Changing Space, Changing City

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The City of Johannesburg stretches approximately 80 km in length and 50 km in width along a diagonal north-east/south-west bearing. Its elongated form covers an array of topographical, geological, vegetative, soil and climatic zones. Zonal differences are visible, for example, in the denser vegetation north of a line of ridges that cuts in an east-west direction across the centre of the city, the concentration of grasslands in the south and south-west, and the natural wetlands and lakes in the south-east (Plate 40). The variety in the physical geography and the natural environment reflects to some extent the impact of human settlement in the region, especially since the late 1800s, as well as the choices that have been made around the planning and design of these settlements. The characteristics of the physical environment also recursively shape the possibilities and prospects for the human interventions that impact on nature and on the city’s natural assets.

Unfortunately, as I show in this chapter, many of the historical and even some of the present planning and development decisions and actions shaping space in Johannesburg take little cognisance of the physical constraints implied by the pre-existing natural forms and features on which the city is built. This is apparent both at the settlement level, for example with respect to where certain urban forms are allowed to exist, as well as at the level of the urban fabric, where interventions such as greening of neighbourhoods through tree-planting initiatives are applied. Contradictions between the physical nature of the city and the urban planning processes sometimes lead to unexpected or undesired results. If some of the difficulties in the way the city interacts with its natural environment are to be overcome, the differences in the geographical expanse of the city and the limits implied
by each of the city’s varied geologies, topographies and ecosystems, have to be taken into account when spatial policy is developed and planning decisions are made.

I cover three matters in this chapter. In the first section I provide an overview of the natural environment, highlighting key geological, climatological and ecological characteristics across the city, and the most important implications thereof for human settlement planning and design.

In the second section I provide a summary of some of the key impacts that the dramatic expansion of human settlement in and around Johannesburg has had on the natural environment – both positive and negative. The key issue is not simply whether damage has been caused to nature. In all rapidly growing cities, where millions of people gather together and millions of tons of concrete are poured into built forms, damage is unavoidable. The question is rather how, in ways that are particular to this city, urban development has interacted with nature in ways that could have been avoided, and where the long-term costs and risks, for both the natural environment and for the people living in potentially physically vulnerable areas, have not always adequately been considered and planned for.

In the same vein, but from a different angle, in the third section I look at how human intervention in relation to the environment seems to have had some positive impacts, but there are nevertheless some poorly understood challenges. The conservation of certain areas, even in the face of very rapid urban development, is worth noting, and in this regard, I discuss why the Klipriviersberg Nature Reserve (KNR) is one of the potential success stories. However, some apparently positive environmental interventions that are being augmented by the City of Johannesburg are potentially problematic precisely because they do not adequately take into account the limits implied by the pre-given natural characteristics of the areas in which they are being implemented. I consider this issue using the case of Johannesburg’s remarkable urban forest. While the urban forest is a source of pride locally, is recognised internationally and provides key ecosystems services that hard infrastructure cannot furnish, it also has some intrinsic drawbacks. More importantly, I argue that the massive tree-planting programmes in the south of the city, that aim to replicate the urban forest that has existed for more than a hundred years in the city’s wealthier northern suburbs, are somewhat misguided.

While these greening programmes reflect well-intentioned equity concerns, they fail to consider the very real limits imposed by the given natural differences, such as vegetation zones and rainfall patterns, between the north and south of the city. In the pursuit of homogeneity – and in the face of inescapable variations in soil composition, climate, rainfall and predominant vegetation types – these projects may miss valuable opportunities for the development of more suitable natural assets, features and spaces that more appropriately reflect the micro-environmental conditions of the local areas and that would be more sustainable in the long term, requiring less maintenance and upkeep.

I conclude with some thoughts on the implications of this analysis for the potential design of improved urban planning policies and environmental programmes that aim to either preserve or transform the natural environment.
The given natural environment

Key geological features of the city

Johannesburg’s geological past determines its topography, and this in turn shapes some of the physical changes that are possible and probable in the city’s natural and constructed environments. It is therefore necessary to understand how the area’s underlying geology determines the urban form and natural environment.

Approximately 3.5 billion years ago, the ‘Johannesburg Dome’ appeared in the Gauteng region as a granite intrusion. The granite eroded over millions of years to reveal ridges that characterise many areas of the city today. The Dome is situated within what is known in geological terms as the Witwatersrand Supergroup, which forms an approximately 8-km-thick sedimentary layer (Cripps 2011). The concentration of gold in conglomerate upper layers of the substrata is unique, since most of the world’s other gold deposits occur in fault zones (Gibson and Reimold 2001). A large number of the gold-bearing seams occur in layers of kerogen or carbon, which have their origins in lichen-like organisms. When they were alive, these organisms accumulated inorganic materials, particularly radioactive and heavy metals such as uranium, iron sulphide, cobalt, nickel, manganese and aluminium (Cripps 2011; McCarthy 2010). Throughout the city’s mining past, these minerals have been exposed to oxygen, and together with the deposition of mining waste rock on surface dumps, they ultimately gave rise to the acid mine drainage (AMD) concerns now facing the city (McCarthy 2010).

Approximately 2.3 billion years ago, the Witwatersrand Supergroup was overlaid by the Ventersdorp Supergroup when a 1.6-km-thick outpouring of lava took place. This led to the creation of faults and folds on the northern edge of the Witwatersrand Basin, creating additional ridges and valleys. Shortly thereafter a marine intrusion laid down one of the earliest carbonate deposits on Earth (Cripps 2011), forming a collar of dolomite around Johannesburg (Plate 40). Dolomite presents the risk of subsidence (dolines) and sinkholes, and poses a significant challenge to the densification of settlements in some parts of the city. Around the same time, a 10-km-diameter meteorite crashed into the Basin near Vredefort, 120 km south-west of Johannesburg. The impact caused the geological layers to slope towards the impact zone, forming Johannesburg’s quartzite ridges which range from 150 m to 250 m in height. These physical features, along with apartheid town planning in the region, forced an environmental habitat and a human socio-cultural divide which remain in place even though historical town planning policies have since been abandoned.

The influence of topography, hydrology and climate on development

The perennial rivers (Plate 40) that have their origins in the ridges of Johannesburg are on a continental watershed between the Indian and Atlantic oceans. The northern streams run into the Crocodile River, ultimately joining the Limpopo River that flows to the Indian Ocean on South Africa’s east coast. The southern rivers flow into the Vaal River (‘vaal’ meaning dull), and then into the Orange River towards the Atlantic Ocean on the west
Thus, the region forms a ‘water tower’ for southern Africa, which means that water management in Johannesburg, and any associated water usage or contamination that takes place in the area, has repercussions far away from the city.

The slope of the ridges has a bearing on the velocity of stormwater, with the ridges often having steeper slopes to the north. The clear water of the fast-flowing northern rivers contrasts with the slower-running southern rivers that tend to be muddy and characterised by wetlands. It is necessary to take these physical differences into account when considering the homogenisation of the natural environment of Johannesburg. Given these physical differences, it is somewhat inappropriate to expect river programmes on the north and to the south of the divide to achieve streams with similar physical properties. This is true even when considering water quality concerns related to mining and industrial activity to the south of the city.

The areas north of the ridges show slightly higher rainfall and temperatures and experience less frost in winter than the south of the city. The effect of urban heat islands (where buildings retain heat during the night, thereby effectively raising the ambient temperature) exacerbates the seemingly insignificant differences and causes less temperature fluctuation between day-time and night-time temperatures in the more densely populated areas of the city. This means that the city centre and formally built areas are slightly warmer. In addition, the northern areas are more humid due to increased moisture retention as a result of the increased number of trees, thickets and shrubs in these areas. These details influence vegetation types in small but significant ways. In contrast, spatial interventions such as the planting of trees and development of parks often consider average moisture and temperature conditions in the region. The significance of slight and seemingly benign differences in micro climates results in dramatic differences in the viability and predominance of certain types of vegetation in different parts of the city. Given to these different micro climates, it could be deemed inappropriate to plant the same species of vegetation in the north of the city and in the south (where grasslands historically dominate) – something that seems to be forgotten when designing greening programmes for the city.

Topography also drives property price differences and open space delineations. Properties on the ridges are generally more expensive and sought after. The northern suburbs are also better served by public amenities and by the spatial distribution of developed parks and public open spaces versus population density than the south of the city (GCRO 2012). The ridges and valleys further drive development related to bulk infrastructure and transport routes which often double as biodiversity networks providing protective links despite increased development pressure and densification of the city. Where the servitudes and ridges are more defined or isolated, biodiversity has a greater chance of reproduction. Such areas also present ideal locations for urban ecotourism, such as walking trails. These elements reinforce the spatial inequalities that urban planners have to overcome when considering the need for equitable open space for all citizens in Johannesburg. In the drive towards decreasing inequalities in the city, the physical nature of the land is key to the reasons for and solutions to continued disparities.
Soils and vegetation lend the landscape its character

Apart from climatological and topographical considerations, the soils to the far south and far north of the city tend to be sandy, and historically used to support a variety of grassland species (Plate 41). In contrast, the rich soils in the central and northern suburbs, along with years of fertiliser application (albeit with associated groundwater contamination) through private and public garden maintenance, provide growth opportunities for more leafy shrubs and water-hungry trees. The bluegum trees planted to provide material to support underground mine workings during the early mining years are part of this latter group.

The south-east of the city is desperately in need of improved environmental amenities to enhance the quality of life of the inhabitants of the area. However, it seems difficult to utilise and maximise the value of the large stretches of wetlands in this area. The quality of the wetlands has been undermined through inappropriate development and unstructured land use. Although environmental practitioners and officials recognise the value of these resources for their ability to provide ecosystem services, notably to act as filtration systems in aid of water-quality improvement, without public appreciation their task remains a difficult one.

These challenges give Johannesburg opportunities to harness the varying characteristics of its natural environmental and to transform its greening policies and methods through more appropriate planting regimes, including the planting of species that are best suited to the different micro climates that stretch across the city.

Key impacts of human settlements on the natural landscape

Large and densely populated human settlements invariably alter the natural environment. The key is to prevent negative and avoidable impacts wherever possible and to apply customised solutions for different parts of the city, depending on available resources and residents’ needs. This means that it may not be possible to afford every resident in the city access to the same types of natural resources, but rather to provide for the equitable distribution and quality of such resources. In this section I explore some of Johannesburg’s relationships with and impacts on its natural landscape, using selected examples.

Even though integrated town planning incentives were developed after apartheid policies and planning were abandoned in South Africa, the main thrust of development has unfortunately perpetuated historical spatial patterns. These policies placed poor communities away from the city centre, albeit in formal settlements. The added impact of infrastructure interventions that do not consider municipal cross-border effects exacerbates the plight of these communities.

The history of the Johannesburg region is one of polycentrism, with smaller towns and urban centres springing up first along the gold reefs and then spreading to the north and immediate south as suburbs stretched away from the inner city. Surrounding most of these town centres were low-density single-unit stands in neighbourhoods served with accessible public open spaces, reserves, road networks and well-serviced infrastructure. The management of the former smaller towns as separate municipal entities created...
disparate natural landscape patterns that did not follow the regional, networked approach that is critical to effective ecosystem functioning. Apart from the provincial conservation estate, each town council or municipality decided autonomously where and how natural spaces would be created. This meant that even though town planners in what is now the metropolitan municipality of Johannesburg had good intentions and well-planned internal spatial designs, their programmes for the creation and maintenance of reserves, open space networks and wetland and ridge policies were disjointed across the early town boundaries.

Within this disconnected suburban model, areas such as Soweto, Orange Farm, Tembisa and Alexandra have attracted large population densities along with few open spaces and generally derelict ecosystem services, where residential areas often encroach into unsuitable areas such as wetlands, flood plains and dolomitic land. This disjointed interaction between the physical environment and human need, especially in densely populated areas, presents challenges. If these challenges are approached from the perspective of utilising the available and remaining natural environment effectively and in accordance with the given topographical and climatological elements, the city could be transformed into a more sustainable and liveable entity.

The concepts of environmental development planning, including recognition of the importance of ecosystem services and biodiversity corridors, are relatively recent considerations in urban design. The notion of ‘designing with nature’ emerged in the 1970s and only took a firm hold in South Africa in the early 1990s, with associated legislation promulgated much later. This historically determined form and function of Greater Johannesburg has resulted in an urban centre that is for the most part devoid of well-maintained and accessible open spaces, suburbs that often have parks that are underutilised, and lifestyle estates that protect enclosed ecosystems. Although these spaces were not particularly well planned to begin with, there are attempts to preserve natural areas. The KNR, which is discussed later in this chapter, is worth highlighting.

Development on potentially dangerous ground

When considering the physical environment within which Johannesburg’s planning and development regime finds itself, the management and maintenance of, and awareness programmes about, potentially dangerous ground require attention. Areas such as flood-prone locations, ground underlain by dolomite and land close to mine-residue areas (MRAs) are often perceived by residents to be ‘worth the risk’ of living on, given the benefits of these areas being close to transport networks, work opportunities, schooling and other amenities. Often, development responses and awareness programmes that are designed without an understanding of the potential dangers result in contentious decision-making, misunderstandings and even court cases. It places a responsibility on decision-makers to consider that, should they fail to take into account key natural constraints and educate residents about them in a non-technical manner, residents would potentially face great risks in future.
Dolomite

As mentioned earlier, a feature of the Johannesburg geology includes a band of dolomite that lies across the city from east to west. Karst landscapes result from the interaction between weathering forces such as rain and leaking water infrastructure, and the water-soluble dolomite (Jack 2011). Dolomitic ground refers to land underlain by dolomite up to 100 m underground (Heath et al. 2007). In essence, water combines with carbon dioxide \((\text{CO}_2)\) in the surface soil to produce a weak solution of carbonic acid \((\text{H}_2\text{CO}_3)\) which slowly dissolves the dolomite (Jack 2011), resulting in the dissolution of the rock over many years. As a result, fissures and underground caverns may gradually open throughout the sub-surface. When the ground can no longer withstand the topsoil or infrastructure weight above it, subsidence or sinkholes may occur – either over a period of time or instantaneously.

Dolomite does not present an even hazard pattern across any given area: hazard zones occur based on the presence of underground water, caverns, bedrock or rock ‘pinnacles’. The water table also plays an important role, since when it is lowered it opens up voids which may eventually cave in (Florida Department of Environmental Protection n.d.). Therefore, predicting the hazard level is a challenge because it follows no defined pattern or definable arrangement.

When allowing settlement on dolomitic ground, developers need to fully understand the hazard level as well as changes that may occur in the hydrological regime after development. Poor maintenance of water-bearing infrastructure, resulting in leaks or long-term ponding of water, the presence of unlined stormwater canals, and unmanaged borehole water extraction escalate the hazard level beyond what may have originally been estimated (Brackley et al. 1986; DPW 2010; Schöning 1990).

Development on this type of land is often avoided, the preference being to set it aside for park or conservation purposes. Where development does occur on dolomite, strict planning processes are involved. In South Africa, well-defined requirements and guidelines govern the development of human settlements on dolomitic ground. Unfortunately, these guidelines do not take into account the construction of backyard dwelling units and informal settlement types that are characteristic of a rapidly expanding city such as Johannesburg. This situation poses significant challenges to city planners who are faced with a dual need to safeguard communities and to provide basic services to residents.

Flooding

Stormwater infrastructure designs, floodline delineation and flood frequency estimation all apply systematic approaches which have been subjected to significant research (Van Bladeren 2007). As a result, the flood plains in Johannesburg have been delineated in much of the city (Plate 41). However, flood plain delineation in itself does not preclude development from taking place in these zones. In addition, the strategic and legislative requirements for development in flood plains do not remain constant – in the 1970s, the 1-in-20-year floodline was considered adequate within which to restrict development; this was changed to the 1-in-50-year floodline in 1998, and currently there is a drive to manage
development even within the 1-in-100- and 1-in-200-year indicative floodlines. Thus, considerations regarding the type of development and the perceived benefits of developing in or near the flood plain sometimes override common sense.

In the city context, the weather patterns of the Highveld and topographical characteristics of the region require stormwater infrastructure to disperse vast quantities of water in short time periods. Towards the north of the city an active effort was made, even in the early 1900s when the city started developing, to manage this concern. However, more recent densification within the urban fabric has reduced the surface infiltration characteristics, and increased the stormwater velocity to such an extent that some of the earlier-built canals are unable to cope with the new flow dynamics. The channels are often overloaded beyond capacity and often existing attenuation structures are insufficient to manage the flow.

Towards the south of the city where level ground abounds, stormwater challenges manifest differently. Areas of high-velocity flow and deep flows remain, but in general the flood plains are wider than in the north. Here, a common problem is the long-term ponding of water after storms, even where areas are far away from streams (Ngie 2011). In addition, informal development and the proliferation of backyard dwelling units are placing an increased burden on the capacity of stormwater reticulation systems, canals and rivers to manage the run-off that ensues after rainstorms.

In all areas across the city, the collection of solid and garden waste in stormwater channels and in rivers is cause for concern. So too are the large quantities of oil and heavy metals that collect from road surfaces and end up in the streams. Too often, litter is simply allowed to flow into the stormwater collection sumps and pipes, often blocking them. When the stormwater eventually reaches a natural watercourse, it is comparable to waste water rather than rainwater, with downstream dams, users and waterworks bearing the load of not only the solid waste, but also the associated contamination of the water.

Another challenge is the local diversion of watercourses to solve stand-based stormwater problems. Changes on stands are often made privately without consideration of the effects thereof downstream. Some building alterations, such as paving previously grassed driveways, are not required to be formally logged, but cumulatively such small-scale changes may result in a flooding hazard downstream. On-site changes may also result in unintended effects on planned stormwater run-off characteristics for which municipal roads and stormwater engineers plan. Therefore the responsibility for hazard management lies not only with planning officials, but with each individual in the city.

Mine-residue areas and acid mine drainage

Mining-related hazards represent some of the most visible challenges of the impact of human settlement on nature in the Johannesburg region, with potentially devastating effects. These risks have arisen due to the gold mining, mineral processing and waste rock dumping that started in the 1800s. The processes released radiation- and heavy-metal-laden soil, water and sludge in and around Johannesburg, most notably along a central ‘belt’ (Plate 40). The concern, however, stretches far beyond the mining belt where it originates, creating large
expanses of contaminated air, water and land, and requiring significant resources to be committed to remediation.

When considering the location of MRAs and AMD, the city is presented with a challenge but also an opportunity. While the land affected by these hazards may be dangerous, the strategic placement of MRAs provides an opportunity to remediate well-located land for future development close to the city centre; and extraction and treatment of AMD has the potential to provide potable water for future generations of residents in the region. Examples of MRA remediation and subsequent establishment of new developments include areas such as Stormill, Robertville, NASREC, Aeroton, Ormonde, Crown, Selby and Heriotdale. Once remediated, such areas provide opportunities in the form of much needed space in the heart of the city. At the same time MRAs may relieve the pressures on the natural environment by providing alternative positions for densification of industries, other than pressurising the existing open spaces and green networks.

Unfortunately, a number of hurdles remain. Key concerns relate to the lack of funds to roll out remediation and treatment options. The contaminated soil and water contain heavy metals and may be radioactive, thus being toxic to humans, animals and the ecology. Although the direct land area that is covered is relatively small, the impact of the mining hazards is significant in terms of the pollution downstream, with suburbs such as Davidsonville, Fleurhof and Riverlea staring major environmental health concerns in the face.

The presence of hazards such as dolomite, AMD and the envisaged impact of climate change, which predicts increased storm intensity in the region, highlight the need for careful consideration of greening strategies and interventions that promote urban sustainability, as opposed to merely managing environmental hazards. A proactive process that focuses on preventative action and awareness among citizens is necessary to ensure that development and upgrading take place in a more sustainable manner, and that residents apply an awareness of risk not only to themselves and their households, but in the wider community too.

Environmental services in the city
Parks and the urban forest

In this section I step back from the geology- and topography-driven environment, opportunities and challenges and investigate the interaction of humans with the environmental services which the city provides. I investigate the negative and avoidable impacts of development on the environment, which rebound on the residents of Johannesburg.

Throughout Johannesburg’s history, the need to formalise the establishment of natural reserves within or close to the city was recognised. The large number of proclaimed nature reserves in the city is proof of the psychological value placed on the ecology as part of city governance. In an effort to consolidate the combined open space estate of Johannesburg and address imbalances the municipal-owned enterprise (MOE), Johannesburg City Parks, has focused on the maintenance of existing reserves and the development of approximately
60 ‘flagship parks’ since the early 2000s (some of which had been previously developed to some extent). In addition, there are more than 1 200 other developed parks distributed throughout the city (JCP 2010). Within this natural landscape, the opportunity exists to enhance its significance further, and focus on increased public service delivery through the utilisation of natural ecosystems and networks. Such a shift would provide much needed socially acceptable open spaces across the city, in particular in areas where publicly accessible natural spaces are lacking.

The opportunity that exists for green space enhancement goes further, and includes activities related to the urban forest. In addition to the sandy soils mentioned earlier, the south of the city and Midrand in the north have a low natural forest base to reproduce from. Since there is naturally more grassland and fewer existing trees in these locations, there are fewer seeds from which new trees can naturally propagate. Where trees do take hold they often present stunted growth. In comparison, the trees and shrubs in the northern suburbs provide intensive seeding opportunities, thereby promoting natural growth of the urban forest in these locations. The cycle of such increased urban forest regeneration and associated increased moisture retention further improves the conditions for vegetation growth, and the high percentage of foliage ensures that small trees and shrubs are protected from the sun, thereby improving the potential for younger trees to establish themselves and in turn become ‘forest giants’. Since these conditions generally do not exist in the far north and the south, it is far more difficult for trees and shrubs to flourish.

Tree-planting initiatives throughout the city over past decades have faced practical inefficiencies related to the micro climate, as well as predominant soil and vegetation conditions. One of these programmes committed to planting approximately 200 000 trees across the city between 2006 and 2010. Although it was recognised that these initiatives in the south of the city required special attention with regard to the supply of water and regular watering of saplings, some of the trees did not survive due to a combination of factors, such as being too small and not getting adequate water at the right time, or they were damaged during the transport and planting process. In addition, the trees that were selected for planting were sometimes unsuited to the colder, harsher winters and dryer southern environments, or planted at times when optimal growth was not ensured, resulting in stunted growth and in some cases loss of the investment. Realising these errors, the tree selection and planting process was adapted in order to better apply the resource allocation associated with the greening of Johannesburg, especially towards the south.

The conservation estate

Most of Gauteng is covered by South Africa’s grassland biome, and Johannesburg plays an important part in ensuring protection of this ecosystem by contributing the Walter Sisulu Botanical Gardens, the Johannesburg Botanical Gardens and at least nine reserves. It is also reassuring to see a significant number of policies in place that direct the development of small-scale ecological spaces and networks in the city, for example within industrial, office and residential complexes. The Gauteng Department of Agriculture and Rural Development
and the South African National Biodiversity Institute recognise the Klip River and KNR as 2 of the 12 priority grassland areas in Gauteng.

With up to 83 per cent of the river ecosystems in the province being classified as endangered and 48 per cent being critically endangered, alien vegetation encroachment on the rivers in Johannesburg is of concern to conservationists. National programmes such as Working for Water, Working for Wetlands and Working on Fire, as well as Expanded Public Works Programmes, are actively engaged in clearing riverine areas such as the Jukskei River, where particular difficulties arise due to its location – river banks are often difficult to reach or sections are on private land.

While many of the ridges in Johannesburg have been transformed into residential areas, current policy and legislation in this regard is stronger than it was a few decades ago, and ridges are considered sensitive to development. The remaining natural ridges form important green belts in Johannesburg and provide safe harbour for a wide variety of species of fauna and flora, as well as promote human–nature interaction (GDACE 2008).

The challenge that officials face in attempting to maintain the city’s ecological integrity is often related to enforcement, with insufficient resources being available to police and manage the fast-developing urban area.

Although the above-mentioned programmes and activities signal a positive outlook for the city’s conservation estate, the land development threats to such areas are a constant concern. The municipality is accused of ‘selling off conservation areas that are valuable long term assets, to finance short term needs’ (KNRA 2011). Such conservation areas will be needed by future generations, not only for socio-psychological purposes, but also for their ability to provide ecological services to the city. To date, nature reserves such as the KNR, Kloofendal and Melville koppies have been preserved, but Moffat Park, the Zoo Farm, Klipriver Valley, Huddle Park and Delta Park remain under threat. The ‘Zoo Farm’ property, for example, was purchased by the city council in the early 1940s as part of a green-belt programme. A large part of the property is now being investigated by the city for residential development purposes. In the case of Moffat Park, the parkland was donated to the city with the title deed stating that it should be used for open space. However, Propco, the MOE property development company, is investigating residential development on the site. Similarly, since 2007, the redevelopment of Delta Park has been on the cards, with the land being put out to tender for private development.\(^3\) These are but a few examples, and although such development usually has to go through a process of environmental impact assessment and public consultation, it denotes the trend to develop and privatise green spaces in the city.

**Food security and the natural environment**

With agricultural land in the city representing some of the highest agricultural soil potential in South Africa, the implication is that there is spare capacity to increase local food production. However, since residential and industrial developments are mostly based on land values, valuable agricultural land in the city is often rezoned into residential areas,
as opposed to utilising the land for food security. An example of such an action without public consultation is a 2012/2013 decision made by the city to rezone agricultural smallholdings near the Walter Sisulu Botanical Gardens as residential zones, thereby paving the way for densification of residential development and subsequent loss of valuable future agricultural potential.

Other concerns in terms of remaining agricultural land in the city revolve around encroachment, unsustainable agricultural practices and safety and security. There are not many large agricultural areas left in the city, although smaller plots of urban agriculture on open land or within municipal parks (for example Bezuidenhout Park) are notable. Even on urban farming plots, traditional tillage methods and use of chemical fertilisers result in associated contamination of water resources, loss of topsoil and lower long-term yield. Therefore the city faces a real challenge to utilise not only natural open spaces, but also agricultural land, according to its ecological sustainability potential and for its best-suited purpose.

Ecosystem service provision

In this section I highlight a few diverse elements related to ecosystem services provision which, if considered when implementing greening interventions, could transform the face of the city. Improved co-ordination of tree-planting initiatives may see more indigenous trees along transport corridors as opposed to foreign species. The urban forest provides an important ecological service, reduces the urban heat island effect, reduces stormwater run-off and associated topsoil loss, and provides much needed psychological serenity to the city’s inhabitants. Unfortunately, the financial value of these less tangible elements of the city’s environmental resources has not been calculated yet and can therefore not be added to the city’s financial asset register. This opens up an opportunity to value these services in a more tangible and intervention-driven manner.

The early parks, reserves and cemeteries that are remnants from the gold-mining era serve a much needed ecosystem services function, and together with newer parks, conservancies and wetland reserves form the backbone of a network that serves the entire city. Where such spaces are derelict or are perceived to present a safety hazard, they often come under scrutiny when densification is considered. This in turn puts pressure on their natural processes, which are critical to ensuring a healthy living environment. Therefore, when greening strategies are considered, not only should the hydrologic and climatic conditions of unique areas be taken into account, but these existing spaces and their utilisation should be considered when implementing ecological decision-making processes.

Over the past decade, private-sector property developments have given rise to a significant number of ‘lifestyle’, ‘golf’ and ‘security’ estates, often on the periphery of the city. It is necessary to understand the form and function of such estates in order to recognise how they influence changes in the natural landscape. Although characterised by exclusive access to social and ecological spaces, these estates should not be discouraged outright as...
they present increased ecosystem service provision – in contrast to former township areas, which remain ecosystem-service poor.

The significant absence of rivers to the south of the city, as is evident between Lenasia and Orange Farm in particular (Plate 40), highlights the need for consideration of alternative approaches to the provision of stormwater services, parks and open space services in these predominantly water-scarce areas. In addition, wetlands, often occurring in these southern areas, require specific mention in that they have the ability to accumulate pollutants such as heavy metal minerals and radionuclides (GDACE 2008). However, there is a limit to this ability, which is heavily dependent on natural dormant and regeneration periods (i.e. dry and wet phases), and interventions that disrupt this process may have far-reaching implications. Thus, wetlands should be regarded as critical ecosystem service providers, no matter what phase they are in, and city greening strategies should focus on these areas as key ecosystem service delivery providers.

Pressures and processes in the changing natural landscape: the example of the Klipriviersberg Nature Reserve

Thus far, I have considered a range of changes impacting upon the natural environment of Johannesburg. In this section I focus on the specific example of the KNR, which stands out as the largest proclaimed nature reserve in the city, at approximately 680 hectares in extent. The pressures upon it and the management of these pressures by private-sector players and city authorities provide a prime example of how a key asset has been preserved against the odds. Some of the many pressures to which the reserve is subjected are detailed below.

Situated 11 km south of the city centre, next to the suburb of Mondeor, the reserve consists of open grassveld and ridges, which is characteristic of the transition zone between the grassland biome and the Bushveld. The reserve is host to approximately 170 species of birds and 650 indigenous tree and plant species, some of which are on the red data list. The Bloubosspruit meanders its way through the reserve which is well stocked with wildlife, including zebra, wildebeest and hartebeest (Footprint Hiking Club 2011). The area also has a rich history that can be traced back 250 000 years, when a Stone Age community lived in the area. Evidence of settlement can be found in artefacts discovered in the reserve, including ancient stone circles and the remains of dwellings that date from the 1500s (KNRA 2011).

The reserve was bought by the Johannesburg City Council in 1939. The Klipriviersberg Nature Reserve Association (KNRA) was established in 1981 as a registered non-profit organisation and public benefit organisation. The KNRA seeks to preserve the reserve for future generations and to make it available to the entire community, at little or no cost, for outdoor experiences and recreational, educational and cultural activities. In the 1980s the KNRA persuaded the then Transvaal Provincial Administration to proclaim the farm Rietvlei on which part of the KNR is located as a nature reserve. When proclamation was achieved in 1984, the KNRA assumed the role of an interest group, funded via donations, sponsorships and fund-raising activities.
At the time, the KNRA acted as managers of the reserve. In the early 1990s, the KNRA commissioned a development plan for the reserve based on land south of the proclaimed reserve that is no longer in a pristine natural state. This land, belonging to the city, contains a number of items of historical and cultural interest. These are proposed to form the focus of the plan to attract the public, in so doing increasing the utilisation and social value of the reserve as a whole. The development is earmarked to generate funds which may be sufficient to take the pressure to be self-sustaining off the reserve, thereby increasing its potential to remain as a nature reserve long into the future.

The City of Johannesburg’s parks department assumed management of the reserve in 1999, with the KNRA remaining an important link between its approximately 800 members and the authorities (KNRA 2011). By mid 2000, the KNRA’s development plan was accepted by Johannesburg City Parks. However, the latter decided to extend the fund-generating activities into the proclaimed area of the reserve and proposed that an upmarket tented camp be constructed in the reserve – thereby restricting equitable usage of the area. The KNRA opposed this proposal and requested that an environmental impact assessment be carried out before such development is agreed to.

The reserve also faces threats from infrastructure developments that detract from the recreational, spiritual, cultural and educational value of the space, and reduce the ecological service provision potential of the reserve (KNRA 2011). Some of the developments include water and sanitation pipelines running criss-cross underground and on the surface across the reserve; water reservoirs; a television booster station; an electrical substation and overhead power lines and pylons, which present visual disturbance as well as fire hazards. Other developments that presented concerns included the construction of a high mast on the highest point in the reserve, and the development of a petrol pipeline that was to cut right across the reserve. Both these developments were protested and alternative options were considered. The estimated cost for the alternative routing of the petrol pipeline was in excess of three times that of the route through the reserve. In light of the lack of measurement tools to quantify ecosystem service provision in financial terms, it was not easy to justify the cost of this alternative alignment to avoid the reserve (KNRA 2011).

Across the city, developments such as those described undermine the continued value of environmental assets that should provide social and ecosystem services to current and future generations. Since changes in the landscape remain a constant in the pursuit of densification of urban living space, the future existence of the KNR and similar reserves will probably remain under threat. While infrastructure or property developments around the reserve’s borders are visible threats, the biggest threat lies in the ignorance and apathy of the residents of Johannesburg (KNRA 2011). This case shows how a partnership between authorities and communities that are concerned about natural areas can ultimately promote more sustainable urban living. Such collaboration focuses on facilitating the protection, promotion and enhancement of the natural environment in Johannesburg, but above all else, sets a baseline for the financial and social valuation of ecosystem services.
Conclusion

The urban features of Johannesburg have an undesired influence on the efficient functioning of ecosystem services in many cases. They fragment the bio-network and contaminate the basis of its processes through, for example, soil, water and air pollution. The spatially inefficient urban form that characterises Johannesburg means that its natural landscape and ecological network is fragmented, resulting in biodiversity loss. The general encroachment of the built environment on natural open spaces and the few remaining agricultural spaces in the city plays a critical function in enabling the city’s transition to sustainability. If Johannesburg’s urban form and function follow ecologically sustainable principles by incorporating natural landscapes and ecological networks along the lines of hydrological, topographical and climatic considerations, the outcome of a densified city may be more positive. The natural environment denotes unharnessed potential for these networks of green city spaces, which run like veins of life through the built environment, to guide future changes in the city landscape.

Land-use policies, plans and programmes have critical effects on development patterns, affecting the future ability of communities to sustain themselves. Changes in the natural landscape in Johannesburg should thus take into account the intersecting issues of environmental integrity, societal demands and economic values. This leads to the following conclusions.

In Johannesburg’s fast- and ever-changing environment, there is an increased need for more space to be allocated to development. A change in the approach of officials and residents alike towards transforming the urban environment into a place where there is equitable access to quality natural environments, and where these environments are treasured and utilised, will diminish existing concerns regarding loss of natural habitats in the city.

Much benefit can be gained from community awareness campaigns that focus on the value of ecosystem services and urban agriculture, and such education should not be left up to a ‘rural development agenda’, but rather integrated into all avenues of community interaction with environmental matters. Promotion and awareness campaigns in communities regarding tree planting and gardening methods are therefore important.

Public initiatives such as revegetation (for example of MRAs) and tree planting, as well as private residential gardening and landscaping plans, should take into account local topography and soil conditions, dominant vegetation types and micro-climate characteristics, and areas should be utilised in ways to which they are best suited.

Although existing protected areas in Johannesburg may be in an acceptable state, there is a fine balance between financial resources and political will to ensure their future status. For this reason, the value of ecosystem services should be a standing item on budget sheets of municipal entities, with the suitability and value of each type being considered.

When considering the physical development framework within which Johannesburg is set, it is clear that the city cannot be managed from a singular or homogenous basis. This means that with equality being the ultimate goal of development interventions, the
objectives of policies, strategies and programmes across the city should consider the unique opportunities and constraints characteristic of each area. Just as it is inconceivable to create vast tracts of wetlands in the north of the city, so it is necessary to adjust the vision of open space delivery in the south to be more consistent with the climatic and vegetation regime of that specific area. Official changes in the natural landscape management approach also have to be mirrored by private development policy, and taken to the community through education and awareness campaigns focused on persuading communities to value the unique natural resource base of their local area.

In this chapter I explored the driving forces behind the characteristics of the natural environment, as well as changes that are taking place in the landscape, by referring to geographical setting as well as constructed changes and adaptations. By recognising the constraints that exist from a physical perspective, I highlighted the potential for land management policies, strategies and programmes to play a far greater role in purposefully transforming the natural environment into a more sustainable one. This transformation could see the emergence of an environment that is sustainably maintainable, psychologically beneficial to society, provides biodiversity habitats and networks, and acts as a catalyst for the provision of ecosystem services. In essence, despite some laudable changes which have taken place over the past few decades, the approach to transform the city into a homogenous space does not always consider differences in soil composition, climate, rainfall and predominant vegetation types.

Notes
1 Personal communication with A Barker, KNRA stakeholder and Development Consultant, Johannesburg, October 2011.
2 Personal communication with G Heath, Council for Geoscience, Pretoria, 12 October 2011.
3 Personal communication with A Barker, Johannesburg, October 2011.
4 Personal communication with A Schäffler, based on an article submitted to Ecological Economics, June 2012.

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