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Sustainability of Indigenous Solid Waste Management Practices in Rural Communities of South Africa

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Abstract: Solid waste disposal methods within indigenous communities present unique challenges and opportunities for sustainable development. However, the current knowledge on solid waste management focuses on formal waste collection systems, neglecting the practices and sustainability aspects of solid waste management in indigenous communities. Thus, it becomes imperative to undertake research studies that evaluate the sustainability of these practices as they play a pivotal role in ensuring sustainable development. The current study systematically evaluates the views and judgments associated with the sustainability aspects of indigenous waste management practices in the rural communities of South Africa using the Analytic Hierarchy Process (AHP) model. The data analysis was carried out using the AHP model. The findings of this study showed that the rural communities of Bushbuckridge Local Municipality prioritize the sustainability of the environment (weight: 0.590) over the economic (weight: 0.240) and social sustainability (weight: 0.165) based on the AHP evaluative framework. The validity of the priorities was tested through the computed degree of consistency (<10%) and an eigenvalue of 5.107. Furthermore, according to the assessment in the current study, the AHP evaluative framework dominantly prioritizes the sub-criteria of environmental sustainability (composting) at a responding rate of over 70% almost across all indigenous communities except for Acornhoek (30%), Casteel (25%), and Mambumbu (24%). Likewise, the sub-criterion of social sustainability, which is associated with communal cleaning labor, was found to be of extreme importance (60%), outperforming taboos (10%) that are anchored in cultural and spiritual beliefs. With a response rate > 50%, waste trading proved to be of economic efficacy. Using the AHP model to evaluate the sustainability aspects associated with indigenous solid waste management practices addresses a substantial gap in the comprehension of the role of indigenous knowledge towards sustainability in the discipline of solid waste management. However, it also offers a valuable sustainability perception that is associated with indigenous waste disposal methods that local governments and policymakers should include for consideration in integrated waste management plans. This can lead to the development of waste disposal programs that are well-coordinated and in accordance with indigenous sustainable waste management practices that advance the circular economy and promote environmental protection.

Keywords: indigenous solid waste management; sustainability; indigenous communities; analytic hierarchy process; rural communities; indigenous knowledge

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1. Introduction

In the 21st century, the concept of indigenous knowledge (IK) has become exceptionally significant in envisioning the global future associated with sustainability. This is primarily because there are gaps in the current knowledge systems that have over time proven to be ineffective in providing sustainable solutions to many of the universal

challenges confronting the world [1] this is especially with regard to poor solid waste management practices encountered by Global South countries [2,3]. This gap in the Global South countries persists amid limited municipal budgets and poor infrastructure, that subsequently translates into inadequate waste collection services within the economically marginalized indigenous rural communities of developing nations. Since they generally do not use conventional waste management practices, indigenous communities resort to indigenous cultural practices to manage their own waste. Indigenous communities around the globe use various pathways to manage their solid waste. Indigenous waste management methods are believed to be instrumental in the preservation of the natural environment, and in some instances, they go as far as rehabilitating the natural environment from previous impairment [4], as such numerous indigenous waste management practices have been documented across the globe. The practices range from the combustion of waste, burying, composting, and recycling [5,6]. The concept of recycling waste material is not a new practice; it has been practiced for centuries [7]. The indigenous practices of recycling waste material have been widely associated with steel metal [4]. However, recycling within the indigenous communities is not only limited to metal waste, but includes, amongst others, the recycling of paper, glass, plastic, and the recycling of organic solid waste into compost [8–10]. Furthermore, in some instances, the recycling of food waste into feedlots is very common within indigenous communities [7]. However, the literature indicates, that to date, steel metal continues to be one of the most recycled materials wastes. Moreover, indigenous waste management ontology is believed to focus on the concept of sustainability, in contrast to conventional methods that are centered around the disposing of waste [11]. However, the problem with many, if not all, local governments is that they solely focus on indigenized conventional waste management strategies that focus on disposing of waste as a panacea for all waste management solutions. Guran et al. [12] caution that given that the world population is estimated to reach 9.7 billion by 2050, resulting in an increased demand for resources and the increased production of waste, the conventional approach to waste management strategies will not be adequate. Therefore, this gap may present a platform for the inclusion of marginalized and overlooked waste management techniques, such as indigenous waste management practices that are thought to be strategically aligned with sustainable development objectives to advance waste management. Hart and Vorster [13], as well as Naidoo et al. [14], contend that indigenous knowledge (IK) is one of the single largest resources that is not yet fully mobilized to inform policies and strategies for the management of scarce resources such as waste management.

To this end, numerous scholars highlight that incorporating indigenous knowledge has the potential to expand the range of scientific understanding as well as scrutinize the dominant ways of knowing and contribute to a fair, unbiased, and inclusive knowledge framework [15–17]. However, it is important to emphasize that this assertion does not promote the erosion of the prevailing or dominant knowledge systems. Instead, it advocates for the incorporation of other ways of knowing, such as indigenous knowledge, which has throughout history been marginalized [18]. Tengö et al. [15] and Smith [16] premise is founded on the notion that by recognizing and appreciating the variety and complexity of knowledge systems, society may advance to more comprehensive and long-term sustainable strategies for managing the environment, also highlighted by Tran and Saalamanca [19]. This is especially the case in this era, where sustainable environmental management practices have become necessary on all fronts [20–22].Additionally, indigenous knowledge is believed to provide a holistic framework for an approach that effectively promotes sustainability [23].

Similarly, Mazzochi [24] corroborates that indigenous knowledge provides a concrete framework for an approach that effectively promotes sustainable development. The framework incorporates the three pillars of sustainability that underpin social, economic, and environmental benefits. It is noteworthy that the concept of sustainability or sustainable development, as it pertains to solid waste management, is established on these pillars [25–27]. These pillars work together to create an all-encompassing approach to solid

waste management. It is for this reason that the present study applied the sustainable pillars as used in the AHP model of Tsydenova et al. [28]. In the model, Tsydenova et al. [28] acknowledge environmental, economic, and social aspects as the three critical pillars that underpin sustainability. According to McBride et al. [29], these pillars have been helpful in assessing the sustainability practices of any entity. In the current study, the environmental, social, and economic indicators associated with indigenous waste management practices help in highlighting the benefits, costs, and resource uses, as well as creating a cohesive society where the needs of all individuals are met. This fundamentally informs or determines sustainability associated with the indigenous waste management practices in the rural communities of Bushbuckridge Local Municipality. This is because sustainability has emerged as a fundamental framework for managing solid waste by balancing economic considerations and environmental as well as social considerations [30,31].

Therefore, the environmental, economic, and social considerations are associated with sustainable waste management practices in the current study, as the sustainability practices of indigenous solid waste management are uncharted territory. These practices promote the efficient use of resources through recycling and reusing, among other methods. This reduces the costs of livelihood for indigenous communities, not to mention the costs associated with waste disposal. In the context of social considerations, social equity is promoted and marginalized rural communities are protected from the adverse effects of inadequate waste management by guaranteeing that all communities, irrespective of their poor economic status, manage waste effectively using indigenous knowledge [23]. As a result, social consideration in the context of indigenous communities fosters community involvement and an awareness of cultural values as well as social norms, thereby enhancing community identity and social cohesion. Indigenous practices, including communal labor cleaning initiatives and taboos, are essential in this context [32]. Moreover, in the context of environmental consideration, it is about the responsible interaction with the environment to avoid the depletion or degradation of the natural environment and allow for long-term environmental quality [28]. It involves practices such as composting, amongst others, that reduce environmental impact and ensure that ecosystems can maintain their essential functions and processes over time. In essence, it focuses on practices that are associated with environmental benefits.

IK as a knowledge system has received a lot of attention in recent decades at United Nations conferences on sustainable development and the environment [33]. This follows the premise that achieving sustainable development requires a diverse variety of knowledge systems and integrated information. Some knowledge systems, especially indigenous knowledge, are deeply ingrained in the cultural practices and traditions of indigenous communities. For instance, rural communities delve deep into indigenous cultural knowledge or practices to effectively manage solid waste to safeguard their interconnected environment and well-being. This has been observed in Bushbuckridge Local Municipality (BLM), as rural communities devoid of formal waste collection services resort to indigenous knowledge. BLM experiences a backlog of solid waste removal service provision ; as a result, according to Madonsela et al. [23], BLM has about a 93% backlog of refuse collection [23], while the backlog in Makhado Local Municipality amounts to 90%. Therefore, the indigenous communities within the jurisdiction of these rural municipalities are obligated to exploit indigenous knowledge disposal methods to manage refuse.

Concomitant to the challenge above, the BLM only collects about 7% of solid waste; hence, it is confronted with a huge (93%) waste collection backlog [23]. In essence, over 70% of the population lacks access to waste collection services. Therefore, they are compelled to resort to unaccounted indigenous waste management practices in the absence of formal services to manage waste. Given that overall solid waste management (SWM) is a substantial environmental challenge for rural local governments of developing countries [24,34], if not managed with caution, it can impede the realization of the Sustainable Development Goals (SDG), particularly SDG 3 that strives to advance good health and well-being. However, in as much as indigenous knowledge is extensively associated with promoting sustainability

practices, Madonsela et al. [23] have noted with concern that this assertion only remains a fallacy in the indigenous solid waste management discipline. This is not because the skills and technologies used by indigenous communities for solid waste disposal are incapable of being sustainable, but rather due to a lack of extensive research in the literature documenting the sustainability aspects of indigenous solid waste management practices. Subsequently, this has created a substantial gap in understanding the role of indigenous knowledge towards sustainability in the discipline of solid waste management. However, this observation contrasts with other disciplines such as agriculture, climate change, biodiversity, water quality management, fishing, farming, and education, as well as nature conservation, that have, by and large, proved how indigenous knowledge contributes to sustainable development [35–38]. Therefore, against this background, the current study aims to evaluate the sustainability practices of indigenous solid waste management in rural communities of Bushbuckridge Local Municipality, South Africa.

Considering this viewpoint, the present study utilized the Analytic Hierarchy Process (AHP) model to evaluate the sustainability practices. The AHP is a multi-criteria decision-making approach that was introduced in the 1970s [39]. The multi-criteria decision-making approach "provides strong decision making in domains where selection of best alternative is highly complex" [40]. The AHP facilitates decision-making using pairwise comparisons of predetermined criteria, which are assessed by experts [39]. In this case, the experts are indigenous communities. Generally, the AHP is a decision-support tool which can be used to solve complex decision problems. It is in this light that Tsydenova et al. [28] posit that in the absence of well-established, environmentally sound solutions, the AHP method is extensively utilized in developing nations where waste management decisions must be made. This is because the AHP approach has been extensively used in many applications, demonstrating its efficacy as a decision-making tool for guiding decision-makers in choosing sustainable waste management methods [41,42]. In the current study, the decision(s) was about determining the indigenous solid waste management sustainability practices of Bushbuckridge indigenous communities, which is a complicated problem with many criteria (environment, economy, and social) and sub-criteria, as depicted in Table 1. Furthermore, the complexity is further compounded by the fact that the sustainability aspect of indigenous solid waste management practices is a relatively unexplored area in the discipline of solid waste. This is the first study to evaluate the sustainability of indigenous solid waste management practices systematically and comprehensively within the rural communities of South Africa, to the best of the authors' knowledge.

Table 1. Example of the ranking questionnaire for indigenous waste management practices experts, demonstrated using the fundamental scale of absolute numbers.

	Ranking of Importance									
Economic Aspect	**Extreme Importance**	**Very Strong Importance**	**Strong Importance**	**Moderate Importance**	**Equal Importance**	**Moderate Importance**	**Strong Importance**	**Very Strong Importance**	**Extreme Importance**	**Economic Aspect**
Waste trading	9	7	5	3	1	③	5	7	9	**Recycling**
Waste trading	⑨	7	5	3	1	3	5	7	9	**Re-using**

Indicate the relative importance of the indigenous waste management practice indicator in the left column to the indicator in the right column by using a scale from 1 to 9 (where 9 represents extreme importance and 1 represents equal importance). All situations are intermediate between the numbers 1 and 9. Only one entry is permitted in each row.

Legal Framework

The South African legal framework that regulates waste management progressively recognizes the role and importance of indigenous knowledge practices in achieving sus-

tainable waste management. South Africa's government has enacted numerous laws and policies to manage waste in a manner that is both responsible and sustainable. However, it is interesting to note that in the center of managing waste in the manner that upholds sustainability, the regulations provided by the South African government make provisions that stress respecting and integrating indigenous knowledge systems. To this end, the Indigenous Knowledge Systems (IKS) Policy, enacted in November 2004, emphasizes the recognition, integration, and promotion of South Africa's wealth of indigenous knowledge resources. Although the policy is not solely focused on waste management, it highlights the importance of integrating indigenous knowledge across all sectors, including the sustainability of waste management. Moreover, in addition to this national policy, is the National Environmental Management Act (NEMA) of 1998, which is accountable for providing a broader framework for environmental protection and sustainable development in South Africa. Similarly, this national legislation advocates for indigenous knowledge by fostering a participatory approach to environmental management. This breeds a conducive environment in which indigenous knowledge systems are valued to develop waste management practices associated with sustainability. Furthermore, the primary legislation governing waste management in South Africa, the National Environmental Management Waste Act (NEM: WA) of 2008, establishes the basis for minimizing waste, promoting recycling, and encouraging sustainable waste disposal practices. This primary legislation includes, amongst others, the provisions for public consultation and stakeholder engagement. This subsequently allows indigenous communities to voice their perspectives on waste management issues which consequently has the potential to lead to the integration of the sustainability of the indigenous waste management practices. It is for this reason that, given the legislative framework that advocates for the inclusion of indigenous knowledge systems within integrated waste management practices, the sustainability of indigenous solid waste management practices in communities of South Africa must be investigated and documented to advance the agenda of the circular economy and promote environmental protection. This is fundamental to achieve the realization of the sustainable development goals.

2. Results and Discussion

This study utilized an Analytic Hierarchy Process framework to facilitate the evaluation of sustainable indigenous solid waste disposal methods by experts who are the custodians of indigenous knowledge in the rural communities of BLM. The elements of the array represent the relative importance of one criterion over another, using the scale proposed by Saaty [39] as reported in Table 1. To this effect, Table 1 provides an example and elaborates on how the indigenous solid waste management practices associated with sustainability were pairwise compared with each other to derive the priorities of judgments among the criteria by the respondents. The scores from the Table 1 comparisons were used in the generation of each value reported in Table 2, which represent the sub-criteria weights of environmental sustainability aspects in the Casteel indigenous community. Table 2 presents the sub-criteria weights derived from the pairwise comparisons prioritized by the indigenous communities of BLM in accordance with Saaty's scale. Consequently, Table 2 was produced with the pairwise comparisons criteria weights outcome, which illustrates the desirable example of a decision-making matrix for environmental sustainability in one of the surveyed study areas.

Overall, the maximum calculated eigenvalue that was calculated for the environmental criteria aspect was 4.775, followed by economic sustainability at 5.326 and social sustainability at 5.222. The overall calculated CR was 0.06 (6.06%) for environmental sustainability, 0.070 for economic sustainability, and 0.301 for social sustainability, since the matrix for both environmental and economic sustainability had a maximum size of 10 and corresponded to a random index of 1.49; the social sustainability matrix size is 2, corresponding to a random index of 0. The consistency of the judgements in the decision matrix about the sustainability of the indigenous solid waste management practices is validated by the fact that the

Consistent Ratio is overall below 10%. Therefore, the outcome of the judgment in the form of pairwise comparison sub-criteria weights (Table 3) is acceptable. The compliance in the present study conflicts with popular beliefs which suggests that establishing consistency is difficult, especially when decision-makers deliberate on the sustainability aspects [43,44].

Table 2. Example of decision-making matrix for environmental sustainability in Casteel indigenous community.

Indigenous Waste Management Methods	Burning	Backyard Pits	Composting	Open Dumping	Informal Waste Collection
Burning	1	0.20	0.14	0.50	0.11
Backyard pits	5.00	1	0.33	3.00	0.11
Composting	7.00	3.00	1	7.00	0.33
Open-air dumping	2.00	0.33	0.14	1	0.11
Informal waste collection	9.00	9.00	3.00	9.00	1

Table 3. The average consistencies of random matrices that inform the random index—RI—values.

Size	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

2.1. Priority Rankings of the Sustainability Pillars

The evaluative framework used in the current study demonstrates a distinct structure amongst the criteria sustainability aspects of indigenous solid waste management across the rural communities of Bushbuckridge Local Municipality. This is evidence, according to the acquired data, that the respondents preferred each of the criteria sustainability pillars (environment, social, and economic) at different scales and none of the respondents regarded the pillars as being equally important. It is for this reason that in the present study, the AHP evaluative framework acknowledges environmental sustainability (weight: 0.590) as of extreme importance, followed by economic sustainability (weight: 0.240) and social sustainability (weight: 0.165), as shown in Figure 1 below. These priority rankings of the sustainability pillars are comparable to that of Bandara et al. [45] that they discovered in Thailand. Similarly, Bandara et al. [45] found that ranking prioritized environmental sustainability ahead of economic and social sustainability.

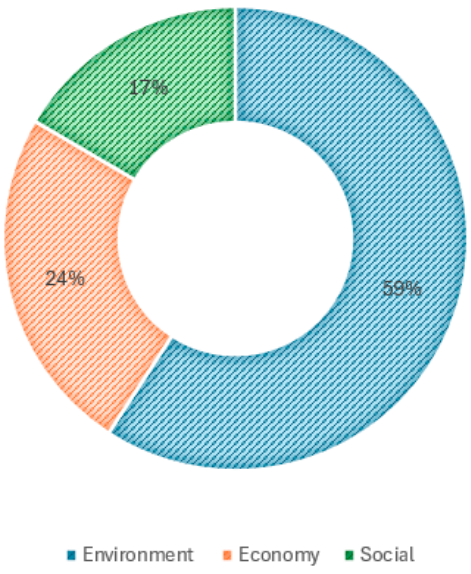

Figure 1. Priority rankings based on criteria.

In essence, this indicates that the indigenous solid waste management practices of BLM communities in the spectrum of sustainability are more skewed towards environmental sustainability in contrast to their counterpart. However, the findings indicate that the waste treatment methods across the indigenous communities of BLM as sub-criteria of environmental sustainability are characterized by spatial variability, as depicted in the priority preferences (Appendix A). This is not surprising given that indigenous knowledge practices are unique and confined to a neighborhood and therefore they are bound to vary in approach [37].

To this end, the AHP model indicates that in as much as the priority correspondence is characterized by variability across the study areas, composting and informal waste collection at a respondent rate of 70% are the waste treatment methods that are frequently prioritized as environmentally sustainable across the rural communities of BLM, as shown in Appendix A. The informal waste collection and composting waste treatment method emerges ahead of the other three alternatives, namely backyard pits, open-air dumping, and burning. In essence, under the environmental criterion, a significant number—as much as 70% of the rural communities of BLM as custodians of indigenous knowledge—recognize composting and informal waste collection as their preferred solid waste treatment methods which have the least negative impact on the environment, thereby associating them with sustainability. The top prioritization of composting is not surprising given that the composting of organic waste is the standard practice in numerous households in developing countries [46]. Furthermore, according to Tanaka [47], this sustainable disposal method is attributed to the advantages of reducing the burden on open landfills, as well as the reduction in waste collection and transportation expenses. This finding is comparable to that of Milutinović et al. (2014) who discovered that the composting of organic waste is the most sustainable practice associated with waste management. Moreover, the neighborhoods of Casteel (25%), Mambumbu (24%), and Acornhoek (30%) were the only neighborhoods in which the composting waste disposal method was ranked as a second priority over informal waste collection (Appendix A: A, F, G).

This discovery is not astounding, as the three neighborhoods are in close proximity to an open waste dump that is facilitated by the Bushbuckridge Local Municipality. Consequently, these communities generate an income by salvaging the valuable refuse material that has been discarded. This is the primary reason why the preference in Mambumbu for open-air dumping is 59%, in Casteel for informal waste collection is 57%, and in Acornhoek for informal waste collection is 51%; these waste disposal methods are prioritized as contributing to environmental sustainability in contrast to composting. However, the environmental sustainability attributes of practices such as open-air dumping are questionable since they are fraught with environmental degradation. Chavan et al. [48] posit that the practices of these neighborhoods are not uncommon, as 50% of the municipal solid waste that is disposed of in open dumps could have been compostable at the place of residence. This makes sense, particularly because even though the current study prioritizes an informal waste collection disposal approach as sustainable, the waste material that is collected ultimately ends up being disposed of at open dump sites, polluting the air as well as water resources in the environment [49].

Furthermore, it is fascinating to observe that the waste management practices of backyard pits and waste burning are at the bottom of the priority hierarchy in numerous indigenous communities of BLM. This indicates that the custodians of indigenous knowledge appear to lack confidence in their environmental sustainability, although waste burning and backyard pits are the bedrock of waste disposal methods associated with solid waste within indigenous communities [50]. Essentially, this is evidence that indigenous communities are generally cognizant of the environmental health risks associated with these practices, i.e., open dumps and waste burning. However, in the absence of formal waste collection methods, such practices continue to be the best practicable environmental options.

2.2. Economic Sustainability of the Indigenous Solid Waste Disposal Methods

In the current study, the pairwise comparison between five economic sustainability sub-criteria, namely waste trading, recycling, waste buttering, reusing, and animal feed, were compared in accordance with Saaty's scale. The pairwise comparison between the economic sustainability sub-criteria was used to derive the decision-making matrix which is further used to calculate the weights of the prioritized economic sustainability elements. In line with the results in Figure 2 below, it is evident that comprehensive prioritization underscores recycling and waste trading as the preeminent solid waste disposal methods associated with the economic benefits in the rural communities of Bushbuckridge Local Municipality. Given the modern approaches to waste reduction and avoidance in waste management in advanced countries around the world, it is evident that recycling is emerging as the preferred method of waste disposal, even in rural villages. The recycling waste treatment methods secured the highest prioritization at 63%, 60%, 56%, 52%, 50%, 38%, and 31% in Casteel, Bushbuckridge, Justicia, Lilydale, Utah, Shatale, and Mambumbu, as shown in Figure 2, respectively. However, waste trading indigenous management methods are prioritized by 65%, 46%, 35%, and 25% in the Mkhuhlu, Shatale, Mambumbu, and Matsikitsane indigenous communities. Usually, these economic sustainability practices accentuate the efficacy of preventing pollution caused by reducing the need to buy new products across rural communities. It is for this reason that waste trading and recycling have a well-balanced performance across the BLM rural communities, as shown in Figure 2 below.

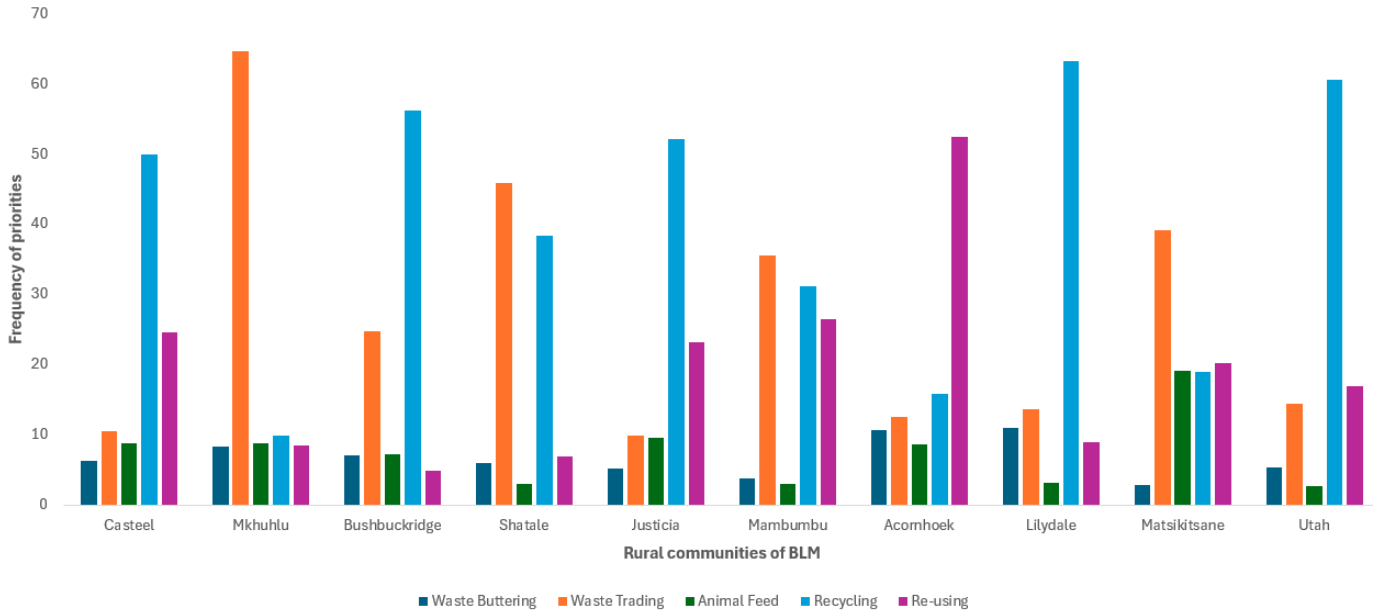

Figure 2. Priority preference of economic sustainability sub-criteria.

Figure 2 depicts that the above practices are the primary contributors to economic sustainability in the indigenous communities of BLM. Given the high rate of unemployment in the rural communities of BLM, the society relies on trading recyclables as a means of livelihood. Hence, waste trading and recycling are perceived as mechanisms that can help alleviate poverty. Thus, after observing the recovery of potentially recyclable materials and their trading in the rural communities of San Quintín, Taboada-González et al. [51] are convinced that waste trading and recycling are prevalent practices associated with generating an income in rural areas. Additionally, this is in line with the premise of Nguyen [52], who accentuates that in recent decades, waste trading and recycling have emerged as one of the fundamental sources of livelihood for millions of people around the globe, especially within the indigenous communities. This is in response to a global waste trade that has been experiencing a significant increase in association with the increasing demand for recyclable materials in developing industrial nations.

Lastly, following closely behind recycling and waste trading, is reusing, found across the Acornhoek (52%), Mambumbu (27%), Casteel (25%), Justicia (23%), Matsikitsane (20%), and Utah (17%) neighborhoods.

However, considering the economic quagmires faced by rural communities, it is logical that the reuse of waste material is prioritized after waste trading and recycling, which are more closely tied to financial gains, whilst reusing is associated with efficient resource management, which in this context can result in minimizing spending for economically marginalized indigenous communities. The prioritized reusing practice corresponds with the findings of Kalina et al. [53] regarding the widespread and diverse patterns of reuse amongst African indigenous communities. Likewise, Siragusa and Arzyutov [54] corroborate that indigenous communities have always prioritized the creative and sustainable appropriation reuse modality of waste material. It is for this reason that indigenous communities are often perceived as models of sustainability, although the indigenous patterns of reuse may not necessarily conform to Western notions of reuse [53]. Therefore, the nuanced priority preferences associated with the economic sustainability prioritized in accordance with Saaty's scale provide a comprehensive understanding of the relative merits of each indigenous solid waste management practice, thereby providing valuable insights for local government and policymakers in the formulation of well-coordinated waste disposal programs that are consistent with the current economic sustainable strategies of the indigenous communities.

2.3. Frequency Respondents on the Social Sustainability Pairwise Comparisons of Indigenous Solid Waste Management Practices

This section presents the percentage of community members who gave responses to their preferred indigenous solid waste treatment method which have elements of social coherence. The custodians of indigenous solid waste disposal methods respondents selected the best treatment method between communal labor and the influence of taboos as a mechanism to advance solid waste management. Thus, Figure 3 presents the frequency rates of the responses. In line with the acquired data, it is evident that the respondents preferred each of the solid waste treatment methods at different scales and none of the respondents regarded the solid waste management methods as being of equal importance. The frequency of responses in the overall areas studied in Bushbuckridge Municipality indicated that respondents observed the communal cleaning methods of waste treatment to be of very strong importance and extremely important at a respondent rate of 10% and 60%, respectively. This highlights the collective effort and responsibility in maintaining a clean and healthy environment. This communal approach not only ensures efficient waste management but also strengthens social cohesion and fosters a sense of ownership, unity, and belonging. The convenience of communal labor as a solid waste treatment method is common amongst indigenous communities. To this end, Kosoe et al. [55] have recently recorded communal cleaning as one of the prioritized indigenous solid waste management practices within the Jaman South Municipality in Ghana.

Meanwhile, in the other observations, 10% of the respondents regarded communal cleaning as of moderate importance as depicted in Figure 3. On the other hand, taboos were selected equally as of extreme and very strong importance, but only at a respondent rate of 10%. These taboos are often rooted in cultural and spiritual beliefs and facilitate behavior and promote environmental protection, although they are less emphasized in the present study compared to communal cleaning. This is concerning because it essentially indicates that most of the indigenous communities in the Bushbuckridge Local Municipality are beginning to doubt the viability of taboos as a way of advancing solid waste management. In the indigenous communities of BLM, this knowledge of taboos is therefore at risk of extinction. This discovery is in stark contrast to that of a Zimbabwean community that has discovered that taboos continue to play a significant and effective role in the management of solid waste within indigenous communities [56].

Moreover, in contrast to the rural communities of BLM, Kosoe [55] posits that indigenous communities in Jaman South Municipality in Ghana continue to believe in the implementation of taboos to manage solid waste disposal. However, a decline in the belief of taboos as a socially sustainable mechanism to advance solid waste management has implications. It spells a loss of cultural heritage, thus eroding the fabric of their unique identity as well as the traditions of BLM society. The erosion of taboos as sustainable practices from the indigenous communities of BLM risks a paradigm shift from sustainable solid waste management practices that advance living in harmony with the environment. This has the potential to result in environmental degradation in the future, as taboos serve as informal pollution deterrents that safeguard the natural environment.

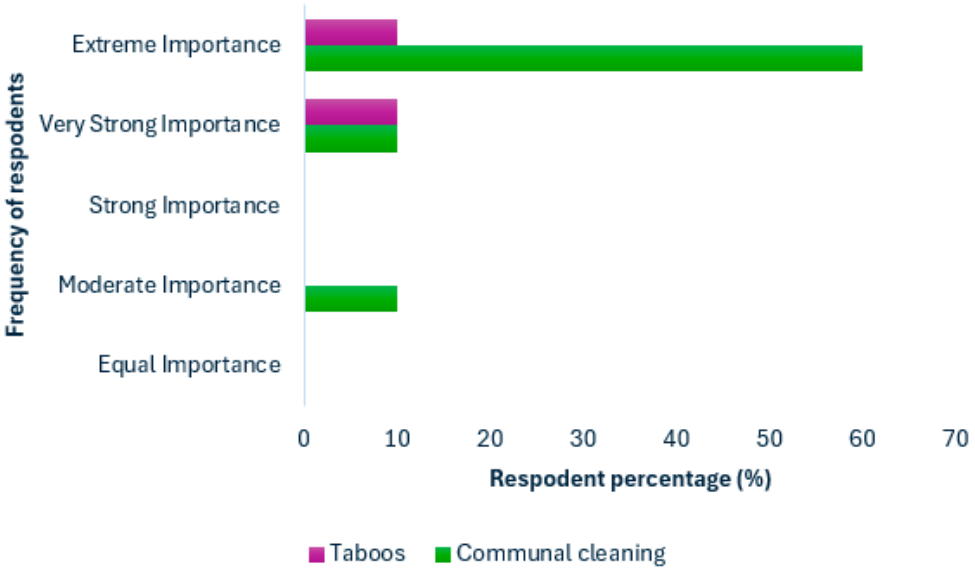

Figure 3. Indigenous waste management practices associated with social sustainability.

3. Materials and Methods

3.1. Description of the Study Area

Bushbuckridge Local Municipality (BLM), a category B municipality founded in 2000, served as the study's location [23]. A category B municipality is a local government that, among other things, is required by the constitution to provide solid waste municipal services [57]. However, to date, the only available waste management infrastructure provided by the municipality is a designated dumping site area in the three rural communities of Mambumbu, Casteel, and Acornhoek (Figure 4). The selection of BLM in the current study, which aims to document the indigenous waste management techniques in numerous study locations as seen in Figure 4, is therefore justified by its high cultural diversity status and the lack of waste management services provided by the local authority. The municipality is a prime example of a rural local government authority facing several issues, including high rates of unemployment, a high percentage of the population lacking a high school education (67.4%), a backlog in the provision of waste removal services, and inadequate access to basic services [23]. Consequently, BLM has a 52% unemployment rate and a 93% backlog in the collection of waste, according to Statistic South Africa [23]. There is a 93% backlog in waste collection since the BLM only picks up 7% of refuse waste [23]. More than 70% of people do not have access to services for collecting waste. Despite these difficulties, BLM is among the most linguistically and culturally diverse municipalities in South Africa [58]. Because of their varied cultural histories, distinct ethnic and linguistic groups may have different indigenous knowledge and practices of waste management.

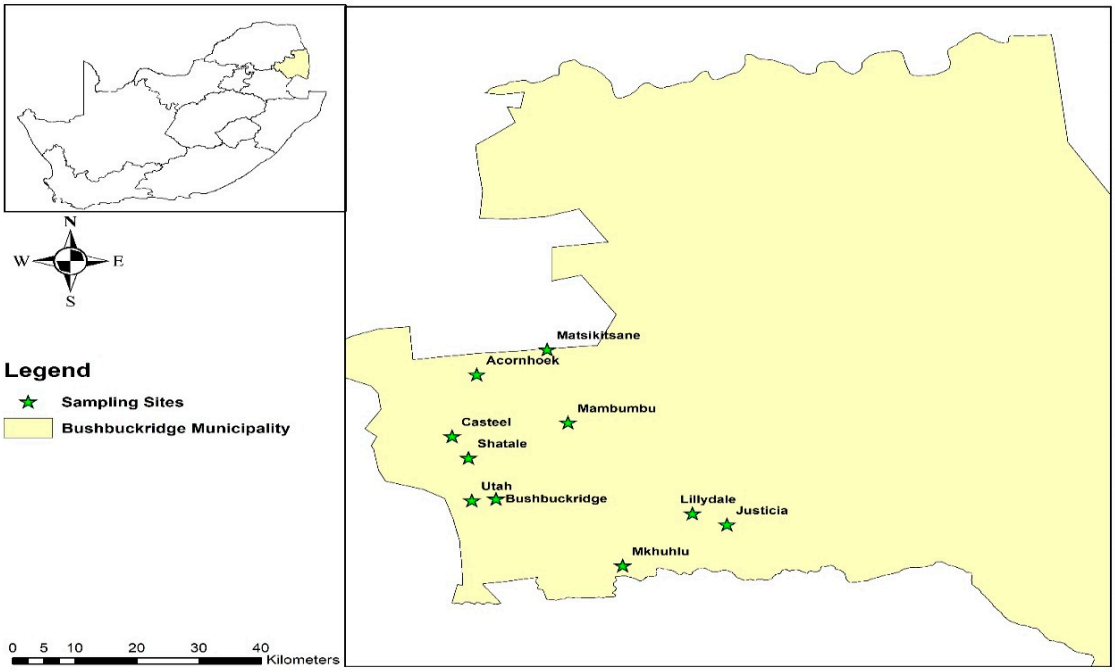

Figure 4. Map of Bushbuckridge Local Municipality showing indigenous communities sampled in Mpumalanga province, South Africa.

The municipality consists of the two former administrations of the apartheid homelands, Gazankulu and Lebowa, which were partitioned historically based on ethnic groupings [59]. According to Maluka [60] Gazankulu was reserved entirely for the Shangaan and/or Tsongas-speaking tribe, whereas Lebowa was home only to Mapulana-speaking individuals. Thus, the three notable native populations of BLM are the Mapulana tribe, who speak the dialect of the Sepedi-speaking tribe, Vatsonga, and AmaSwati [60].

3.2. Data Collection Methods

3.2.1. Focus Group Discussion

In the initial phase of data collection, focus group discussions were employed as the fundamental method of data collection for gathering the indigenous waste management practices of the Bushbuckridge rural communities. A focus group is a group of four to twelve individuals who convene under the supervision of a facilitator to discuss a specific topic, as defined by Sim and Waterfield [61]. The adoption of focus group discussion in BLM was encouraged by the ability of the method to facilitate an atmosphere that is conducive to reflecting and sharing a wealth of community information at a deeper level. As Crang and Cook [62] elaborate, focus group discussions provide an opportunity for participants to reconcile conflicting viewpoints and produce collective knowledge of the community.

In the current study, a total of ten focus group discussions were conducted with one category of key informants: the environmental organizations of every study area, as shown in Figure 4. The selection of focus groups in this research study was consistent with the concept of sampling units [63,64]. In BLM, the sampling units were members of the population from which data were gathered. This sampling unit is like the one employed by Mwai et al. [65]. The Bushbuckridge Local Municipality was used as the gateway to the indigenous communities (Figure 4). Therefore, the database that comprised all environmental organizations within the jurisdiction was requested from the Bushbuckridge Local Municipality. The database contained the names of the contact details as well as the geographical location of the environmental organizations registered with the Bushbuckridge Local Municipality. The Google Earth map was used to select cases that would capture the spatial cultural diversity of indigenous communities. Subsequently, the indigenous communities of BLM were classified into strata based on the Google Earth map. The purpo-

sive non-probability sampling technique was employed to sample the environmental focus groups of interest from the designated strata of indigenous communities. The focus groups were chosen based on being purposive [32]. The sample size of the study population in Bushbuckridge was determined using Slovin's formula as prescribed by Dalasile et al. [66] to determine the sample size, as presented below:

$$n = \frac{\mathrm{N}}{1 + \mathrm{N}e^2}$$

This formula guarantees a 95% confidence interval with a margin error of 0.05%. n denotes a sample size, N = total population, and e = 0.05%.

Moreover, the focus group discussions were recorded using a Digital Voice Recorder device. It was important to carry out the single focus group discussions before drafting the structured questionnaires to discover relevant indigenous waste management practices that could be used to inform the line of questions in the Analytic Hierarchy Process. This process was deemed essential for establishing the sustainability aspect associated with indigenous solid waste management practices. Additionally, this approach was important for realizing the transition of researching from an indigenous perspective [23], especially since the current study employed the interpretive paradigm that sought to describe and understand the sustainability practices of indigenous solid waste management within the Bushbuckridge rural communities without imposing external viewpoints.

3.2.2. Structured Questionnaire

In the second phase of data collection, having established the indigenous solid waste management practices, a structured questionnaire was created and utilized to inform the line of questions instrumental for the establishment of the Analytic Hierarchy Process. AHP was considered crucial in establishing the sustainability aspect of indigenous solid waste management practices. In this regard, the focus groups were requested to answer all sustainability-related questions associated with the main criteria of environment, economy, and social aspects of the indigenous solid waste management practices. The questionnaire required respondents to indicate their judgment using Saaty's scale of 1 to 9, as shown in Table 1.

3.2.3. Validity and Reliability

To ensure compliance with the validity of the collected data, the focus groups were reminded about the objectives of the focus group discussion and the questionnaire. The points of discussion as well as the questionnaire for the focus groups were reviewed and approved by experts in the discipline of waste management prior to their use in the field. Furthermore, before being administered in the field (pretests), the questionnaire and the points of discussion were administered to a group of six people to assess how participants would approach the discussion. In this instance, the feedback from the small group assisted the researcher to accordingly adjust the points of discussion and the questionnaires. These points were administered to the participants on two occasions within a three-week interval to determine validity. The intervals between testing and retesting were prolonged to prevent participants from memorizing the questionnaire as well as the broad discussion responses. The results were compared with the previous findings to establish validity. However, to ascertain the reliability of the discussion outcome, Cronbach's alpha was calculated. An acceptable satisfactory Cronbach's alpha of 0.76 was obtained from the pilot study, while for the AHP model, the consistency ratio was below 0.10 (10%), indicating that the judgements were consistent and reliable.

3.3. Ranking of Sustainability Aspects

The sustainability aspects were compared in pairs using Saaty's scale, ranging from 1 to 9 to create a priority rating. Table 1 contains a sample of a questionnaire that was administered to the indigenous experts who were carrying out the rating process. For

example, when the number "3" is selected in the first row, the recycling practice of indigenous waste management becomes highly significant for the sustainability of waste management in BLM. This is based on expert opinion (indigenous communities), emphasizing the economic efficacy associated with the indigenous solid waste management. On the other hand, selecting "9" in the second row indicates that waste trading holds considerably extreme importance for the economic sustainability of indigenous communities compared to reusing waste materials.

3.4. Analytic Hierarchy Process

The utility of the AHP model in the current study followed four fundamental phases that constitute the process as prescribed by Saaty [39]:

- Define the objective

In this instance, the goal, which was to assess the sustainability of indigenous solid waste management practices, was defined.

- Structure the elements in criteria, sub-criteria, and alternatives.

The elements that are important for evaluating the sustainability of the waste disposal methods were identified and put in a hierarchy, as illustrated in Figure 5. These criteria included the environmental aspect and social aspects as well as the economic viability of the indigenous waste management practices. This part structures the hierarchy by identifying the elements or variables. In this phase, the decomposition of complex issues into smaller, more manageable sub-problems transpired.

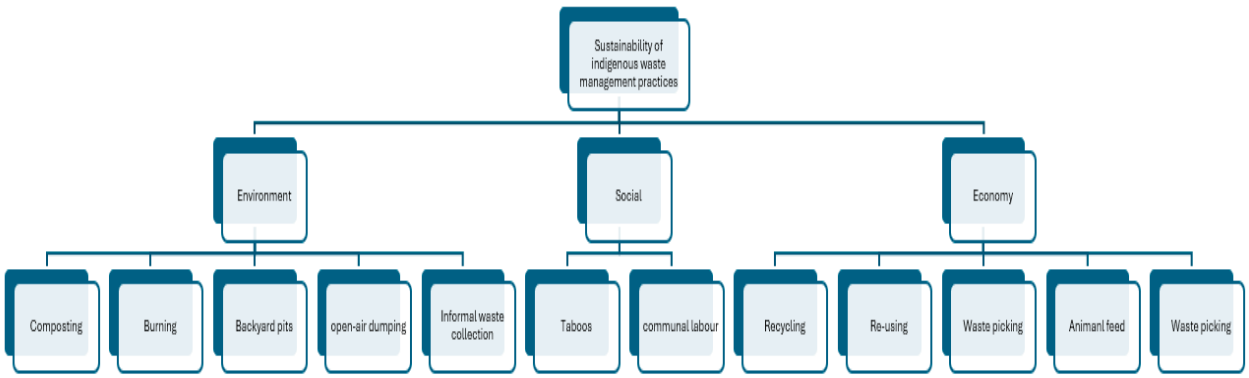

Figure 5. A simple AHP model for sustainability of indigenous waste management practices in BLM.

- Perform a pairwise comparison of elements in each group

A pairwise comparison was made between each criterion to determine their relative importance. These contrasts measured how important each component or variable was in relation to the others.

- Calculate weighing and consistency ratio (CR)

The pairwise comparison results were used to calculate the priority weights for each criterion. In this instance, the matrix consistency was calculated, and numerous required adjustments were implemented to obtain a satisfactory consistency:

i. Determine the eigenvector that corresponds to the highest eigenvalue of the pairwise comparison matrix;
ii. Specify the weight between each criterion and that in its upper level;
iii. Determine the overall ranking weight between each criterion and the goal;
iv. Subsequently conclude in accordance with the consistency test premise.

The consistency ratio and weighing calculation procedure were adopted from Saaty [39]. As such, Saaty [39] prescribed the following procedure for calculating these parameters:

i. Calculate CI, which stands for the consistency index. λmax is the maximum eigenvalue of the pairwise comparison matrix, n is the size of a matrix;
ii. $CI = \frac{\lambda max' - n}{n-1}$
iii. Find the corresponding RI, which stands for the random index, from the existing average consistencies (Table 3) of random matrices created by Saaty [39]:

i. Calculate CR, which stands for the consistency ratio

$$CR = \frac{CI}{RI}$$

If CR < 0.10, the consistency of the matrix is tolerant, otherwise the matrix should be modified. Therefore, due to the complex process of assessing the sustainability of indigenous solid waste disposal methods, the current study resorted to a mixed methods approach, as shown in Table 4. This was carried out in an attempt to comprehend the complex sustainability aspects of indigenous solid waste management associated with the environmental, social, and economic implications.

Table 4. Summary of method(s) and instrument(s) used for data collection.

Method (s)	Instrument (s)	Type of Data Collected
Focus group AHP	Audio Voice Recorder Questionnaire	• Indigenous solid waste disposal methods of Bushbuckridge rural communities • Sustainability practices of indigenous solid waste management methods

3.5. Data Analysis

The current study used mixed analysis techniques to analyze the qualitative data collected in the rural communities of BLM. Given the predominant qualitative nature of the focus group research data that were collected from BLM, the current study mostly used qualitative coding to analyze the in-depth discussion data from BLM communities. To identify, organize, and categorize themes within the datasets of the current study, thematic analysis was employed to analyze focus group discussions. The thematic analysis process was combined with inductive logic. Analysis was iterative and reflexive, proceeding through phases. As such, the coding framework was developed based on the themes that emerged from the focus group discussion data. The analysis then proceeded via an inductive and iterative process of listening, reflecting, and coding, and as new themes emerged, the coding framework was progressively expanded. This analysis process has been published in detail elsewhere [32]. The data of the focus group were captured and analyzed using Microsoft Excel 2019, whilst the AHP dataset was similarly computed using Microsoft Excel 2019 but was analyzed using the AHP Priority calculator software.

4. Conclusions

Given the extensive research gap in the literature regarding the sustainability aspects of indigenous solid waste disposal methods, utilizing an Analytic Hierarchy Process model, the current study systematically evaluated the environmental, social, and economic sustainability aspects of indigenous waste management practices in the rural communities of South Africa. Using the AHP evaluative framework, it was discovered that indigenous communities prioritize environmental sustainability (weight: 0.590), followed by economic (weight: 0.240), and social sustainability (weight: 0.165). The highest priority sub-criteria of environmental sustainability are composting at a response rate of over 70%. Similarly, the sub-criterion of social sustainability, which is associated with communal cleaning labor (60%), was found to be of extreme importance, outperforming taboos (10%) that are anchored in cultural and spiritual beliefs, while with a response rate >50%, waste trading proved to be of economic efficacy. This research innovatively introduces an AHP model

into the discipline of indigenous solid waste management, which offers a comprehensive understanding of indigenous waste disposal methods relative to sustainability, thus providing valuable understanding for local government and policymakers in formulating well-coordinated waste disposal methods programs in line with the current established sustainable approaches of the indigenous communities. Incorporating indigenous practices into formal waste management plans offers local governments an opportunity to build more sustainable and community-driven approaches towards waste management. To achieve this, it is necessary to involve indigenous leaders and community members in the integrated development plans of the municipality to ensure that their expertise and skills are prioritized. However, future research should be streamlined to investigate how indigenous waste management practices can be better integrated into formal waste management systems. Moreover, research could be maximized to merge indigenous knowledge with modern technologies, evaluating how this integration could improve sustainability and efficiency in rural waste management. Lastly, the findings of the present study contribute to the discourse on the contribution of indigenous solid waste management practices to sustainable development, thereby presenting evidence-based findings that can facilitate a robust discourse on the inclusion of indigenous waste disposal methods in the integrated waste plans of the local authority.

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Data Availability Statement: Data is available from the corresponding author upon reasonable request.

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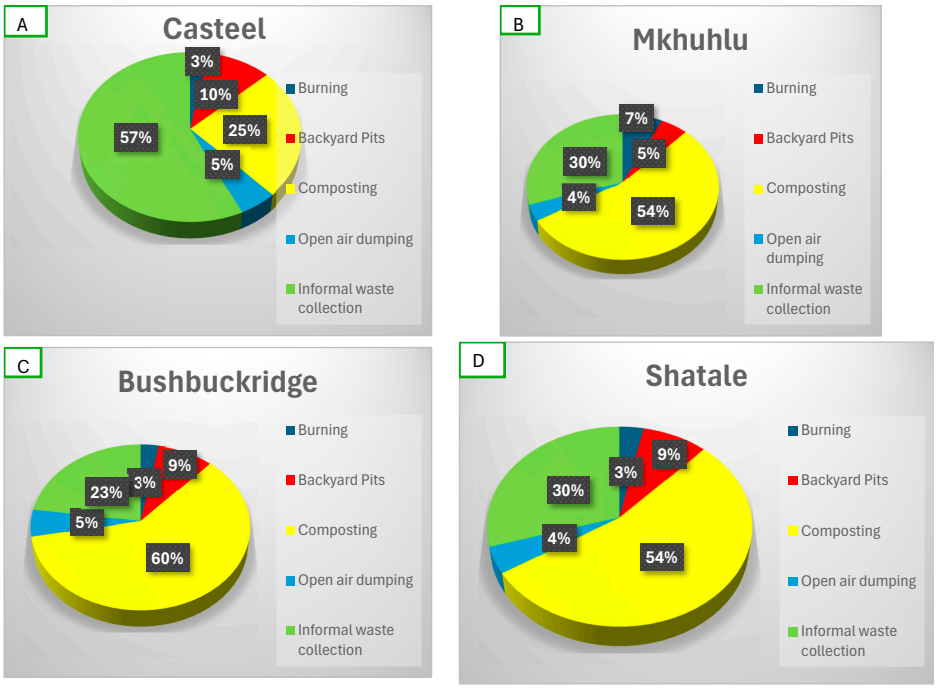
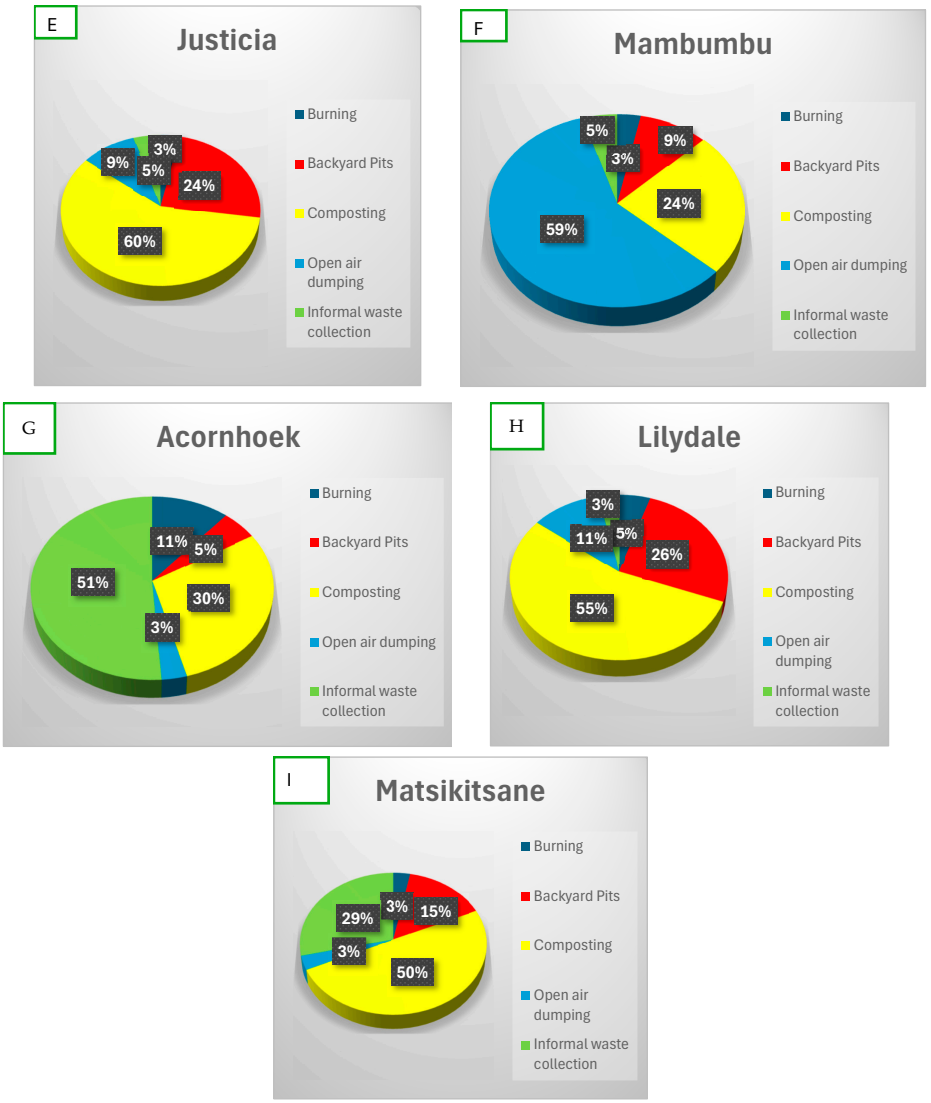
Conflicts of Interest: The authors declare no conflict of interest.

Appendix A





References

1. Ndlovu, M. Why indigenous knowledges in the 21st century? A decolonial turn. *Yesterday Today* **2014**, *11*, 84–98.
2. Grangxabe, X.S.; Madonsela, B.S.; Maphanga, T.; Gqomfa, B.; Phungela, T.T.; Malakane, K.C. An overview of waste management practices of street vendors in Sub-Saharan Africa: A meta-analysis. *J. Environ. Manag.* **2024**, *364*, 121464. [CrossRef]
3. Jakeni, Y.; Maphanga, T.; Madonsela, B.S.; Malakane, K.C. Identification of Illegal Dumping and Community Views in Informal Settlements, Cape Town: South Africa. *Sustainability* **2024**, *16*, 1429. [CrossRef]
4. Izugbara, C.O.; Umoh, J.O. Indigenous waste management practices among the Ngwa of Southeastern Nigeria: Some lessons and policy implications. *Environmentalist* **2004**, *24*, 87–92. [CrossRef]
5. Oyegunle, A.; Thompson, S. Wasting indigenous communities: A case study with garden hill and Wasagamack First Nations in Northern Manitoba, Canada. *J. Solid Waste Technol. Manag.* **2018**, *44*, 232–247. [CrossRef]
6. Assuah, A. Examining the Role of and Potential for Indigenous and Social Learning Through Community-Based Solid Waste Management in Canadian First Nation Communities. Ph.D. Thesis, University of Manitoba, Winnipeg, MB, Canada, 2020.
7. Ajibade, L.T. Indigenous knowledge system of waste management in Nigeria. *Indian J. Tradit. Know.* **2007**, *6*, 642–647. Available online: https://www.scribd.com/document/640898587/Untitled (accessed on 2 April 2024).
8. Fruitema, M.L. A Political Ecology of Solid Waste Management in Niadub, Panama. Doctoral Dissertation, University of Miami, Coral Gables, FL, USA, 2015.
9. Hamzah, A.H.P.; Anggoro, S.; Puryono, S. Solid waste management in coastal communities based on local wisdom "Meresik" in Tapak Kuda Village, the District of Tanjung Pura, Langkat. *Pros. ESEC* **2020**, *1*, 121–132.
10. Asomani-Boateng, R. Local Networks: Commodity Queens and the Management of Organic Solid Waste in Indigenous Open-Air Markets in Accra, Ghana. *J. Plan. Educ. Res.* **2016**, *36*, 182–194. [CrossRef]
11. Clark, N. Aboriginal cosmopolitanism. *Int. J. Urban Reg. Res.* **2008**, *32*, 737–744. [CrossRef]

12. Guran, S. Options to feed plastic waste back into the manufacturing industry to achieve a circular carbon economy. *AIMS Environ. Sci.* **2019**, *6*, 341–355. [CrossRef]
13. Hart, T.; Vorster, I. *Indigenous Knowledge on the South African Landscape: Potentials for Agricultural Development (No. 1)*; HSRC Press: Pretoria, South Africa, 2006.
14. Naidoo, N.; Longondjo, C.; Vrdoljak, M. Investigating Operational Indigenous Knowledge of Water and Waste Management and Establishing Ways to Integrate Them into Water Services Management. 2013. Available online: https://www.wrc.org.za/wp-content/uploads/mdocs/1941-1-131.pdf (accessed on 22 May 2023).
15. Tengö, M.; Hill, R.; Malmer, P.; Raymond, C.M.; Spierenburg, M.; Danielsen, F.; Elmqvist, T.; Folke, C. Weaving knowledge systems in IPBES, CBD and beyond—Lessons learned for sustainability. *Curr. Opin. Environ. Sustain.* **2017**, *26*, 17–25. [CrossRef]
16. Smith, L.T. *Decolonizing Methodologies: Research and Indigenous Peoples*; Bloomsbury Publishing: London, UK, 2021.
17. Baloyi, T.M.; Maphanga, T.; Madonsela, B.S.; Mongwe, Q.G.; Malakane, K.C.; Grangxabe, X.S.; Gqomfa, B. Indigenous Strategies for Managing Bush Encroachment in Rural Areas of South Africa. *Challenges* **2024**, *15*, 33. [CrossRef]
18. Madonsela, B.S.; Machete, M. A systematic review of Indigenous knowledge in global contexts. *Diaspora Indig. Minor. Educ.* **2023**, 1–7. [CrossRef]
19. Tran, M.; Salamanca, A. *Advancing Climate Policy: Harnessing Indigenous Knowledge at the Science-Policy Interface*; Stockholm Environment Institute: Stockholm, Sweden, 2022.
20. Chidi, B.S.; Okudoh, V.I.; Hutchinson, U.F.; Ngongang, M.M.; Maphanga, T.; Madonsela, B.S.; Shale, K.; Lim, J.W.; Ntwampe, S.K.O. A Perspective on Emerging Inter-Disciplinary Solutions for the Sustainable Management of Food Waste. *Appl. Sci.* **2022**, *12*, 11399. [CrossRef]
21. Grangxabe, X.S.; Maphanga, T.; Madonsela, B.S.; Gqomfa, B.; Phungela, T.T.; Malakane, K.C.; Thamaga, K.H.; Angwenyi, D. The escalation of Informal Settlement and the high levels of illegal dumping post-apartheid: Systematic review. *Challenges* **2023**, *14*, 38. [CrossRef]
22. Maphanga, T.; Madonsela, B.S. Evaluating waste management practices of street vendors in the informal settlement of Cape Town: A case study of Khayelitsha. *Anthropog. Pollut.* **2023**, *7*, 1–11.
23. Madonsela, B.S.; Machete, M.; Shale, K. Indigenous Knowledge Systems of Solid Waste Management in Bushbuckridge Rural Communities, South Africa. *Waste* **2024**, *2*, 293–311. [CrossRef]
24. Mazzocchi, F. A deeper meaning of sustainability: Insights from indigenous knowledge. *Anthr. Rev.* **2020**, *7*, 77–93. [CrossRef]
25. Soni, A.; Das, P.K.; Hashmi, A.W.; Yusuf, M.; Kamyab, H.; Chelliapan, S. Challenges and opportunities of utilizing municipal solid waste as alternative building materials for sustainable development goals: A review. *Sustain. Chem. Pharm.* **2022**, *27*, 100706. [CrossRef]
26. Mandpe, A.; Paliya, S.; Gedam, V.V.; Patel, S.; Tyagi, L.; Kumar, S. Circular economy approach for sustainable solid waste management: A developing economy perspective. *Waste Manag. Res.* **2023**, *41*, 499–511. [CrossRef]
27. Awino, F.B.; Apitz, S.E. Solid waste management in the context of the waste hierarchy and circular economy frameworks: An international critical review. *Integr. Environ. Assess. Manag.* **2024**, *20*, 9–35. [CrossRef] [PubMed]
28. Tsydenova, N.; Vázquez Morillas, A.; Cruz Salas, A.A. Sustainability assessment of waste management system for Mexico city (Mexico)—Based on analytic hierarchy process. *Recycling* **2018**, *3*, 45. [CrossRef]
29. McBride, A.C.; Dale, V.H.; Baskaran, L.M.; Downing, M.E.; Eaton, L.M.; Efroymson, R.A.; Garten, C.T., Jr.; Kline, K.L.; Jager, H.I.; Mulholland, P.J.; et al. Indicators to support environmental sustainability of bioenergy systems. *Ecol. Indic.* **2011**, *11*, 1277–1289. [CrossRef]
30. Chong, Y.T.; Teo, K.M.; Tang, L.C. A lifecycle-based sustainability indicator framework for waste-to-energy systems and a proposed metric of sustainability. *Renew. Sustain. Energy Rev.* **2016**, *56*, 797–809. [CrossRef]
31. Lakiotia, E.N.; Moustakas, K.G.; Komilisc, D.P.; Domopouloua, A.E.; Karayannisa, V.G. Sustainable solid waste management: Socio-economic considerations. *Chem. Eng.* **2017**, *56*, 661–666.
32. Madonsela, B.S.; Semenya, K.; Shale, K. A review of indigenous knowledge systems and their application in sustainable solid waste management. *World* **2024**, *5*, 219–239. [CrossRef]
33. Simpson, L.R. Anticolonial strategies for the recovery and maintenance of Indigenous knowledge. *Am. Indian Q.* **2004**, *28*, 373–384. [CrossRef]
34. Grangxabe, X.S.; Maphanga, T.; Madonsela, B.S. Public participation on waste management between nature reserves and surrounding informal settlement: A review. *J. Air Waste Manag. Assoc.* **2023**, *73*, 589–599. [CrossRef]
35. Magni, G. Indigenous knowledge and implications for the sustainable development agenda. *Eur. J. Educ.* **2017**, *52*, 437–447. [CrossRef]
36. Hosen, N.; Nakamura, H.; Hamzah, A. Adaptation to climate change: Does traditional ecological knowledge hold the key? *Sustainability* **2020**, *12*, 676. [CrossRef]
37. Zidny, R.; Sjöström, J.; Eilks, I. A multi-perspective reflection on how indigenous knowledge and related ideas can improve science education for sustainability. *Sci. Educ.* **2020**, *29*, 145–185. [CrossRef]
38. Das, M.; Das, A.; Seikh, S.; Pandey, R. Nexus between indigenous ecological knowledge and ecosystem services: A socio-ecological analysis for sustainable ecosystem management. *Environ. Sci. Pollut. Res.* **2022**, *29*, 61561–61578. [CrossRef] [PubMed]
39. Saaty, T.L. Decision making with the analytic hierarchy process. *Int. J. Serv. Sci.* **2008**, *1*, 83. [CrossRef]

40. Aruldoss, M.; Lakshmi, T.M.; Venkatesan, V.P. A survey on multi criteria decision making methods and its applications. *Am. J. Inf. Syst.* **2013**, *1*, 31–43.
41. Goyal, P.; Rahman, Z.; Kazmi, A.A. Identification and prioritization of corporate sustainability practices using analytical hierarchy process. *J. Model. Manag.* **2015**, *10*, 23–49. [CrossRef]
42. Ho, W.; Ma, X. The state-of-the-art integrations and applications of the analytic hierarchy process. *Eur. J. Oper. Res.* **2018**, *267*, 399–414. [CrossRef]
43. Noble, B.F. Strategic environmental assessment quality assurance: Evaluating and improving the consistency of judgments in assessment panels. *Environ. Impact Assess. Rev.* **2004**, *24*, 3–25. [CrossRef]
44. Brent, A.C.; Rogers, D.E.; Ramabitsa-Siimane, T.S.; Rohwer, M.B. Application of the analytical hierarchy process to establish health care waste management systems that minimise infection risks in developing countries. *Eur. J. Oper. Res.* **2007**, *181*, 403–424. [CrossRef]
45. Bandara, S.; Chaichana, C.; Borirak, N. Assessing the Sustainability of Broiler Waste Management Strategies in Thailand through Analytical Hierarchy Process Analysis. *Int. J. Food Agric. Nat. Resour.* **2024**, *5*, 128–136. [CrossRef]
46. Takahashi, Y.; Nomura, H.; Yabe, M. Modeling home composting behavior toward sustainable municipal organic waste management at the source in developing countries. *Resour. Conserv. Recycl.* **2019**, *140*, 65–71.
47. Tanaka, M. Waste management for a sustainable society. *J. Mater. Cycles Waste Manag.* **2007**, *9*, 2–6. [CrossRef]
48. Chavan, D.; Arya, S.; Kumar, S. Open dumping of organic waste: Associated fire, environmental pollution and health hazards. In *Advanced Organic Waste Management*; Elsevier: Amsterdam, The Netherlands, 2022; pp. 15–31.
49. Siddiqua, A.; Hahladakis, J.N.; Al-Attiya, W.A.K. An overview of the environmental pollution and health effects associated with waste landfilling and open dumping. *Environ. Sci. Pollut. Res.* **2022**, *29*, 58514–58536. [CrossRef]
50. Famo, M. Documentation of Indigenous Methods of Waste Management in Chief Albert Luthuli Municipality, Republic of South Africa. Master's Thesis, University of South Africa, Pretoria, South Africa, 2023. Available online: https://uir.unisa.ac.za/handle/10500/30686 (accessed on 19 July 2024).
51. Taboada-González, P.; Armijo-de-Vega, C.; Aguilar-Virgen, Q.; Ojeda-Benítez, S. Household solid waste characteristics and management in rural communities. *Open Waste Manag. J.* **2010**, *3*, 167–173. [CrossRef]
52. Nguyen, M.T. Trading in broken things: Gendered performances and spatial practices in a northern Vietnamese rural-urban waste economy. *Am. Ethnol.* **2016**, *43*, 116–129. [CrossRef]
53. Kalina, M.; Ngcoya, M.; Nkhoma, B.; Tilley, E. Conceptualising reuse in African households: Perspectives from Chembe, Malawi. *Environ. Dev. Sustain.* **2021**, *24*, 12404–12426. [CrossRef]
54. Siragusa, L.; Arzyutov, D. Nothing goes to waste: Sustainable practices of re-use among indigenous groups in the Russian North. *Curr. Opin. Environ. Sustain.* **2020**, *43*, 41–48. [CrossRef]
55. Kosoe, E.A.; Diawuo, F.; Osumanu, I.K. Looking into the past: Rethinking traditional ways of solid waste management in the Jaman South Municipality, Ghana. *Ghana J. Geogr.* **2019**, *11*, 228–244.
56. Konyana, E.G.; Konyana, S. From taboos to ecological wisdom: Ndau women's indigenous practices on menstrual waste management. *Afr. Thought J. Afro-Centric Knowl.* **2021**, *1*, 34–48.
57. Rankwana, E.M. The Influence of the Transformation of Local Government on Service Delivery in Category B Municipalities in the Eastern Cape. Doctoral Dissertation, University of the Free State, Bloemfontein, South Africa, 2004.
58. Sibuye, R.; Uys, M.; Cocciaro, G.; Lorenzen, J. The Bushbuckridge BCP: Traditional health practitioners organise for ABS in South Africa. *Particip. Learn. Action* **2012**, *65*, 101–108.
59. Thornton, R. Environment and land in Bushbuckridge, South Africa. In *Human Rights and the Environment*; Routledge: London, UK, 2012; pp. 229–250.
60. Mathebula, J.H. Determinants of Household Participation in Agricultural Production in Shatale Region of the Bushbuckridge Local Municipality, Mpumalanga Province. Doctoral Dissertation, University of Limpopo, Polokwane, South Africa, 2015.
61. Sim, J.; Waterfield, J. Focus group methodology: Some ethical challenges. *Qual. Quant.* **2019**, *53*, 3003–3022. [CrossRef]
62. Crang, M.; Cook, I. *Doing Etnographies*; Sage Publications Ltd.: London, UK, 2007. [CrossRef]
63. Acharya, A.S.; Prakash, A.; Saxena, P.; Nigam, A. Sampling: Why and how of it. *Indian J. Med. Sci.* **2013**, *4*, 330–333. [CrossRef]
64. Kabir, S.M.S. Basic guidelines for research. In *An Introductory Approach for All Discipline*; Book Zone Publication: Chittagong, Bangladesh, 2016; Volume 4, pp. 168–180.
65. Mwai, G.M.; Namada, J.M.; Katuse, P. Influence of organizational resources on organizational effectiveness. *Am. J. Ind. Bus. Manag.* **2018**, *8*, 1634–1656. [CrossRef]
66. Dalasile, S.; Itoba Tombo, E.; Madonsela, B.S.; Mpungose, P.P.; Mshicileli, N.; Menziwa, M. Alcohol-Based Hand Sanitizers Used for COVID-19 Prevention in the Informal Settlements of Cape Town, South Africa. *COVID* **2024**, *4*, 1655–1675. [CrossRef]