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## Brownfield development is the new green for sustainable mine-dump redevelopment

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### Abstract

Rapid urbanisation, industrialisation and globalisation created a legacy of derelict and vacant mine dumps in the South African Gauteng province urban landscape that is viewed as an environmental problem rather than a development opportunity towards effective sustainable development. The article entails a systematic analysis of greenfield and brownfield development attributes, evaluated in terms of sustainable development target indicators, in order to determine which development category best contributes to sustainable development. A qualitative research method was applied using a combination of interviews, case studies and literature reviews. Based on content analysis and coding, the thematic analysis results confirm that the long-term sustainability benefits of brownfield developments outweigh the short-term financial gains of greenfield developments. Recommendations, including establishing partnerships and funding models, identifying and defining development strategies for brownfield sites as well as implementing and enforcing legislation, could contribute towards realising sustainable, resilient, safe and inclusive human settlements on vacant mine dumps.

**Keywords:** Brownfield, climate change, globalisation, sustainable development, sustainable development goals, urbanisation, urban sprawl

### BRUINVELDONTWIKKELING IS DIE NUWE GROEN VIR VOLHOUBARE HERONTWIKKELING VAN MYNHOPE

Verstedeliking teen 'n hoë tempo, industrialisasie en globalisasie het 'n erfenis van verlate en onbenutbare mynhope in die Suid-Afrikaanse provinsie, Gauteng, geskep. Dit word gesien as 'n omgewingsprobleem eerder as 'n ontwikkelingsgeleentheid vir effektiewe volhoubare ontwikkeling. Die studie behels 'n stelselmatige ontleding van groenveld- en bruinveldontwikkelingsseienskappe, wat geëvalueer is in terme van teikens vir volhoubare ontwikkeling, ten einde te bepaal watter ontwikkelingskategorie die beste bydra tot volhoubare ontwikkeling. 'n Kwalitatiewe navorsingsmetode is toegepas deur gebruik te maak van 'n kombinasie van onderhoude, gevallestudies en literatuurstudies. Gebaseer op inhoudsanalise en kodering, bevestig die tematiese ontledingsresultate dat die langtermyn-volhoubaarheidsvoordele van bruinveldontwikkelings meer voordelig is as die korttermyn finansiële winste van groenveldontwikkelings. Aanbevelings, insluitende die vestiging van vennootskappe en befondsingsmodelle, die identifisering en definiering van ontwikkelingstrategieë vir bruinveldsterreine, asook die implementering en toepassing van wetgewing, kan bydra tot die verwesenliking van volhoubare, aanpasbare, veilige en inklusiewe nedersettings op leë mynhope.

**Sleutelwoorde:** Bruinveld, globalisasie, klimaatsverandering, stadspreiding, verstedeliking, volhoubare ontwikkeling, volhoubare ontwikkelingsteikens

### NTLAFATSO EA LIBAKA KE NALA E NCHA TOKISONG EA LITHOTOBOLO TSA MERAFO

Ho eketseha ha litoropo ka potlako, nts'etsopele le ho ikopanya ha machaba a lefats'e li hlahisitse lefa la lithotobolo tse sa sebelisoeng tsa merafo litoropong tsa profinse ea Gauteng, Afrika Borwa, ka hona litoropo tsena li nkuoa ele bothata ba tikoloho, hona le hore li lekoloe ele monyetla oa ntsetsopele e tsitsiseng. Boithuto bona bo kenyetsetsa tlhahlobo e hlophisehileng ea makhabane a ntshetsopele ea tikoloho e nang le lintlafatso le e se nang tsona, ho lekanya makhabane ana ho latela lipontsho tsa sepheo sa ntshetsopele, ele ho tseba karolo e kenyang letsoho ntlafatsong e tsitsiseng. Mokhoa oa boleng oa ho etsa lipatlisiso o sebelisitsoe ka lipuisano, boithuto ba libaka le tlhahlobo ea lingoliloeng. Ho ipapisitsoe le tlhahlobo le thlophiso ea liphetho, boithuto bo tiisa hore melemo ea nako e telele ea ntshetsopele ea libaka tse ntlafalitsoeng e feta melemo ea nakoana ea chelete nts'etsopeleng ea libaka tse se nang lintlafatso. Litlhaliso, ho kenyetsetsa tsebelisano 'moho le mekhoha ea ho etsa chelete, ho khetha le ho hlalosa maano a nts'etsopele a libaka tse ntlafalitsoeng, hammoho le ho kenya tsebetsoeng melao, ho ka thusa ho fihlella ntlafatso e bolokehileng ea metse libakeng tse neng li sebelisoa ele lithotobolo tsa merafo.

### 1. INTRODUCTION

Two undisputed uncertainties pertaining to the status quo of the world are the economic and social disparity between developed and developing countries as well as constant environmental degradation (Tladi, 2007: 1). As the world entered an era where human beings started to have a significant impact on the earth's geology and ecosystems sustainable development, specifically environmental issues such as global warming, biodiversity loss, habitat loss, deforestation and increased greenhouse gas emissions sparked interest worldwide. Griggs, Stafford-Smith, Gaffney, Rockström, Ohman, Shyamsundar, Steffen *et al.* (2013: 306) and Moran, Wackernagel, Kitzes, Goldfinger and Boutaud (2008: 471-474)

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further agree that human pressure risks, including globalisation, urbanisation, urban sprawl, migration patterns, settlement patterns and transportation, have an adverse effect on the earth's system processes. Tladi (2007: 2) adds that industrialisation and various ancillary activities as well as poverty, due to the lack of development, are intricately linked to unsustainable cities and environmental degradation. Economic progression and development paradigms have prevailed up to now, albeit to the detriment of social development as well as environmental protection or conservation (Griggs *et al.*, 2013: 305).

Social development and economic growth aspects are mutually dependent, have a detrimental impact on the environment, and affect the sustainability of our cities (WCED, 1987; UN, 2015a; UN, 2015b; Adams & Watkins, 2002: 90). Sustainable development is unquestionably linked with growing global environmental concerns, including climate change (Griggs *et al.*, 2013: 305; Moran *et al.*, 2008: 470).

Considering that this article entails the redevelopment of mine dumps located within an urban setting, the article compared brownfield and greenfield attributes by applying relevant sustainable development indicators. These indicators include urban landscape dynamics that explored symbiotic relationships between urbanisation, industrialisation, urban sprawl, population dynamics, human settlements, transportation and spatial development. Elements concerning sustainable development, including defining brownfield and greenfield areas, spatial development patterns, population dynamics and related measurements or indicators, were investigated.

## 2. LITERATURE REVIEW

In order to understand the redevelopment of mine dumps in urban settings, it is important to introduce the current theory on urban

landscape dynamics and sustainable development included in this article. A literature review explores the existing theory and approaches of sustainable development, urbanisation, urban sprawl, as well as brownfield and greenfield development in urban settings.

### 2.1 Sustainable development

Sustainable development is a multifaceted concept traversing economic, social and environmental spheres, originally defined in the Brundtland Report titled *Our Common Future* (WCED, 1987). The report outlines that interactions between social needs and economic growth adversely affect the natural environment. These interactions are commonly represented by the triple bottom line model (Figure 1). As environmental issues gain international momentum through awareness and advancement in research and technology (Strydom & King, 2009: 11), the configuration of the spheres evolved (Figure 2). Progressive transformation is also confirmed through continuous refinement of the United Nations' (UN) sustainable development goals (SDGs) outlined in Agenda 2030, compared to the previous millennium development goals (MDGs) (Senge, Smith, Kruschwitz, Laur & Schley, 2008: 4; Sachs, 2012: 2208; Griggs *et al.*, 2013: 306; UN, 2015b). In addition, it is important to note that sustainable development and sustainability are noticeably different. Jepson and Edwards (2010: 418) and Moldan, Janouskova and Hak (2012: 4) rationalise that the concept of sustainability is an outcome or objective of the process of sustainable development.

Since sustainable development is a global phenomenon that transgresses geographical boundaries, international law motivates the development of treaties, charters and national legislation. The Millennium Declaration, outlined by eight MDGs, was unanimously adopted at the UN Millennium Summit in 2000 (UN, 2000; Griggs *et al.*, 2013: 306). Building on the MDGs, an

additional nine goals were included in the 2030 Agenda held at the UN Sustainable Development Summit in 2015 (Griggs *et al.*, 2013: 307; UN 2015b: 2).

In a South African context, bearing in mind the spheres of government and administration functions, the national department devised a National Development Plan (NDP) in line with international SDGs which guides strategic development on a national scale (RSA-NPC, 2011). Each province subsequently develops independent policies aligned with the NDP expressing a unique growth strategy, while upholding the Constitution and other national laws. Continuity is ensured as strategies and actions are subsequently aligned and implemented on provincial and municipal levels.

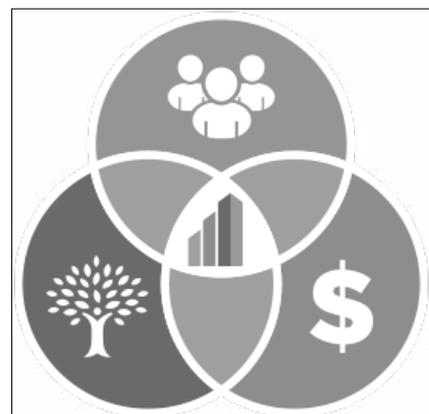


Figure 1 : Triple bottom line of sustainable development

Source: Adapted from REAL Building Consultants (n.d.: online)

Figures 1 and 2 portray the relationship between economic, social and environmental systems and the evolution of the triple bottom line sustainable development model. The Three Pillars Model is typically illustrated by three equal circles, all things being equal, with the intersecting epicentre representing sustainability. In the past, however, the Mickey Mouse Model depicted a more realistic interpretation, where the economy is more dominant than society or the environment. As our understanding grew and perceptions changed, it was recognised that these systems are dependent rather

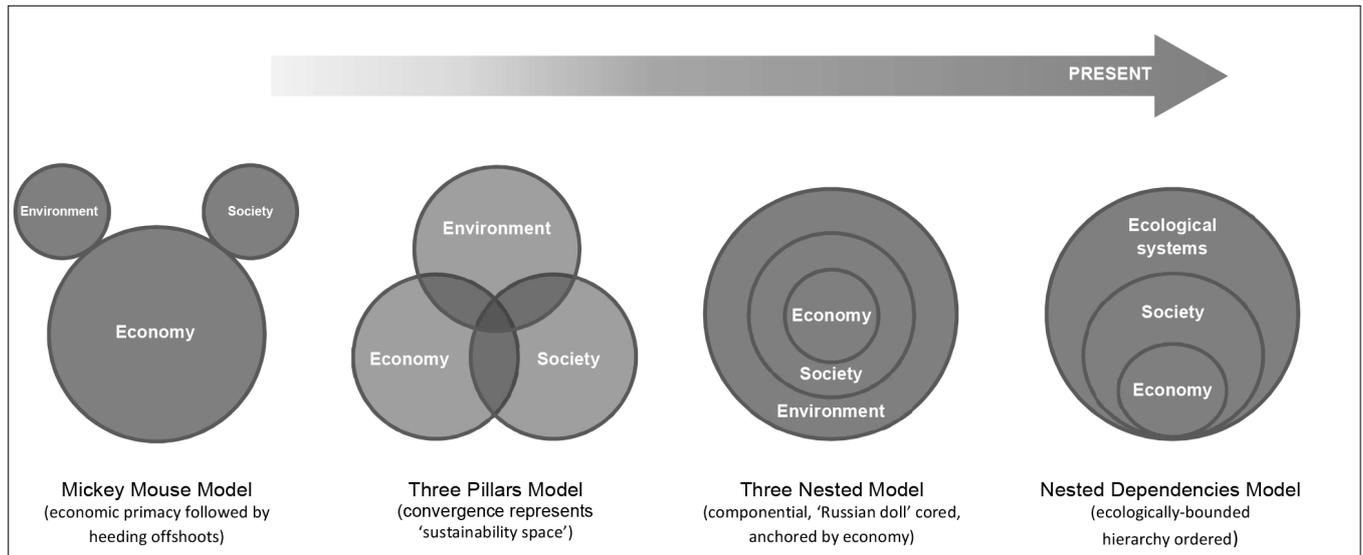


Figure 2 : Evolution of sustainable development models

Source: Adapted from Skringar, Makris and Williams (2013: 18)

than intersecting ambits. Contrary to the interdependent Russian Doll Model, the Nested Dependencies Model expresses that the systems are co-dependent. The former model suggests that the economy cannot exist without a healthy and coordinated society, and a society cannot exist without a healthy environment. The latter advocates that society is entirely dependent on the environment and that, without natural resources, society and economy cannot survive. Although not depicted in the illustrations, the co-dependent sustainability model further evolved to include governance as an underpinning factor, and the use of fuzzy boundary models to assess sustainable development is increasing (Rosciaa, Zaninellib & Lazaroiuc, 2011: 2225-2235; Cornelissen, Van den Berg, Koops, Grossman & Udoa, 2001).

## 2.2 Urbanisation and urban sprawl

Urbanisation is the outcome of an increase in the natural population combined with population migration and economic development. Various research reports and publications estimate that the global population will exceed 9 billion by 2050 (Sachs, 2012: 2207; Griggs *et al.*, 2013: 305; PRB, 2014; PRB, 2016; World Bank Group,

2016). Migration towards urban areas in South Africa is consistent with global trends (PRB, 2014; PRB, 2016). Data confirms that urban population has increased by 3% since 2014 and that approximately 70% of South Africa's population will reside in urban areas by 2030 (NDRDLR, 2019: 51). Migration trends to urban cities are not solely indicative of poor communities in search of employment prospects; they are also a reflection that urban living offers a wider range of opportunities. This is, however, a human perception, and the unfortunate reality is that the majority of job-seeking migrants often end up even deeper in poverty (World Bank Group, 2016). Migrants generally resort to live in informal settlements at the urban fringe or on vacant land, often in precarious locations that compromise their health and well-being (EMM, 2011: 13).

Urban sprawl is closely linked to transportation. Our ability to travel further distances, due to improved road infrastructure, promotes development at the urban fringe, where land is cheaper. In the South African context, it is perceived that success is measured by vehicle ownership (GCRO, 2011: 86-87); therefore, private vehicles are the preferred means of transport. In addition, public transport is seemingly

unsafe, expensive and not readily available. A study conducted by Nagengast, Hendrickson and Lange (2011) established that greenfield development consumes double the amount of energy and emits almost twice as much greenhouse gasses than redeveloped brownfield areas, due to increased travelling distance, time and congestion as well as the preference for road-based transport (GCRO, 2011: 86; Nagengast *et al.*, 2011: 303).

## 2.3 Brownfield and greenfield development

The catchphrase "brownfield development" was conceived by the American Environmental Protection Agency, and globally accepted to represent the opposite of greenfield development (De Sousa, 2000: 833; Adams & Watkins, 2002: 15-18; CLARINET, 2002: 9; Raco & Henderson, 2006: 500; Thornton, Franz, Edwards, Pahlen & Nathanail, 2007: 116; Popescu & Pătrășcoiu, 2012: 91-92). The broadly accepted international definition for brownfield comprises underused, neglected, and potentially contaminated properties (land and buildings). It usually occurs as the relicts of former industrial, agricultural, residential, military, or other such activities (Martinát, Dvorak, Frantal, Klusacek, Kunc

& Navratil *et al.*, 2016: 79). On the contrary, no formal definition exists in a South African context. Although an article published by Potts and Cloete (2012: 394-395) made a proposal for adoption, subsequent development policies, including the EMM Metropolitan SDF, EMM Regional SDF, GGMP, NDP as well as the Draft National Spatial Development Framework 2019, omitted reference to brownfield in its entirety.

The occurrence of brownfield sites can be attributed to various factors, including globalisation, urbanisation and deindustrialisation (Behan, Maoh & Kanaroglou, 2008: 292-295; Skaburskis 2006: 233-234). It is further indicated that globalisation proliferates the structural change of economies on a worldwide scale. Industry-based economies transform into manufacturing and consumer-driven markets, resulting in several vacant or underused brownfield sites located within the inner city. Industries are either displaced in search of larger spaces, or deindustrialisation. Continuous growth of metropolitan areas envelops industry-related activities originally located at the periphery of the city (Bobbins, 2013: 1365-1366) such as, for instance, Eagle Canyon Golf Estate, Elsburg Tailings Complex, Benoni Dump, and the Van Dyk Slimes Dam (5L29).

Risks associated with environmental degradation and economic decline of brownfield sites are well documented (GDARD, 2012: 9). However, discourse on whether these risks are real or perceived continue (Fiksel, McDaniel & Mendenhall, 1999: 8; CLARINET, 2002: 3-6; McCarthy, 2002: 287; Nijkamp, Rodenburg & Wagtendonk, 2002: 237). Perceived risks are mostly fiscal concerns, including stigmatised low market values, uncertainties regarding rehabilitation and associated costs, restricted land use, marketability of properties, and rehabilitation liability (Mackenzie Group, 2004: 4). On the other hand, real risks are issues such as water and soil contamination, air quality and dust, geotechnical stability, health risks, redundant

infrastructure as well as safety and security that could be remediated (Thornton *et al.*, 2007: 117; Schädler, Morio, Bartke, Rohr-Zänker & Finkel, 2011: 830; Schädler, Morio, Bartke & Finkel, 2012: 92; GDARD, 2012).

### 3. STUDY AREA

The first encounter with urbanisation on a grand scale in Gauteng can be associated with the gold rush in the Witwatersrand. Worldwide, prospectors and entrepreneurs flocked to the area, driven by hopes of prosperity and wealth. Overnight, the area was covered with rudimentary dwellings that constituted the shanty town known as Johannesburg. The industry grew rapidly when coal was discovered and small towns such as Benoni were established as transport routes for the coal supply railway line (GCRO, 2011: 10; Harrison & Zack, 2012: 555-557). Over time, continuous development and urban sprawl resulted in wall-to-wall development, which meant that mining activities previously located at the periphery of urban areas are enveloped by the urban landscape (Figure 3).

Measuring approximately 217 hectares in extent, Ebotse, an exclusive golf estate around Rynfield Lake, in Benoni, Gauteng province,

was developed on a brownfield site in the centre of a predominantly residential neighbourhood. Due to specific development constraints, including adverse geological and topographical conditions, environmental constraints, future provincial road infrastructure and servitudes, the nett developable area measures approximately 70 hectares. The estate consists of 870 homes and features a wide range of activities, including golf, squash, tennis, cricket training nets, park run, fishing, walking trails, and bird watching. In addition, the estate is located within 2 kilometres of the N12 freeway, 11 kilometres from the N17 and R21 freeways and 15 minutes' drive from OR Tambo International Airport. Accessibility and the feature Rynfield Lake were undoubtedly vital attributes in achieving the elite lifestyle as envisioned (Figures 4 and 5).

### 4. RESEARCH METHOD

The study systematically analyses greenfield and brownfield development attributes in terms of sustainable development target indicators, in order to determine which development category best contributes to sustainable development. Using a qualitative research approach, a combination of

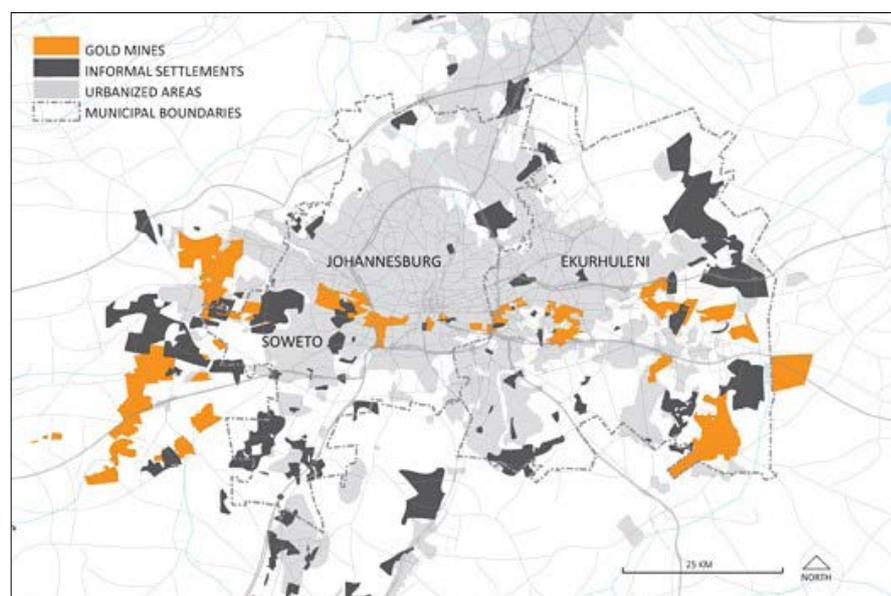


Figure 3 : Gauteng mining belt

Source: Taken from Health-E News (2015: online)



Figure 4 : Ebotse pre- and post-development  
 Source: Google Earth (2016)

		Relevance			
		Relevant	Related indicator relevant	Relevant but missing	Irrelevant
Data availability	Available				
	Potentially available				
	Related data available				
	Not available				
Legend			To be used		To be identified
			To be modified		To be removed

Figure 5: Relevance and data availability matrix  
 Source: Taken from UN (2007: 34)

interviews, case study information, results from examining the literature on sustainable development, and analysing development policies forms the data for this study. Qualitative research allows for thematic analysis to analyse and compare data; this is a flexible method used to present a detailed and nuanced account of data by transcribing, coding and setting themes from the literature, interviews and case studies (Clarke & Braun, 2013: 120).

**4.1 Data collection**

Some information was not available in the public domain. In 2016, interviews were conducted with nine key industry professionals and public officials, including the Operations Director: Ergo Mining Operations (Pty) Ltd, Town Planning Consultants, Environmental Assessment Practitioners, EMM: City Planning Head of Department, EMM Regional Development Planners

and EMM Division Head: Spatial Planning. Typical questions included what their respective roles and input were; what risks were identified; what constraints were encountered during the development process; what environmental management techniques were imposed; familiarity with sustainable development goals; new growth objectives or sustainable development technologies; whether such goals, objectives or technologies were incorporated in the development; environmental quality pre- and post-development; whether the development added value to the area and how; if inclusionary housing alternatives were considered; financial models, expenditure and funding, and what incentives were received or granted, for example, regulatory concessions or liability relief. Consent of all participants to be interviewed and voice recordings were obtained.

The primary (Ebotse) case study was selected, due to location, significance as well as access to information and key stakeholders. National and international case studies identified and evaluated included Eagle Canyon Golf Estate, Elsburg Tailings Complex, Benoni Dump and mine tailings 5L29 and 5A4, as well as Karvina and Svinov in the Czech Republic.

## 4.2 Data analysis

Voice recordings of the interviews were transcribed into written text, making use of gisted transcription (Denscombe 1998: 130; Braun & Clarke, 2006: 87-88). Gisted transcription retains sufficient context for analysis; yet it excludes utterings and vocal sounds that do not influence the core information. In addition, fieldnotes were used to capture non-verbal communication (body language) and situational context (Paulus, Lester & Dempster, 2014: 98; Denscombe 1998: 127, 130). While systematically examining and evaluating literature and transcripts, themes were categorised as patterns, and ideas emerged (Strauss & Corbin, 1998: 66; Braun & Clarke, 2006: 79-80). Thematic analysis combines and arranges written text into a coherent data set, which was triangulated with transcriptions of the interviews.

For content analysis, ‘sustainable measurement tools’ were used, specifically, Smart Growth Concepts (SGCs) (Jepson & Edwards, 2010: 421-422; Arku, 2009: 256) and ‘sustainable development indicators’ developed by the Leadership Council of the Sustainable Development Solutions Network (SDSN) (SDSN, 2015: 34-35). SDSN indicators were specifically developed to track sustainable development progress on a domestic level aligned with

global MDGs and SDGs goals and targets (UN, 2007: 6, 21-22, 27-28). The measurement tools, specifically Goal 11: Sustainable Cities and Communities (UN, n.d.: online), proved to be flexible enough, as the research data could be linked to primary themes, using a ‘relevance and availability of information matrix’ (Figure 5) (UN, 2007: 34).

For the purpose of analytical comparison, a generic SWOT analysis indicating internal and external advantages and disadvantages of greenfield and brownfield developments was compiled, forming the basis to determine which is more sustainable. The compared information was quantified using a basic Likert scale, where SC = substantial compliance/efficiency, PC = partial compliance/efficiency, and LC = limited compliance/efficiency.

## 4.3 Limitations

Comparative case studies and the majority of the written text examined apply to the Gauteng province; therefore, the outcomes could differ from one province to another. In addition, the study parameters were restricted to the measurement indicators of Goal 11, as defined by the UN’s SDGs. Some documents were also formulated prior to the publication of the SDGs and do, therefore, not account for environmental considerations previously excluded from the MDGs.

## 5. RESULTS

### 5.1 Thematic analysis

Smart Growth Concepts (SGCs) have inadvertently been implemented for almost two centuries and Sustainable Development Solutions Network (SDSN) such as creating a sense of place, providing various housing types, public transportation modes, densification, etc. were easily aligned with SDSN indicators. Relevant indicators were also determined, using the relevance and availability of information matrix (Figure 5) (UN, 2007: 34). The applicable primary themes are listed vertically in Tables 1 and 2.

The themes are broad overview concepts that have been divided into second tier themes as part of the thematic analysis process. Table 3 shows a comprehensive record of subthemes adapted to sustainable urban development represented by SDSN indicators 67 to 71 in combination with SDGs. The availability of applicable information is divided into four categories comprising information that is fully available, information that is potentially available at reasonable cost and time frames, alternative related information, and information that is not available. For instance, although it is recognised that “poverty” comprises additional issues such as income equality,

Table 1 : Sustainable Development Solutions Network indicator thematic linkages

SDSN indicator	Poverty	Governance	Health	Demography	Atmosphere	Land	Fresh water	Biodiversity	Economic development	Consumption and production patterns
	67 Percentage of people within 0.5km of public transit running at least every 20 minutes	■	■	■	■	■	■	■	■	■
68 Ratio of land consumption rate to population growth rate, at comparable scale	■	■	■	■	■	■	■	■	■	■
69 Mean urban air pollution of particulate matter (PM10 and PM2.5)	■	■	■	■	■	■	■	■	■	■
70 Percentage of urban solid waste regularly collected and well managed	■	■	■	■	■	■	■	■	■	■
71 Area of public and green space as a proportion of total city space	■	■	■	■	■	■	■	■	■	■

Table 2 : Smart growth concept thematic linkages

SGC principle	Poverty	Governance	Health	Demography	Atmosphere	Land	Fresh water	Biodiversity	Economic development	Consumption and production patterns
1 Work-housing balance	■					■				■
2 Spatial integration of employment opportunities and transportation	■					■				■
3 Mixed land use			■			■				■
4 Use of renewable energy sources		■	■			■				■
5 Energy- and resource-efficient building and site design		■				■				■
6 Pedestrian accessibility			■		■	■				■
7 Housing affordability	■	■		■						
8 Housing diversity	■			■		■			■	
9 High-density development	■			■		■		■	■	■
10 Protection of natural and biological functions and processes			■		■		■			■
11 Involvement and empowerment				■						■
12 Social spaces			■						■	
13 Sense of place			■	■						
14 Inter-modal transport connectivity		■		■	■	■			■	■

social insurance and labour market interventions, the subthemes were excluded, since they are not relevant and no supporting information is available about the primary case study. Although Table 3 shows a comprehensive record of all SDSN indicators relating to Goal 11, only core indicators that are relevant to the primary core indicator and supported by data were selected as suitable evaluation measures (Table 2).

**5.2 Analytical comparison analysis**

The last three columns in Table 3 show the compliance and efficiency comparison results, whether limited, partial or substantial, that was contemplated based on current and applicable local development processes and resources as well as actual case study outcomes. Relevant indicators, in light grey, were also determined, using the 'relevance and data availability matrix' (Figure 5) (UN, 2007: 34).

**6. DISCUSSION**

An analytical comparison determined that brownfield and greenfield

developments represent opposite ends of the development scale. For instance, whereas brownfield sites comprise the redevelopment of previously developed, contaminated, derelict or vacant land, greenfield sites comprise unpolluted and pristine, newly built areas generally located close to the urban fringe. In addition, since land at the periphery of an urban area is usually less expensive than prime infill land, developers can procure larger land

parcels that are typically developed with large erven. Greenfield sites are thus linked to unlimited outward development, contribute to urban sprawl, are less energy efficient and consume a considerable amount of natural resources.

**6.1 Thematic linkages results**

Central thematic linkages indicated in Tables 1 and 2 are illustrated in Figure 6. Socio-economic themes, including Governance, Land and

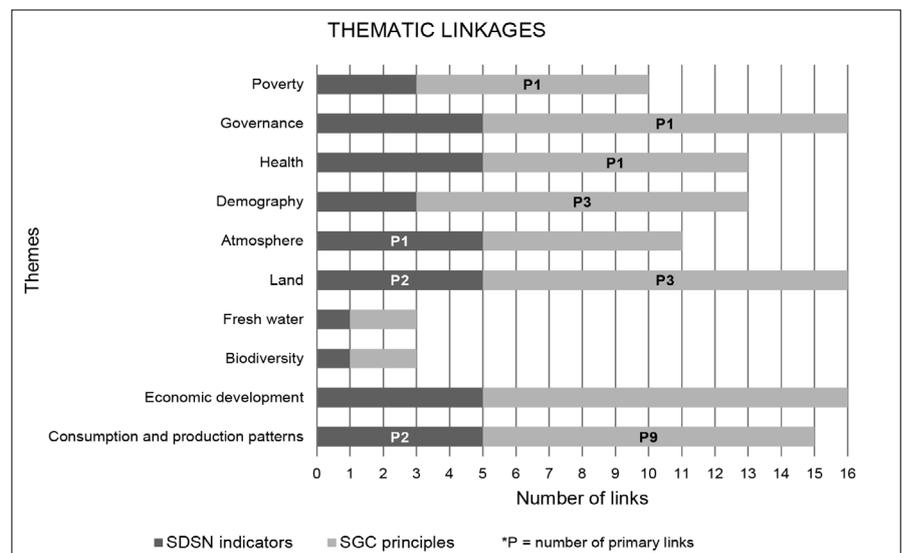


Figure 6: Thematic linkages

Table 3: Combined SDSN and SGC indicator Likert scale

Theme	Subtheme	Indicator	Brownfield			Greenfield			Ebotse*		
			SC	PC	LC	SC	PC	LC	SC	PC	LC
Poverty	Sanitation	Proportion of population using an improved sanitation facility	X			X			X		
	Drinking water	Proportion of population using an improved water source	X			X			X		
	Access to energy	Share of households without electricity or other modern energy services									
	Living conditions	Proportion of urban population living in slums									
Housing affordability			X			X				X	
Governance	Legislation	Regulations and frameworks effectively managing spatial development			X			X			X
		Sense of place	X			X			X		
		Partnerships, meaningful involvement and empowerment			X			X			X
	Capital investment	Proportion of annual budget allocated for infrastructure construction	X			X			X		
Proportion of annual budget allocated for environmental management (actual remediation)				X			X			X	
Health	Healthcare and services	Percentage of population with access to primary healthcare facilities									
Demography	Population	Population growth rate (efficiently accommodated)	X					X			X
		Dependency ratio									
Atmosphere	Climate change	Carbon dioxide and greenhouse gas emissions**	X					X			X
	Air quality	Ambient concentration of air pollutants in urban areas*	X					X			X
Land	Land use and status	Land-use change	X			X			X		
		Land degradation	X					X	X		
		Housing density	X					X			X
		Work-housing balance	X					X		X	
		Spatial integration of employment and transportation	X					X			X
		Mixed land use					X			X	
		Housing diversity	X			X			X		
		Spatial development	X						X	X	
Fresh water	Water quantity	Proportion of total water resources uses									
		Water use intensity by economic activity		X			X		X		
	Water quality	Waste-water treatment	X			X			X		
	Water access	Maintenance and provision of piped infrastructure services	X			X			X		
		Groundwater extraction									
Biodiversity	Ecosystem	Proportion of terrestrial area protected	X					X	X		
	Species	Abundance of invasive alien species		X			X		X		
		Abundance of selected key species									
Economic development	Employment	Employment-population ratio, opportunities	X					X	X		
	Research and development	Expenditure on research and development as percentage of GDP			X			X			X
		Expenditure on sustainable development			X			X			X
Consumption and production patterns	Material consumption	Material intensity of the economy									
	Energy use	Annual energy consumption, total and by main user category									
		Share of renewable energy resources in total energy use									
		Use of renewable energy sources		X			X				X
		Energy- and resource-efficient building and site design	X						X		X
		Intensity of energy use, total and by economic activity		X			X			X	
	Waste generation and management	Waste treatment and disposal	X			X			X		
	Transportation	Modal split of passenger transport	X						X		X
		Energy intensity of transport	X						X		X
		Access to safe, reliable road networks	X			X				X	
		Pedestrian accessibility	X						X		X
		Social spaces	X						X		X
		Inter-modal connectivity	X						X		X
		Access to reliable public transport, excluding passenger taxis			X				X		X
	Open space	Land conversion for urban development	X						X	X	
		Protection of natural and biological functions and processes	X						X	X	
			28	6	6	10	6	24	19	4	17

SC = substantial compliance/efficiency, PC – partial compliance/efficiency, LC = limited compliance/efficiency

\* Ebotse compliance evaluation based on actual outcomes excluding proposed or future initiatives

\*\*Data supported by air quality study (Nagengast *et al.*, 2011)

Economic Development followed by Consumption and Production Patterns have the greatest number of thematic links and are, therefore, the key measurable elements of progress towards sustainable urban cities. Land and Consumption and Production Patterns are also indicative of the most primary thematic linkages (P-value) that correlate with the attributes and elements relevant to urbanisation, globalisation and urban development patterns. Economic development consists entirely of secondary linkages, since the primary SDSN and SGC themes, in this instance, exclude financial aspects relating to investment or gross domestic product. Apart from the Atmosphere theme, it is evident that there is hardly any emphasis on Environmental Health and Biodiversity. This indicates that environmental management, legislation and enforcement, in a local context, are relatively recent.

Figure 7 illustrates that greenfield and brownfield developments shared similar attributes regarding thematic linkages to Poverty, Governance and Fresh Water, since the indicator is dependent on implementation and execution by the local authority. Moreover, brownfield developments

performed slightly better than greenfield developments in areas of Economic Development, Biodiversity and Demography. As supported by data from the EMM's Environmental Management Framework (EMM 2007: 14), it is likely that invasive alien species are present on both development typologies. Demography, in this instance, reflects the density of a development and whether a significant contribution is made to the provision of housing for an increasing population. In addition to being classified as a brownfield site, Ebotse also represents infill development based on its location. Therefore, although densities of up to 120 units per hectare are justified and supported by policy guidelines, a significantly lower density of 12.4 units per hectare was achieved. Optimal development and design were not only inhibited by the physical development constraints, but also because the market demand was severely underestimated. However, in the absence of brownfield development strategies, the local authority consented to low-density freehold erven, in keeping with the wider area. It was modestly confirmed that higher densities would have optimised the development potential of the site, given statistics regarding

increased urban population, shortfall of housing provision and compounding human settlement targets.

In the context of this study, Economic Development indicators comprise budget allocation to research and development as well as sustainable development. Governance-related indicators, on the other hand, are indicative of capital investment in infrastructure and environmental management, the efficiency of regulatory processes as well as the implementation of legislation and enforcement. As was evident from the EMM annual financial report, the integrated development plan as well as the service delivery budget implementation plan (EMM, 2011; EMM, 2016), the bulk of the annual municipal income (±R3.8 billion) is allocated to infrastructure services (maintenance and repairs), human settlements, real estate and administrative costs. Although the EMM declares that it will be a 'sustainable city' by 2030, a mere 0.5% of the annual budget is allocated to the relevant departments required to implement and enforce regulatory processes in order to achieve this goal (EMM, 2016: 16).

### 6.2 Comparative results

The analytical comparison between greenfield and brownfield developments in Figure 8 shows that brownfield developments substantially comply with 28; greenfield comply with ten, and Ebotse with 19 sustainability development attributes, respectively.

Considering that Ebotse constitutes a brownfield development, it was expected that the data should reflect better sustainable development outcomes. However, upon further investigation, it became clear that many of the roles and responsibilities of the target indicators are beyond the scope of the physical impact of the development. For instance, access to, and the availability of reliable public transport (excluding passenger taxis) is a service provided by the local authority. Since the service is not available in this specific area, the development scored poorly

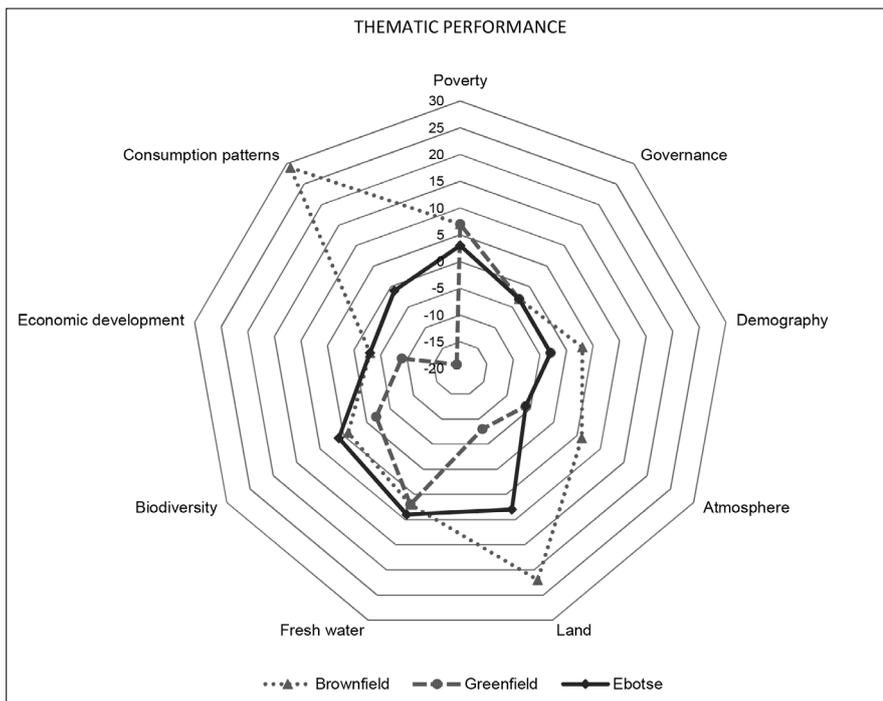


Figure 7: Thematic performance

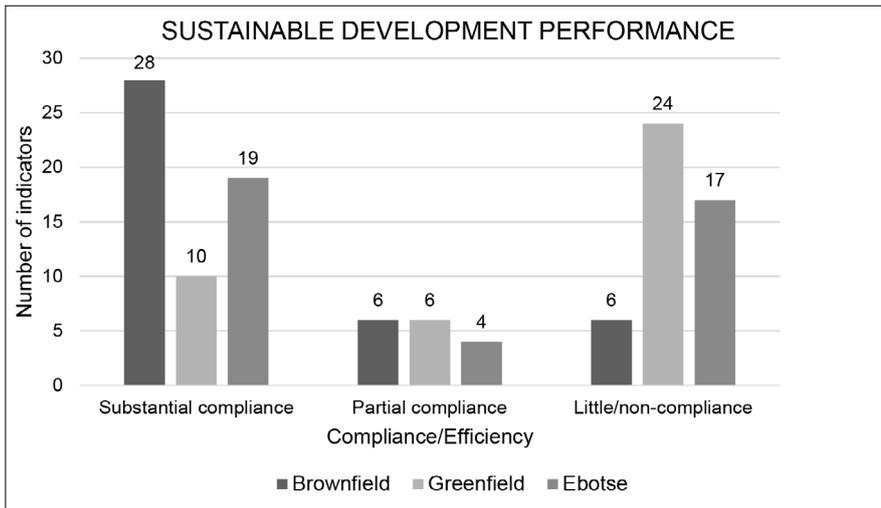


Figure 8: Sustainable development performance

in this regard. The EMM (2015: 48) proposed a bus rapid transport system in close proximity to Ebotse. When implemented, it would sway the results significantly beyond the current sustainable development measures. Unfortunately, neither the funding has been allocated for implementation nor has the project been identified as a priority in terms of the capital investment framework. As the measurement indicator could not be achieved, partial compliance was noted for brownfield sites regarding reliable public transport.

In addition, the initial development model essentially based on location, land-use type and input costs affects the possible outcomes. For example, a brownfield site located in a predominantly residential area will lend itself towards residential development, provided that the proposal complies with the relevant SDF and zoning schemes. Capital expenditure required to acquire the property and rehabilitate the site is also recovered from property sales. Without fiscal or regulatory incentives, it is unlikely that the private sector will redevelop brownfield sites located in previously disadvantaged communities, since development costs will exceed the return on investment. For instance, with Ebotse, the rehabilitation costs, prior to the construction of any habitable facility, were estimated at over R60 million, which cannot be justified in affordable housing schemes

(Ebotse Golf and Country Estate, 2008). These factors determine the target market, which, in turn, is a deciding factor regarding housing type, diversity and affordability. The key indicators relevant to these elements do, therefore, not necessarily reflect decisions made on sustainable development, but rather the feasibility of the project.

As demonstrated by Martín *et al.* (2016: 86) and Martín, Kunc, Klusacek, Krejci, Navratil and Vnenkova *et al.* (2015: 76), international legislation is far more prescriptive regarding the involvement and extent of community consultation, as opposed to the informative approach of South African laws and regulations. Community empowerment and involvement promote a sense of place, which is not necessarily driven by participation, but rather in association with a specific development or community standing. For this reason, both greenfield and brownfield developments as well as the case study contribute to creating a 'sense of place', although not necessarily through meaningful involvement of the community.

From the remainder of the categories such as 'Consumption and development patterns', 'Land' and 'Atmosphere' to a lesser extent, the comparative results demonstrate a significant disparity, which is expected, due to opposing development characteristics. With regard to the

'Land' category relevant to the Ebotse case study, it was confirmed that the development of a golf estate was the most suitable alternative use, given the development constraints. The development scored very well in this regard, but it fell short when measured against 'Land-use diversity' and 'Integration of employment opportunities' and 'Transportation'. 'Consumption and production patterns' comprise various subthemes and indicators from material consumption, energy use, transportation, waste generation and management to the conversion of open space into developed land. By redeveloping, re-using and recycling derelict land, open space systems and terrestrial land are conserved and protected. The consumption of natural resources as well as biodiversity and habitat loss are reduced, and the integrity of natural and ecological systems are subsequently maintained.

In general, Ebotse proved to be marginally more sustainable than typical greenfield developments, not because of imprudent development directives, but due to external factors beyond the developers' control. Such factors include development constraints, ambiguous regulatory processes as well as the lack of supporting public services. Therefore, predictably, the results would reflect similar outcomes for all brownfield sites, due to incoherent and detached development processes and partnerships. It is, therefore, not surprising that the private sector prefers greenfield developments, since land is generally cheaper, undeveloped and flexible in terms of design. Moreover, development of greenfield sites is less challenging, since uncontaminated land reduces risk exposure and remediation costs, and no incentives, whether fiscal or by means of streamlining regulatory processes, are extended by the local authority for brownfield redevelopment. Overall, Ebotse has contributed to revitalising the area, improving the aesthetic value of the site, job creation during construction and operational phases, financial investment as well as an increase

in tax revenue. The development had an overall positive impact on the area and economic growth.

## 7. CONCLUSION

The significance of redeveloping brownfield areas, especially in the Ekurhuleni Metropolitan Municipality in the Gauteng province, are significantly underestimated. This article adopted a thematic analysis based on data from interviews, case study information and literature.

From the literature review, it was clear that mine dumps and slimes dams are prominent features in the urban landscape of the EMM, and the land use category is noted and indicated as such in the relevant SDF. It is obvious that the development potential of these features is not completely understood, since not a single redevelopment strategy is available. For this reason, the article builds on the findings of Potts and Cloete (2012: 398) in that no formal definition or terms of reference for brownfield developments is currently documented.

The EMM Annual Report identified the mine-dumps environment as a priority strategic risk, specifically regarding non-compliance with legislation and regulations by EMM departments as well as private sectors. At present, the Mineral and Petroleum Resources Development Act (MPRDA) effectively regulates such risk and liability factors by delegating the accountability and responsibility to the mining permit holder. However, brownfield sites do not only comprise mine dumps or slimes dams; derelict, vacant and previously developed land is also included. Thus, where mining activities are not applicable, liability and rehabilitation are not regulated. Moreover, the interviews confirmed that the local authority distance themselves from such responsibilities, even on Council-owned land, since alienation of land resolutions specifically states that all costs pertaining to the development are for the developer's account.

Based on the findings from the thematic analysis, brownfield developments, in general, are more sustainable in the long-term than greenfield developments in terms of Demography (population growth rate), Atmosphere (carbon dioxide and greenhouse gas emissions, ambient concentration of air pollutants in urban areas), Land use (land degradation, housing density, work-housing balance, spatial integration of employment and transportation, housing diversity, spatial development) and Biodiversity (proportion of terrestrial are protected).

## 8. RECOMMENDATION

Although the comparative case studies and the majority of the written text examined applies to the Gauteng province of South Africa, overall, the successful implementation of sustainable development challenges cannot happen without recognising the significance of meaningful partnerships.

Sustainable development of mine dumps is possible through effective stewardship of all spheres of government in co-operation with the private sector. It is recommended that limitations within government organisational structures be acknowledged, but that, by engaging in meaningful partnerships expertise, knowledge and information be shared to ensure capacity-building and strengthening. Holistic and sound development outcomes are, therefore, possible through meaningful engagement and the establishment of public-private partnerships.

Although brownfield development is still an emergent concept in South Africa (perhaps due to a lack of knowledge, inexperience, the lack of partnerships, and avoiding any possible risks and liability), it is recommended that the findings of the Potts and Cloete (2012) study be examined and their proposal be adopted, in order to facilitate the formulation and implementation of clear development

strategies and avoid ambiguity. Moreover, it is imperative that redevelopment of brownfield sites be not viewed in isolation, thereby overlooking spatial variation. Policies, regulations and legislation should be aligned and updated accordingly. The implementation and enforcement of legislation with regard to liability and accountability need to be addressed within both public and private sectors. It is recommended that legislative processes and regulation be re-evaluated and refined to ensure effective and impartial enforcement.

It is recommended that government evaluate and consider incentive programmes to stimulate the redevelopment of brownfield sites. Various funding models should be investigated, based on the development potential of the specific site, independent of the local authority's framework for capital investment. For example, the potential yield of undeveloped brownfield sites within EMMs boundaries could contribute approximately 100,000 housing opportunities to the EMM backlog, which is currently estimated at 144,000 units. In addition, redressing a fragmented city form, social inclusion, social inequality and land reform are elements that could be resolved in this manner.

Brownfield development should be recognised as a proactive initiative that has the potential to accomplish several vital development and growth strategy objectives, including land reform. Apparent benefits include, among others, conservation and protection of open space and natural resource systems; reduced vehicle dependence and urban sprawl; contamination and site rehabilitation; improved human and environmental health; increased tax revenue; job creation; optimal use of existing infrastructure services; social inclusion, and reduced inequality. Aside from unique challenges associated with the redevelopment of brownfield sites, it is an essential component in making our cities more sustainable.

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