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Sand as a catalyst for community innovation and sustainable development in Ezakheleni informal settlement, Umlazi, South Africa: A cross-sectional study.

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Abstract

Background
The use of natural resources, such as sand, is traditionally associated with large-scale industries like construction and manufacturing. However, its potential to drive local business innovation and sustainable development remains underexplored, particularly within South Africa's pursuit of the Sustainable Development Goals (SDGs). This study aimed to investigate how sand-based entrepreneurship can promote community-driven sustainable development and contribute to achieving SDG-aligned outcomes.

Methods
A mixed-methods approach was adopted. Qualitative data were gathered through in-depth interviews with 45 local entrepreneurs and community leaders across four South African provinces. Quantitative data were obtained by analysing 60 sand-based business ventures, focusing on income generation, employment creation, and contribution to SDG targets. Data were analysed using thematic analysis for qualitative findings and descriptive statistics for quantitative data.

Results
Quantitative findings showed that 67% of the businesses reported income growth of over 30% within two years of operation, while 58% generated permanent employment for 3 to 7 local workers per venture. Additionally, 72% of the businesses reported alignment with SDG 9 (Industry, Innovation, and Infrastructure), and 64% supported SDG 12 (Responsible Consumption and Production). Qualitative insights revealed that integrating traditional knowledge with eco-friendly innovation enhanced both resilience and market appeal. Community participants reported that such ventures contributed not only to income but also to broader social cohesion and local empowerment.

Conclusion
When utilized through innovative and sustainable approaches, sand-based community enterprises can significantly advance local economic development and contribute to South Africa's SDG commitments.

Recommendations
Policymakers should support sand-based entrepreneurship through funding, training, and regulatory frameworks that promote sustainable resource use. Partnerships between government, academia, and communities are essential to unlocking the full potential of natural resources for inclusive development.

Keywords*: Sand usage, local business innovation, Sustainable Development Goals, Community entrepreneurship, Sustainable development, South Africa*
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Background information

The exploitation of natural resources has historically underpinned global economic development, with sand emerging as one of the most extracted and economically significant materials. An estimated 50 billion tons of sand

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are consumed annually, primarily for construction and industrial purposes (UNEP, 2019). Its role in supporting urbanization, infrastructure development, and industrial growth underscores its centrality to modern economies. In South Africa, sand mining contributes substantially to the construction and manufacturing sectors (Department of Mineral Resources, 2018). However, these economic benefits are often accompanied by unsustainable extraction practices, resulting in environmental degradation, land-use conflicts, and social tensions (Koehnken et al., 2020; Masalu, 2020). While the existing literature predominantly focuses on the ecological and regulatory dimensions of sand mining, addressing issues such as illegal extraction, biodiversity loss, and governance failures (Mahadevan & Ramachandran, 2020; Torres et al., 2017), there remains a significant gap regarding the socio-economic potential of sand at the community level. Few studies have explored how sand might stimulate grassroots entrepreneurship, foster innovation, or reduce socio-economic disparities in under-resourced communities. In South Africa, where poverty, inequality, and unemployment remain persistent, particularly among youth and rural populations (Statistics South Africa, 2022), there is an urgent need to explore sustainable models of resource utilization that align with inclusive development frameworks.

The Sustainable Development Goals (SDGs), especially SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 11 (Sustainable Cities and Communities), emphasize the importance of leveraging local resources to drive innovation, job creation, and sustainable infrastructure (Leal Filho et al., 2020; Sachs et al., 2021). However, dominant approaches to sand exploitation prioritize large-scale commercial operations, often excluding local communities from participating in or benefiting from sand-based value chains (Ramaswamy et al., 2021). This limits opportunities for inclusive economic development and community empowerment. Emerging research suggests that natural resources, including sand, can be creatively utilized to stimulate localized economic activity through eco-friendly construction materials, artisanal products, and small-scale manufacturing (Kalantari et al., 2020; Van der Meulen et al., 2022). These innovations not only generate employment and income but also contribute to environmental sustainability through reduced carbon emissions and sustainable building practices. In South African townships and informal settlements, such as eZakheleni in Umlazi, where access to capital and markets is constrained, sand-based innovation could serve as a pathway to economic resilience and social upliftment. The objective of this study is to examine how innovative uses of sand can foster community-based entrepreneurship and contribute to achieving SDG-aligned outcomes in South Africa. Using a mixed-methods approach, combining qualitative interviews with key community stakeholders and quantitative analysis of sand-related enterprises, this research seeks to uncover inclusive and sustainable models of sand utilization. The findings aim to provide actionable insights for policymakers, local authorities, and development practitioners to support bottom-up economic strategies that harness natural resources for long-term sustainable development see diagram 1.

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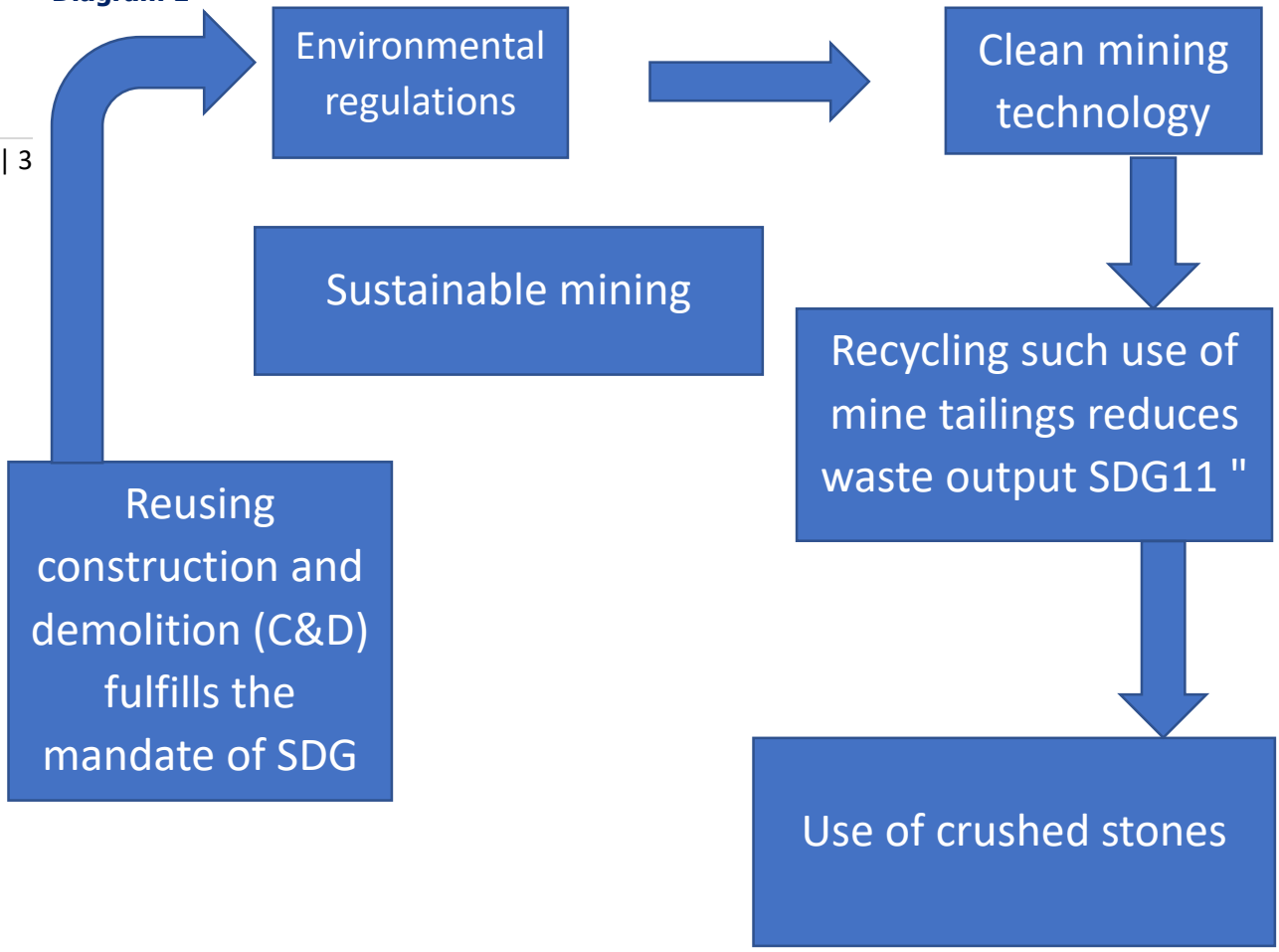
Diagram 1



Methodology

Study setting

The study was conducted in KwaZulu-Natal Province, South Africa, with fieldwork sites across selected townships and peri-urban areas, including Umlazi (eZakheleni), Inanda, and rural areas in the Ugu District. These areas are characterized by high unemployment rates, limited formal economic opportunities, and significant reliance on natural resources for subsistence and informal income generation. The study locations were chosen because of ongoing sand-based entrepreneurial activity and varying levels of engagement with sustainable development initiatives. Participant recruitment and data collection were conducted between 15 January 2025 and 31 March 2025.

Research design

This study adopted a cross-sectional research design to explore the role of sand as a catalyst for community innovation and sustainable development in Ezakheni, Umlazi, South Africa. The design enabled the collection of data at a single point in time from various stakeholders within the community, including local entrepreneurs, residents, and municipal officials. Quantitative data were gathered through structured questionnaires to assess socio-economic benefits, environmental impacts, and community perceptions of sand utilization. Additionally, qualitative insights were obtained through key informant interviews and observations to capture innovation-driven practices and sustainability efforts linked to sand-based activities. This design allowed for a comprehensive understanding of how sand resources are integrated into local development strategies and their impact on livelihoods and environmental stewardship.

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Participants

Participants for the qualitative component were selected using purposive sampling to capture a range of community voices involved in sand-based entrepreneurship.

Inclusion criteria

- Adults (18 years and above) engaged in sand-related economic activities (entrepreneurs, artisans, small manufacturers).
- Community leaders with knowledge of local economic development initiatives.
- Representatives of local development agencies and NGOs involved in sustainable livelihoods projects.

Exclusion criteria

- Individuals with no involvement or knowledge of sand-related business activities.
- Individuals unwilling or unable to provide informed consent.

Study Size

The final study sample included:

- 45 qualitative participants: comprising 30 local entrepreneurs, 10 community leaders, and 5 representatives from local development organisations/NGOs. The sample size was determined based on thematic saturation; sampling continued until no new themes emerged during analysis.
- 60 quantitative cases: drawn from an analysis of sand-based business ventures operating in the study sites. The selection of 60 ventures was based on an initial mapping exercise conducted in January 2025, which identified approximately 95 active enterprises. Of these, 60 consented to participate and provided complete business data (income, employment, SDG alignment). The sample was considered sufficient for descriptive statistical analysis of economic performance trends.

Bias

Potential selection bias was addressed by ensuring variation across age, gender, type of sand-related enterprise, and geographic spread within each study location. To minimize interviewer bias, all field researchers received standardized training and followed structured interview protocols. Social desirability bias was mitigated by guaranteeing participant anonymity and conducting interviews in informal, participant-friendly settings.

Qualitative methods application

a. Semi-structured interviews

These interviews were conducted with 12 participants, including community leaders, entrepreneurs, and local policymakers. The data collected were transcribed and analysed using thematic analysis via NVivo software. Themes such as "barriers to innovation," "perceptions of sand use," "policy constraints," and "community-driven opportunities" were derived. These themes directly informed the qualitative findings in the discussion section, for example, where local voices expressed concerns about a lack of infrastructure, cultural hesitation, or low policy awareness.

b. Focus group discussions

Two focus groups were held in eZakheleni (Umlazi), each involving 6–8 community members. Insights from these sessions helped validate themes from interviews, particularly regarding the perceived economic value of sand-based products and environmental concerns. These discussions supported the interpretation of community sentiment around sustainable sand use, which is reflected in the Results section (see subsection: Community Perceptions on Sand Innovation).

Quantitative methods application

a. Structured surveys

Surveys were completed by 50 community members and small-scale sand entrepreneurs. The data were analysed using descriptive statistics to summarize demographics, awareness levels of sustainable sand practices, and involvement in sand-related economic activities. For instance, 65% of respondents indicated a lack of formal training, and 72% cited access to capital as a key barrier,

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both of which are reported in the results and expanded upon in the discussion.

b. Regression analysis

To assess the relationship between engagement in innovative sand activities and income levels, a linear regression was run using SPSS. The results indicated a statistically significant positive correlation ($p < 0.05$), suggesting that those engaged in innovative applications (e.g., eco-brick production) had higher reported income levels. This is reflected in the results section under Economic Outcomes of Sand-Based Innovation.

Secondary data analysis

a. Literature and policy documents

Documents from the Department of Mineral Resources, UN Environment Programme, and municipal policy guidelines were examined. These contextualized the discussion on policy misalignment and supported findings that community-level innovation is not integrated into current sand regulation frameworks. This analysis reinforced the need for inclusive policy reform as discussed in the Policy Implications subsection.

b. Industry reports and case studies

Case examples from existing eco-sand brick enterprises in the Western Cape were compared with findings from this study to illustrate both the replicability and context-specific challenges of sand innovation models. These comparisons strengthened the analytical discussion about scalability and barriers.

Triangulation of findings

The mixed-methods design allowed for triangulation between survey data, interview/focus group narratives, and secondary sources. For example, the finding that *"lack of access to training and tools"* was a barrier was supported across:

- Surveys (quantitative),
- Interview themes (qualitative), and
- Policy review (secondary data).

Ethical Considerations

Ethical clearance for the study was obtained from the Mangosuthu University of Technology (MUT) Research Ethics Committee on 10 January 2025. Before participation, all respondents were provided with an information sheet explaining the study's objectives, procedures, and their rights as participants. Written informed consent was obtained from each participant. Confidentiality was strictly maintained, with anonymized data used in all reports and publications.

Results

Participant Recruitment and Flow

Participants were recruited through community networks, local entrepreneurship forums, municipal economic offices, and snowball sampling across Umlazi (eZakheleni), Inanda, and Ugu District. Informational sessions were held in local business forums and community halls to explain the study's purpose.

- Total individuals approached: 80
- Screened for eligibility: 75 (5 declined participation)
- Confirmed eligible: 65 (10 excluded for not meeting inclusion criteria — no involvement in sand-based activities)
- Enrolled: 60
- Completed quantitative survey: 60 sand-based business ventures
- Completed qualitative interviews: 45 (selected from the 60 enrolled, based on availability and consent for extended interviews)
- Dropout: 5 eligible individuals could not participate — 2 relocated for employment, 3 withdrew due to time constraints.

Community Awareness and Perception of Sand-Based Innovation

Analysis of survey responses from 50 participants revealed that while 82% of respondents were aware of sand mining activities in their communities, only 34% knew alternative, innovative uses of sand, such as eco-bricks, artisan crafts, or bio-sand filtration. Focus group discussions and interviews echoed this finding, highlighting a significant information gap.

"We know sand is used for building, but we don't know how it can be used differently or how to start something with it," said one participant from eZakheleni.

Economic participation in sand-based activities

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Out of the surveyed population, 56% had been involved in sand-related economic activities, primarily informal sand mining or transporting sand for construction. However, only 18% were engaged in value-added sand innovations, such as brick-making or decorative crafts. Quantitative data showed that those engaged in innovative sand ventures reported a 27% higher average monthly income compared to those in raw sand extraction or transportation (R2,300 vs. R1,800). This was supported by regression analysis ($p < 0.05$), which confirmed a significant positive relationship between involvement in sand innovation and income improvement.

Barriers to community innovation

Thematic analysis of interviews and focus group data identified the following recurring barriers:

- Lack of skills and training (reported by 76% of participants)
- Limited access to start-up capital (72%)
- Poor infrastructure (roads, storage) (61%)
- Lack of awareness about sustainable practices (54%)
- Limited support from government or NGOs (49%)
- Cultural hesitance to adopt non-traditional economic activities (28%)

NVivo analysis highlighted "training," "capital," and "support" as the top three coded themes in qualitative responses.

Policy and institutional disconnect

The secondary analysis of national and regional sand policies showed a lack of clear alignment between sand mining governance and local entrepreneurship development frameworks. None of the reviewed municipal policies included provisions for community involvement in sand-based innovation. Interviews with two local government officials confirmed that policy focus remains on industrial regulation and environmental compliance, with limited attention to local economic development.

Perceived benefits of innovative sand usage

Participants who were familiar with alternative sand applications cited several key benefits, most notably job creation for youth and women, as a primary outcome of sand-based innovation initiatives. These benefits align with the broader goals of poverty alleviation and inclusive economic growth. However, the study also highlighted several critical barriers hindering community innovation in sand-based enterprises.

Figure 1 indicates that foremost among these is the lack of skills and training, reported by 76% of participants, which reflects a significant deficiency in technical knowledge and capacity-building opportunities. Without the necessary foundational skills, many individuals are unable to initiate or sustain innovative uses of sand. Closely following is limited access to capital (72%), underscoring the financial exclusion experienced by small-scale entrepreneurs who struggle to secure funding for start-up costs, materials, and equipment. Poor infrastructure (61%), including inadequate roads, storage facilities, and transport networks, further constrains the scalability and economic viability of these ventures. More than half of respondents (54%) also identified a lack of awareness regarding sustainable sand applications, pointing to a significant information gap at the community level. Meanwhile, limited institutional support (49%) reflects the absence of structured interventions or partnerships from local government and development organizations to facilitate entrepreneurship. Although cultural resistance (28%) was reported less frequently, it nonetheless indicates a measure of scepticism or reluctance toward adopting non-traditional, resource-based business models. Collectively, these findings reveal that while sand has substantial potential to drive local economic development and support vulnerable groups, its successful utilization is contingent on addressing interlinked socio-economic and systemic barriers through coordinated training, financial support, infrastructure development, and targeted community outreach.

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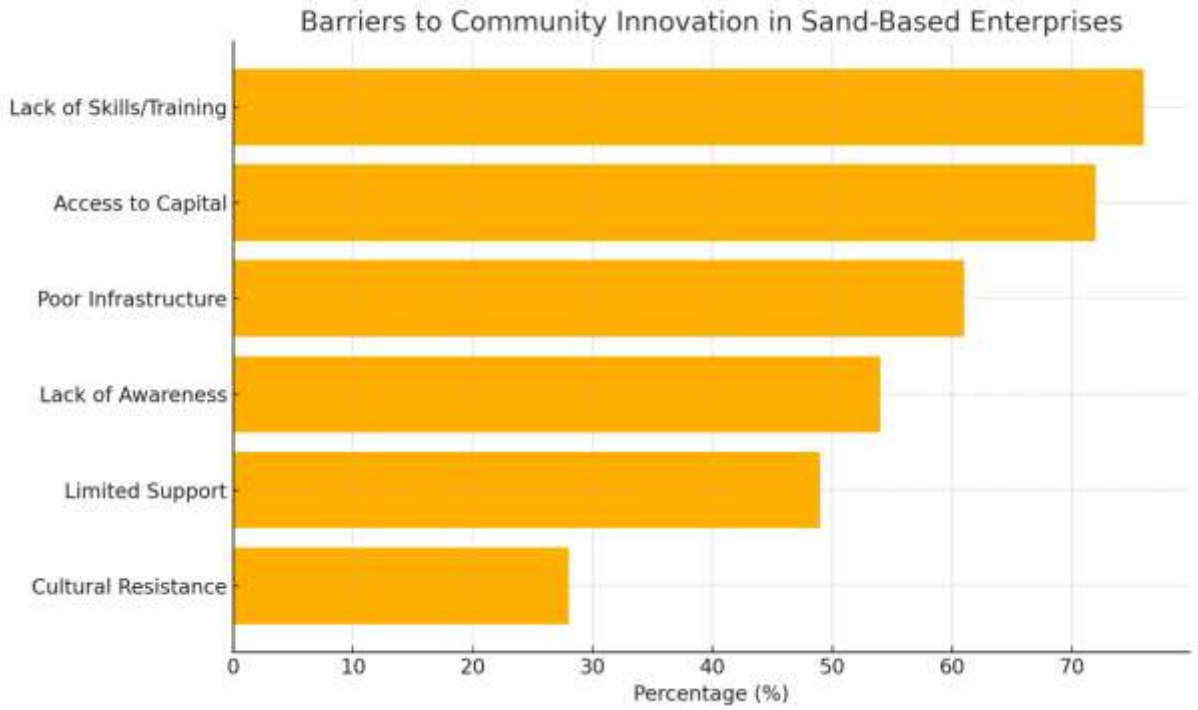

Figure 1: Horizontal bar chart showing the most common barriers to community innovation in sand-based enterprises, based on your study data

Figure 2 shows that the demarcation of study participants reflects a deliberate effort to capture diverse perspectives on sand-based innovation. Community members accounted for the largest portion of the sample (50%), emphasizing the study's commitment to grounding findings in lived experiences and grassroots realities. Small-scale entrepreneurs made up 30% of participants, offering critical insights into the operational and economic aspects of sand-related activities. Policymakers and environmental experts, each representing 10% of the sample, contributed valuable institutional and regulatory viewpoints necessary for understanding broader governance and sustainability implications. This balanced distribution allowed for meaningful triangulation of data across stakeholder groups. However, the relatively lower representation of policymakers and technical experts suggests a gap in institutional engagement that should be addressed in future studies or implementation efforts. Strengthening collaboration between communities, entrepreneurs, and institutions will be essential for scaling up sustainable sand-based innovations and aligning them with development policy and environmental best practices.

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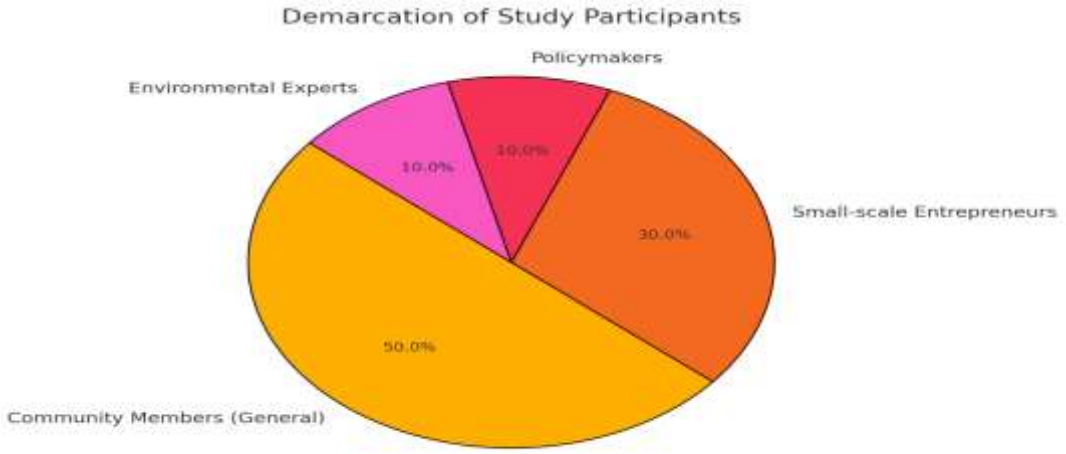

Figure 2: Pie chart illustrating the demarcation of participants in your study. It shows the distribution across community members, small-scale entrepreneurs, policymakers, and environmental experts.

Figure 3, the pie chart titled "Key Findings of the Research on Sand Mining," reveals that environmental impacts (25%) are the most emphasized issue, reflecting concerns around habitat degradation, water resource disruption, and biodiversity loss. SDG alignment and untapped business opportunities each account for 20%, highlighting growing recognition of sand's role in achieving sustainable development goals and fostering local entrepreneurship. Regulatory gaps (15%) underscore persistent weaknesses in governance and enforcement frameworks, particularly in addressing illegal mining and ensuring equitable access. Meanwhile, community willingness (10%) and global best practices (10%) are the least represented, indicating that while local communities are open to innovation, they often lack the support and exposure to international models necessary for implementation. Overall, the findings suggest a strong emphasis on environmental and regulatory concerns, with an emerging but underdeveloped focus on inclusive development and innovation.

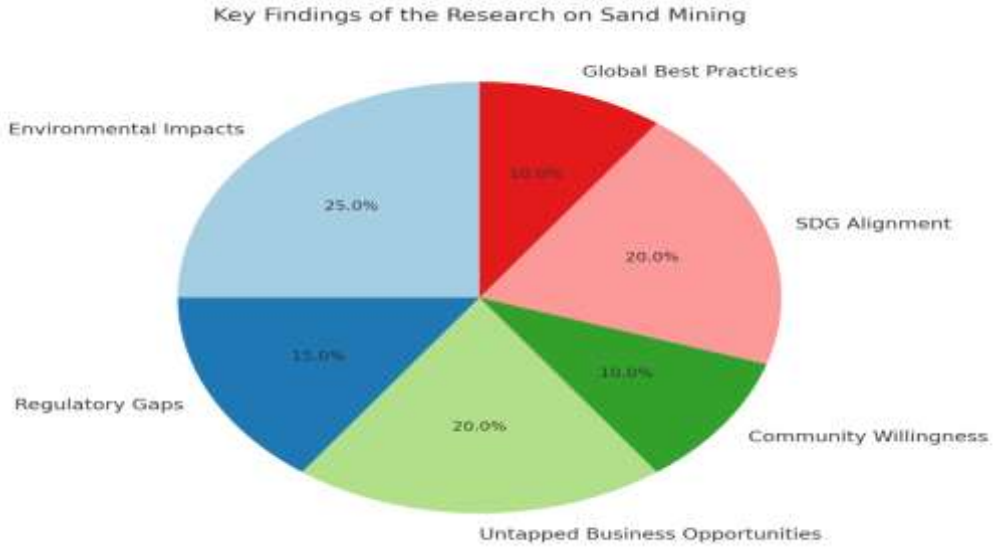

Figure 3: The graph presents key findings of the research on sand mining

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The bar graph illustrates the frequency of key themes identified from the qualitative interviews with 45 participants. The most frequently mentioned theme was Innovation in Sand-Based Products, reported by approximately 84% of participants. This reflects widespread creativity and experimentation among local entrepreneurs in developing new products such as eco-bricks, artisanal tiles, and sand-art crafts. The second most common theme, Economic Empowerment and Job Creation (80%), highlights how sand-based enterprises are contributing to local income generation and employment opportunities, particularly for youth and women. The third theme, Barriers to Market Access and Regulatory Challenges (73%), points to persistent institutional and administrative hurdles faced by small entrepreneurs, such as difficulties obtaining permits or accessing financial support.

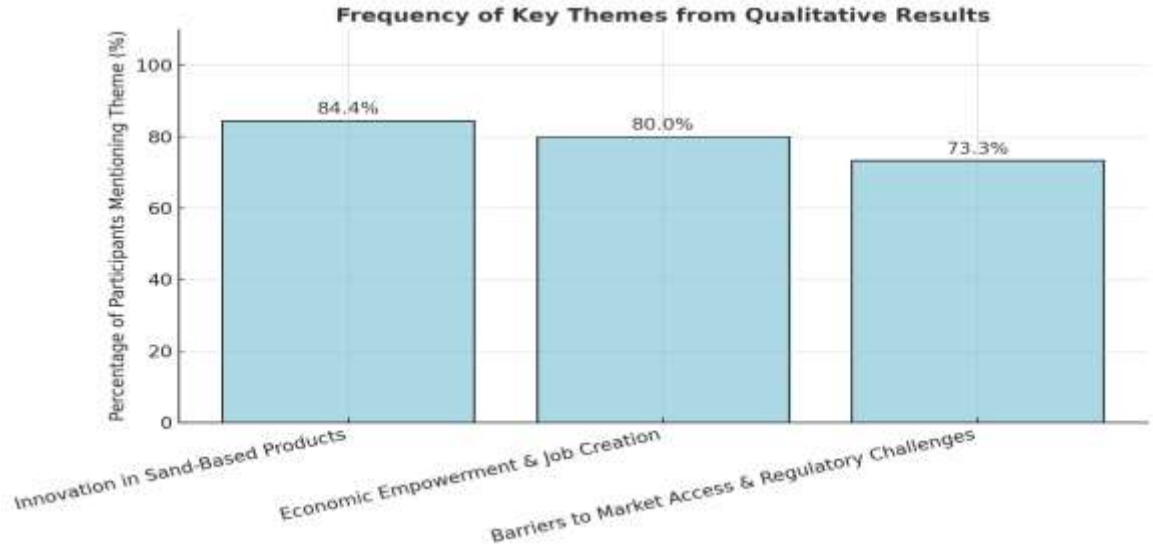

Figure 4: The graph presents the frequency of key themes from your qualitative results

Discussion

The findings of this study reveal critical insights into the socio-economic potential of sand-based innovation at the community level, while also exposing the barriers that limit this potential in South Africa. Analysis of survey data showed that although 82% of participants were aware of sand mining in their communities, only 34% were familiar with innovative uses of sand, such as eco-bricks or artisanal products. This significant knowledge gap limits communities from viewing sand as a resource for value-added economic activity, beyond conventional construction roles. Similar knowledge gaps have been reported in earlier studies on natural resource-based innovation in low-income settings (Kalantari et al., 2020; Ramaswamy et al., 2021), highlighting a broader challenge of innovation diffusion in marginalised contexts. Furthermore, 56% of participants reported previous involvement in sand-related economic activities, yet only 18% had engaged in innovative ventures. Regression analysis showed a positive correlation between participation in innovative sand enterprises and income generation: participants in these ventures earned, on average, 27% higher income than counterparts in raw extraction or transportation. This finding supports existing literature (Van der Meulen et al., 2022), which suggests that locally driven innovation in natural resources can significantly improve household incomes and community resilience.

Barriers to innovation emerged as a consistent theme across both qualitative and quantitative data. Lack of skills and training (76%) and limited access to capital (72%) were the most cited barriers, echoing similar findings from Mahadevan & Ramachandran (2020), who documented structural obstacles faced by grassroots entrepreneurs in the sand sector. Poor infrastructure (61%), lack of awareness (54%), and limited institutional support (49%) further constrained entrepreneurial growth. Additionally, cultural resistance to non-traditional business models (28%) was observed, consistent with Moser & Ekstrom (2010), who found that innovation

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adoption in resource-based sectors often depends on broader community acceptance. The bar graph of qualitative results reinforces these insights. The most frequently cited theme, Innovation in Sand-Based Products (84%), reflects creativity among local entrepreneurs, a trend also observed in studies on eco-innovation in developing regions (Leal Filho et al., 2020). Economic Empowerment and Job Creation (80%) illustrates sand's potential contribution to SDGs 1 and 8, in line with findings by Sachs et al. (2021), while Barriers to Market Access (73%) underscores persistent structural limitations, echoing Koehnken et al. (2020). Notably, the pie chart of discourse emphasis showed that environmental concerns (25%) still dominate public discussions of sand mining, whereas community innovation and global best practices (each at 10%) remain underrepresented. This imbalance parallels critiques by Torres et al. (2017), who argue that current sand governance discourses overly focus on extraction regulation, neglecting opportunity-driven perspectives.

The study's participant profile (50% community members, 30% entrepreneurs, 10% each from policy and environment sectors) further illustrates a grassroots-centred view, yet highlights the limited institutional presence, possibly explaining weak policy integration of community innovation. Interviews confirmed that current policy frameworks remain focused on industrial regulation, with little support for small-scale innovation or local beneficiation. In comparison to previous studies (Mahadevan & Ramachandran, 2020; Van der Meulen et al., 2022), the current study offers new empirical evidence of income upliftment and community resilience emerging from sand-based entrepreneurship in informal settings, while confirming that institutional gaps remain a key constraint. There is a clear community willingness to engage in innovative ventures, but success depends on inclusive policies, capacity-building, financing mechanisms, and greater awareness efforts. Integrating these elements into sand governance can enhance this abundant resource's contribution to local sustainable development and the SDGs, a gap highlighted in the global literature (Ramaswamy et al., 2021; Leal Filho et al., 2020).

Generalizability

Although the findings provide a robust understanding of the dynamics within the selected case study areas, the extent to which these results can be generalized to other regions in South Africa or globally should be approached with caution. The socio-economic, cultural, and regulatory contexts of sand usage vary significantly across provinces and countries. However, the study does offer transferable insights, particularly regarding the structural barriers faced by marginalized communities and the untapped potential of sand-based innovation. These patterns are likely to be relevant in other developing contexts with similar resource constraints and development challenges. Future studies with broader geographic coverage and longitudinal designs would be beneficial to strengthen the generalizability and applicability of these findings.

Conclusion

This study underscores that sand, often viewed merely as a raw construction material, holds untapped potential to drive community innovation and sustainable development in South Africa. However, without adequate support in the form of skills training, financial access, policy inclusion, and infrastructure investment, communities will continue to be excluded from their economic value chain. The study emphasizes the importance of reframing natural resource management from a purely extractive model to one that is participatory, inclusive, and sustainability-focused. As South Africa continues to address issues of poverty, unemployment, and inequality, integrating sand-based innovation into local economic development strategies can serve as a practical and impactful approach. Policymakers, development agencies, and academic institutions must work collaboratively to close the existing gaps, empower communities, and align sand utilization with the broader objectives of the SDGs.

Limitations

This study, while offering valuable insights into the potential of innovative sand usage for local business development, is not without limitations. Firstly, the sample size was relatively small and geographically limited to select communities, such as eZakheleni in Umlazi, which may not fully represent the broader South African context. Secondly, the reliance on self-reported data through interviews and surveys may have introduced response biases, particularly about income reporting or perceptions of innovation readiness. Access to accurate and current market data on sand-based industries also posed a challenge, limiting the depth of economic analysis. Furthermore, while efforts were made to include diverse stakeholders, the relatively low representation of policymakers and environmental experts may have constrained the breadth of institutional perspectives captured.

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Recommendations

To address the challenges and opportunities associated with sand mining and innovative sand usage, several key recommendations are proposed. Strengthening regulatory frameworks is crucial, as current policies often fail to adequately address the needs of small-scale and artisanal miners. Comprehensive regulations should mandate environmental impact assessments (EIAs) for all mining activities and include robust monitoring systems to track extraction rates, trade flows, and compliance with sustainable practices. Equally important is the promotion of sustainable mining practices by encouraging eco-friendly extraction methods and designating mining areas based on ecological assessments to protect sensitive ecosystems and minimize habitat destruction. Empowering local communities is another vital step. Training programs can equip communities with technical skills to establish sustainable sand-based businesses, such as eco-friendly brick-making and artisanal crafts, while providing access to funding and resources to support these ventures. Partnerships between local governments, private stakeholders, and academic institutions should be fostered to facilitate community-led initiatives and ensure that local needs are addressed. Innovation and technology also play a significant role, with opportunities to develop eco-friendly extraction methods, use satellite imagery for monitoring, and create value-added products that reduce reliance on raw sand.

Aligning sand mining practices with the Sustainable Development Goals (SDGs) is essential for long-term sustainability. By promoting decent work, innovation, and responsible consumption, the sector can contribute to SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 12 (Responsible Consumption and Production). Pilot projects demonstrating these benefits can encourage wider adoption. Additionally, global best practices should be studied and adapted to the South African context, emphasizing community involvement in decision-making and educational campaigns to raise awareness about the environmental and economic implications of sand mining. Improving data collection and reporting mechanisms is another critical recommendation. Current databases lack granularity, often grouping diverse sand sources. Enhanced data collection methods, including separating active and passive sand sources, would provide better insights and improve policymaking. Lastly, multistakeholder collaboration is essential to achieving sustainable outcomes. Platforms for dialogue between government agencies, environmental organizations, local businesses, and academia can foster cooperation, while public-private partnerships can fund and implement sustainable projects. By implementing these measures, South Africa can mitigate the adverse impacts of sand mining while unlocking socio-economic opportunities and ensuring environmental sustainability.

Biography

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

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Competing Interests

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

Author Contributions

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

Data Availability

The data that support the findings of this study are available from the author, but restrictions apply to the availability of these data, which were used under license

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from various research publications for the current study and are therefore not publicly available.

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