environmental Affairs and Tourism (DEAT) (2004: 2) states that ‘Consideration of alternatives is one of the most critical elements of the environmental assessment process. Its role is to provide a framework for sound decision-making based on the principles of sustainable development’. They also warn of ‘Political economy or intellectual obstacles, in which barriers may be imposed by groups or individuals, usually holding positions of economic or political power, who wish to advance a particular agenda’ (DEAT 2004: 4). This retrospective analysis of the MMSEZ EIA found that the potential for harvesting and commercialising mopane worms as an alternative land use to the MMSEZ was ignored by the EAP. This is despite the known benefits of nature-based livelihoods afforded to local communities, including food justice. Mopane worms provide a source of income for women who have limited economic opportunities and provide an unrivalled source of nutrition

whilst sustaining and promoting cultural heritage (Hlongwane, Slotow and Munyai 2021; Makhado et al. 2009; Potgieter, Makhado and Potgieter 2012; Rebe 1999; Sekonya, McClure and Wynberg 2020).

It is also concerning that the EAP involved in the initial round of public consultation resigned after refusing to recommend the MMSEZ and a more compliant EAP was appointed to complete the EIA on the MMSEZ (Mbangula, Shirinda and Thompson 2021). An EAP should be unbiased (DEAT 2004:10) and appoint specialists to supplement knowledge gaps. It was a serious error that the EAP commissioned the invertebrate survey at a time when mopane worms would not be visible (Singo 2021), thus, underplaying the benefits that local women could derive from harvesting them. This is an endemic problem. Mograbi, Archer and Fabricius (2023) pointed out that Indigenous Knowledge of biodiversity is not integrated into decision-making in South Africa. Furthermore, the recommissioned invertebrate survey was carried out by a person accused of malpractice (Bloom 2021) and having a SACNASP registration in earth science, not entomology or zoology. Hochkirch and colleagues (2021) highlighted a data deficiency on invertebrates in biodiversity-rich areas, such as the Vhembe District Municipality, and recommended that EIA surveys provide baseline information on species and improve Red List and conservation efforts. In addition, it is essential to access baseline biodiversity information before authorisation is awarded to a development (DEAT 2004). The role of EAPASA and SACNASP is to hold members accountable to a code of practice. In this way, the EIA applies scientific rigour (Hochkirch et al. 2021) rather than becoming an administrative paper exercise to secure environmental authorisation (Bloom 2021).

Best practice procedure for EIAs requires the EAP and specialists to consult existing scientific literature and available integrated management tools. One of these tools is a bioregional plan that assists with biodiversity protection planning (Carnie 2023). It is used to identify areas of irreplaceable ecological function and unique biodiversity that are important for South Africa to meet its international obligations under the Convention on Biological Diversity (Mograbi, Archer and Fabricius 2023). Although a draft version of the Vhembe bioregional plan was approved by the national department in 2019, LEDET has not published and gazetted it into law (Carnie 2023). This delay has worked to the advantage of the MMSEZ, but has undermined LEDET's own biodiversity protection planning tools. Furthermore, the EAP and LEDET accepted an entomology survey by an earth scientist, ignoring public comments and published information. Discrepancies between the scientific literature and the MMSEZ reports indicate that natural resource users' rights and livelihoods (Hlongwane, Slotow and Munyai 2021; Makhado et al. 2009; Potgieter, Makhado and Potgieter 2012; Rebe 1999; Sekonya, McClure and Wynberg 2020) have been ignored and underreported in the EIA. Comments from the public are often disregarded as they may have a vested interest in the outcome, but it is the EAP's responsibility to conduct a literature review and commission specialist reports to corroborate or disprove such comments.

Despite the notable gaps in the invertebrate—and other—reports, authorisation for the MMSEZ project to proceed was granted by LEDET on 23 February 2022 (CER, 2022). An appeal to the Member of the Executive Committee of LEDET by WESSA was rejected on 7 July 2022. This was not unexpected, considering that the EIA protocol had, at best, become a cut-and-paste exercise and, at worst, was corrupted and unethical (Bloom 2021). In January 2023, further developments included a civil suit to rule on the lawfulness of LEDET's decision (CER, 2022), an advisory warning on the MMSEZ impacts, and a query on the legality of the EIA process was published by the Academy of Science of South Africa (ASSAf) Scientific Advisory Group on Emergencies (SAGE) (Bega 2023). In February 2023, the United Nations Development Programme's (UNDP) Social and Environmental Compliance Unit (SECU) visited the area to interview women using mopane worms as a livelihood strategy as well as others objecting to the MMSEZ (Thompson, Shirinda and Mbangula 2023). At the time of writing (November 2023) the SECU case registry indicated the investigation was not complete (United Nations Development Programme [UNDP] 2023).

An EIA should predict, evaluate, and reflect on the impacts of development before they occur and should represent all viewpoints, in particular, women resource harvesters who make use of the green safety net for their food security. Analysis of past Chinese investments in mining and infrastructure projects cautions against poor compliance with environmental standards and protection (Debongo et al. 2022). Thus, the discrepancies in the MMSEZ are a weak start to the FDI. The solution to ensuring green crimes and increased poverty are not perpetuated in Africa may lie in China's Supreme People's Court where two international courts to settle disputes related to the Belt and Road Initiative have been established (ClientEarth 2018).

The MMSEZ EIA failed to consult with, or consider the impacts on, natural resource users. Mopane worms are a good source of protein, fats, and fibre (Hlongwane, Slotow and Munyai 2021; Makhado et al. 2009). In addition, Rebe (1999) determined that a kilogram of mopane worms fed more people than the equivalent amount of meat. Refrigerators are not required for storage—an important consideration for food security at a time when South Africa has an inconsistent power supply. Demand has increased and limitations to harvesting have been documented in the Limpopo province. Meanwhile, recommendations to prevent mopane worm harvesting areas from being lost to development (Netshifhefhe, Kunjeku and Duncan 2018; Sekonya,

McClure and Wynberg 2020) or to facilitate access to new areas have been ignored by the state (Hlongwane, Slotow and Munyai 2021; Makhado et al. 2009) in favour of a development model with a mere 15% success rate in Africa (Paulino 2021). Food processing of the local mopane worm crops could add value through processing, packaging, and marketing, which could create employment opportunities. The bioeconomy in Vhembe District Municipality can only gain momentum as a source of economic growth and sustainable development. This is reliant upon investment in capacity building and inclusive participation to ensure that it is equitable, and socially and environmentally responsible. Empowering women to retain control over their food systems and improve their access to healthy food, such as mopane worms, upholds food justice. As defined by Blake (2018), food justice is the equitable access to nutritious and culturally appropriate food for all people, regardless of their socio-economic status or geographic location. Food insecurity is a major challenge to food justice in Africa and is caused by a range of factors such as poverty, conflict, climate change, and environmental degradation. Food insecurity can lead to malnutrition, stunted growth, and other health problems, particularly for vulnerable groups such as women and children. Food justice requires advocating for policies that promote economic development, social equity, and environmental sustainability, as well as supporting community-based initiatives (Blake 2018).

Many villages in the Limpopo province, such as Musina, have evolved into dense settlements where the original occupants have mingled with communities displaced by the apartheid system and immigrants from other countries (Kolkman 2006). In this paper, we draw on lessons from the World Bank which monitors legal compliance and applies a human-centred approach to funding (Bradlow 2023). The MMSEZ was widely criticised for an inadequate public participation programme (Mbangula, Shirinda and Thompson 2021) and a survey of 39 special economic zones in Africa has been found wanting in the triple bottom line of people, planet, and profit (Paulino 2021). Although developments in the Global South often imply a promise to improve the lives of communities, the public participation methods employed tend to be inadequate, leading to further marginalisation, poverty, and distrust of government entities (Sandham, Chabalala and Spaling 2019). Any development should link conclusively with social change to promote sustainable development and reduce inequities. The World Bank predicted low economic growth even before Covid-19 and the South African energy crisis, and prospects of eliminating poverty by 2030 as envisaged in the National Development Plan now seem untenable (Sulla, Zikhali and Cuevas 2022).

Conclusion

This paper delved into the quality of the EIA process in South Africa, highlighting how it is undermined by inadequate enforcement and alleged political influences. This not only compromises the integrity of the EIA process but also perpetuates environmental and social harm. The findings show that the MMSEZ EIA ignored an important traditional food resource in the area. This was despite the findings of the public participation process and widely available scientific evidence indicating the presence of mopane worms and their potential for food security. Corporations and states often misconstrue scientific information to promote the interests of powerful entities and their economic benefit (Lynch 2020). In this case, the EAP working on the MMSEZ EIA undermined the scientific process by failing to appoint a suitably qualified or registered biodiversity specialist. I&APs provided strong evidence that the invertebrate survey method was not suitable, and the results inadequate, based on previous research findings, but the LEDET accepted the inaccurate report compiled by a person who was not registered nor qualified to conduct this specialist report. Critically, governance of FDI must be geared to drive a country's overall sustainable development goals and objectives, generally outlined in national development plans, to produce beneficial economic, social, and environmental outcomes for indigent communities. Environmental damage undermines the ability of communities to benefit from natural resource endowments to address structural inequalities. The stated aims of governments to boost investment to drive economic development and job creation—as in the case of the MMSEZ—should not occur at the expense of the environment and people's livelihoods. Environmental degradation threatens the well-being of communities. Coupled with climate change, which is altering patterns of rainfall, agriculture, and water availability, it could potentially lead to conflict and undermine South Africa's national development goals and sustainable development outcomes.

A case can be made for valuing each of the many wild-sourced products available in the Limpopo province: notably, termites, baobab and marula fruit, medicinal plants, and mopane tree essential oil. Whilst this paper has focused only on the mopane worm, other lesser known caterpillars, such as *Cerina forda* and the sought-after *Hemijana variegata* (Egan et al. 2014), also occur in the Limpopo province.

This retrospective analysis of the MMSEZ EIA has identified several lessons that can be used to improve the EIA protocol in areas providing nature-based livelihoods.

1. There should be no option of replacing the EAP if their findings disagree with that of the developer. As it is difficult for an EAP to remain impartial when the developer pays them, a rotational appointment of EAPs should be considered, as is done with financial auditing. Alternatively, developers could contribute to a fund from which EIAs would be

paid, on a scale proportional to the scope of the project. This could reduce conflicts of interest as the EAP would not be appointed and paid directly by the developer. Assessment of alternative land uses is often lacking in EIAs, possibly because this is not in the interests of the developer. Thus, an EAP would only be free to do an independent, compliant, and thorough report if their livelihood was not compromised for fear of losing potential income.

2. Specialists must indicate the scientific field for which they have SACNASP registration. They should be restricted to those studies and impact assessments for which they hold relevant specialist knowledge and expertise. Furthermore, it is the responsibility of LEDET, in its capacity as the designated competent authority, to verify registration numbers with the relevant bodies of the appropriate scientific field. The MMSEZ EIA where an earth scientist was allowed to conduct a bat and invertebrate study has compromised the integrity of LEDET.
3. Rule of law promotes sustainable development (ClientEarth 2019), transparency, and low levels of criminality, but in South Africa it has been compromised by those appointed to uphold it (Hartley, Mills and Soko 2023; Rademeyer 2023). In the EIA process, the application of the South African web-based environmental screening tool is the first mandatory requirement. This alerts the EAP and decision-makers to site sensitivities requiring field verification by specialists. The screening tool is still a work in progress. If it could be improved with data on actual and potential natural resource harvesting areas important for informal livelihoods, such as mopane worms, it could serve as the foundation for a robust and incorruptible authority presiding over the environmental authorisation or refusal for development. Registration bodies such as EAPASA and SACNASP also have a legal oversight role and malpractice should be promptly investigated and addressed to avoid repetition. It is further recommended that the use of the iNaturalist app should be a legal requirement so that species baseline information is captured and available for further research (Hochkirch et al. 2021; Lambrecht, Sowman and Day 2023), and identifications can be open to peer review and public scrutiny. Whilst there are many other apps to collect biodiversity, iNaturalist is promoted by the South African National Biodiversity Institute (SANBI) and others for sharing and identifying observations of biodiversity. Moreover, SANBI maintains dedicated curators to ensure high-quality content.
4. On a policy level, it is recommended that the *Species Environmental Assessment Guidelines*, finalised in October 2020, be revisited to include the mopane worm owing to its relevance to food security and the informal biodiversity economy. The guidelines are currently restricted to species that are on the Red List and assist with planning and implementing effective fieldwork. The omission has material consequences since the impact of any proposed development on the local population of the species is effectively downgraded in importance in the assessment. Notably, the first invertebrate study by Greffrath (2019) did not even mention mopane worms and the second one by Singo (2021) conducted the study at a time when this key species was not visible. Moreover, climate change resilience and adaptation form a crucial aspect of EIA assessment and the mopane worm has been identified as a species at risk (Sekonya, McClure and Wynberg 2020; Taljaard 2019) so best practice would have applied these guidelines regardless.
5. The lived reality of people using natural resources should be recognised in all EIA reports. Just as job creation is important for a needs and desirability analysis, so sustainable livelihoods should be thoroughly assessed. In the MMSEZ EIA process, the comments gathered through public participation made sense of local conditions but were not properly considered and responded to. Similarly, Jinnah (2022) argued that, in mining rights applications, the potential socio-economic benefits of the mine are considered, while the value and importance to local communities of traditional practices on land and natural resources, which may be threatened by the mine, are ignored. In areas with rich ethnobiology, the EIA process should consider the biodiversity economy as an alternative to authorising change in land use. Notably, entrepreneurs have recently begun to add value to mopane worms by producing protein powder (Ndabezitha 2022) and baobab oils and pulp (Darr et al. 2020) but they need capital investment and an enabling environment to expand. The local ethnobiology of an area further contributes to the ecotourism potential of an area, a strength already supported by the three UNESCO sites in the Vhembe District Municipality.

These five key recommendations can help South Africa to implement already existing laws and policies to prevent corruption and rent-seeking behaviour common in large FDI projects such as mining and special economic zones. They could be used as a proactive approach to governance, ensuring that FDI is managed in a manner that promotes sustainable development, environmental protection, and the safety and security of people.

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¹ The strategic management or reduction of power to ease pressure on the electricity system.

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Appendix

Table 1: A summary of literature over the last 27 years showing growth and potential of the mopane worm industry in the Limpopo province of South Africa

Economic indicators	Year	Location of study	Source
Valued at US\$188 million in South Africa	1996	Southern Africa	Gardiner et al. (2012)
Price per kilogram was US\$5.42 to US\$6.02	1998	Vhembe and Capricorn District Municipalities, Limpopo province as well as Carletonville and Pretoria, Gauteng province	Rebe (1999)
Price per kilogram was US\$6.50 to US\$13.00	2004/5	Greater Giyani Municipality, Limpopo province	Makhado et al. (2009)
Price per kilogram was US\$2.50 to US\$4.00, which implies that the trade of 16,000 metric tonnes of mopane worms can generate US\$39 million to US\$59 million per year.	2011	Limpopo province	Potgieter, Makhado and Potgieter (2012)
Women headed households are most at risk of food insecurity and use mopane worms to improve nutritional intake, to barter for other food or to generate income.	2013	Greater Giyani Municipality and Greater Letaba District Municipality, Limpopo province	Baiyegunhi and Oppong (2016)
Harvesters cannot access enough. Poaching from protected areas or trespassing on private land occurs. People come from Johannesburg, Gauteng Province in buses. Many camp in the harvesting area.	2016/7	North of Makhado (previously Louis Trichardt), Thohoyandou and Giyani, Limpopo province	Sekonya, McClure and Wynberg 2020 (2020)
Traders reported an annual income of about US\$1400	2019	Vhembe District Municipality, Limpopo province	Hlongwane, Slotow and Munyai (2021)
Price per kilogram was US\$14.60 but some harvesters preferred to barter for school shoes and stationery. A church group collected mopane worms in exchange for musical instruments.	2023	Limpopo province	Recorded in Sibasa in March and confirmed by Wendy Vesela-Ntimbeni owner and founder of Matomani. Pers. Com 2023
Resold through a national online store at US\$31 per kilogram.	2023	Takealot South Africa	Personal observation 7 April 2023

Table 2: Tracking comments relating to invertebrates in two specialist reports commissioned for the Environmental Impact Assessment on the Musina–Makhado Special Economic Zone (MMSEZ), Vhembe District Municipality, South Africa

Comment pertaining to Fauna and Flora Impact Assessment prepared by Greffrath (2019) (letter dated 20 October 2020)	Comment pertaining to recommissioned Fauna report prepared by Singo (2021) (letter dated 25 October 2021)	Appeal on authorisation to proceed (letter dated 21 March 2022)
	Literature on fauna and flora of the Vhembe District was not referenced.	The consultants did not consult with available peer reviewed scientific publications on the mopane worm.
The sampling method was inadequate as only 19 invertebrate species were identified during the field work. A full insect list for this area would be in the region of 100 plus invertebrates.	Re sampling was not done at an appropriate time when mopane worms would be visible. A mere 22 invertebrate species were recorded.	Fieldwork was not done when mopane worms would have been visible therefore the mitigation is inadequate. The Species Environmental Assessment Guidelines were not used. The national Species Protocol was published in October 2020 to provide standardised guidance on sampling and data collection methodologies.
No edible insects were identified in the invertebrate study. Termite mounds are common features of the landscape, but no termite species were listed by the specialist.	Previous comments have been disregarded by the specialist and EAP. No mopane worms and no termite species were reported.	A SACNASP registered entomologist did not do the specialist study.
The invertebrate study relied on chance encounters and sweep netting. No details on the time of the day or month of sampling was provided.	Sampling was not done at an optimum time for mopane worms and other invertebrates, so the wild-food resource remains under reported.	
No mention of the mopane worm population.	Singo (2021: 28) states that ‘mopane worm habitat will be permanently lost, alternative breeding sites and harvesting site should be provided.’ No further explanation was provided to achieve this mitigation measure which cannot be avoided, managed, or mitigated. All mopane worm habitat and the species in that area will be permanently and irreplaceably lost as there is no evidence to suggest that mitigation is possible. Furthermore, information from the Rustenburg mining area indicates that pollutants will drift to other areas in the Limpopo Province and impact the traditional food of its people thus contributing to food insecurity and loss of cultural heritage.	A potential accounting for ecosystem services and asset value assessment is needed. Keystone species such as baobabs and mopane worms cannot be moved to another area. If the option of offsets is to be considered, it needs to be shown whether these areas have the same temperature and precipitation extremes required by mopane worms and how these may change with climate change impacts.