



The making of green urban infrastructure: The Klipriviersberg Urban Biodiversity Corridor

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Abstract

The greening of urban infrastructure is an important issue for cities in the global South. The planning of ecological corridors as part of greening urban infrastructure is a significant theme in Northern cities, especially in Europe. This article investigates the unfolding planning and development of an ecological corridor in Johannesburg, South Africa's largest urban centre. The Kilpriviersberg Urban Biodiversity Corridor has multiple aims including the upliftment of the environment of the Southern areas of Johannesburg. Its key drivers have emerged out of a partnership between a conservation agency and a local tourism and business forum. This collaboration served to implement a range of projects which address challenges in the urban environment of Johannesburg South. The enhancement of leisure and recreation in the project area can be an output of this unfolding innovative development project.

Keywords: Green infrastructure, conservation, recreation and leisure, Urban Biodiversity Corridor, Johannesburg.

Introduction

Over the past two decades 'ecological corridors' have been utilised as a method of conservation in several parts of the global North, assuming a significant role within policy development. Ecological corridors can serve an array of roles from biodiversity conservation to flood control and form part of environmental management. The establishment of green urban infrastructure through ecological corridors can be an important basis for conservation, landscape enhancement as well as the creation of improved spaces for leisure and recreation. A typical urban landscape can consist of impermeable surfaces with interspersed vegetative areas, such as parks and gardens, or remnant natural corridors, such as a watercourse (riparian corridor) with an embankment of small vegetative densities (Schwoertzig et al., 2016). Often these vegetative patches are isolated or placed under selective pressures through the development of man-made infrastructure which often encroaches on surrounding natural areas, creating a clear boundary between the two (McDonnell & Pickett, 1990; Clergeau et al., 2006; Williams et al., 2009). This situation denotes an urban environment as unfavourable for biodiversity as it threatens habitats through successive expansion and frequent changes in land use (Schwoertzig et al., 2016). The fragmentation of landscapes is a global issue which significantly impacts habitat loss and increasing distances between natural patches of vegetation which further decreases biotic populations and results in the loss of species (Hanski, 2011).

In Europe, a high level of political support is provided for the development of green infrastructure (Snall *et al.*, 2016). The European Union has adopted a strategy to improve environmental conservation, protect the status of all species and strengthen green infrastructure throughout all areas situated within its states (European Commission, 2012). Green infrastructure is recognised as a concept which maintains and restores an ecosystem through effective



management (European Commission, 2012). The utilisation of ecological corridors as a method for greening urban infrastructure aims to introduce populations of regional species into the potential habitat such that ecological corridors act as buffers of biodiversity (Snall et al., 2016; European Environmental Agency, 2014; Pauleit et al., 2011) Arguably, the benefits of green infrastructure extend beyond the sole purpose of protecting biodiversity instead they also promote the development of ecosystems services and supporting human wellbeing including by providing improved spaces for recreational purposes (Cimon-Morin et al., 2013; European Environment Agency, 2014; Kopperoinen et al., 2014).

The objective in this paper is to examine one South African case of the making of urban green infrastructure which has multiple purposes, including for recreation and leisure. The article introduces the implementation and development of the Kliprivier Urban Biodiversity Corridor (KUBiC) which is situated within the south of metropolitan Johannesburg, South Africa's largest city. The project serves two definitive roles, namely: the conservation and migration of biodiversity along vegetated road verges and the use of green infrastructure to enhance the landscape of urban areas. Following a review of the importance of ecological corridors for environmental management, the focus turns to the Johannesburg case study.

Green Urban Infrastructure

The importance of green spaces within urban areas serves to represent the quantity, quality, connectivity and accessibility of biodiversity and ecological services (Govindarajulu, 2014). Linear transportation infrastructure such as roads, railways, pipelines, powerlines, rivers and canals can play a significant role in the fragmentation of natural habitats (Munoz et al., 2015). Indeed, the expansion of urbanisation and associated linear transportation infrastructures (LTIs) are the key causes for habitat fragmentation (Antrop, 2004; Laurance et al., 2014). The specific effects of LTIs indirectly result in the decrease of species abundance and biodiversity (Munoz et al., 2015; Vos & Chardon, 1998). The individual effects of each type of LTI can result in a decrease of animal mortality through vehicle collisions, electrocutions or drownings' resulting in the isolations of populations (Gerlach & Musolf, 2000; Zachos et al., 2007; Keller et al., 2004).

Against this background the establishment of ecological corridors can serve as an appropriate tool to mitigate the fragmentation of urban landscapes through the preservation of biodiversity and the enhanced dispersal of flora and fauna between environments (Hess & Fischer, 2001). Beier et al. (2011) describe the idea of using ecological corridors as both a fine-scale and coarse-scale method within green infrastructure. It is suggested that the ability of ecological corridors to function as a site-specific intervention (fine-scale) or a methodology which facilitates movement through migration and evolutionary gene flow (coarse-scale) (Beier et al., 2011). In recent years, emphasis has been placed on developing ecological corridors as an opportunity to expand environmental spaces through habitat restoration which could allow for significant distribution of species (Killeen & Solorzano, 2008; Bernazzani et al., 2009; Rathore et al., 2012). American-based research by Gilbert-Norton et al. (2010) strongly supports the implementation and utilisation of ecological corridors providing evidence that such corridors can increase movement of species between habitat patches by as much as 50 percent.

The utilisation of ecological corridors is described as 'vague' by Van Der Windt & Swart (2007) due to its flexible characteristics and ability to be classified as either a linear, strip or stream corridor depending on the structure of the environment and the function it will serve (Qiang et al., 2005). This means that it is a 'model' which can be utilised for landscape planning (Qiang et al., 2005; Van Der Windt & Swart, 2007). Nevertheless, ecological corridors have become essential components of contemporary urban planning serving as examples of green spaces (Kai-ran, 2010). Indeed, the development of green infrastructure has been of significant importance in recent environmental research (Bennett, 2003). Li et al. (2016) introduce the term 'urban ecological infrastructure' (UEI) as an integrated framework of infrastructure to provide ecosystem services within sustainable urban systems (Li et al., 2016). Li et al. (2016: 1) define



UEI as “an organic integration of blue (water-based), green (vegetated), and grey (non-living) landscapes, combined with exits (outflows, treatment, or recycling) and arteries (corridors), at an ecosystem scale”. Therefore, the UEI framework analyses an ecosystem’s interactions between biotic and abiotic entities which underscores the relationship between the natural and artificial factors. The understanding of these factors improves the circulation of resources within urban ecosystems while the structure of the UEI introduces the significance of corridor classification.

The majority of city governments tend to focus on the form and quantity of green space, rather than its function and quality, which could potentially make it an inefficient tool in environmental management. Green land includes natural and artificial green spaces which range from urban parks to forest, farmlands to street-side green strips. However, this classification of land type plays significant roles through the provision of ecosystem services such as maintaining microclimates, filtering air, developing biodiversity or providing aesthetical appeal to urban landscapes (Li et al., 2016). A decrease in the sustainability of green land is significantly associated with the uneven distribution of ecological resources, the onset of alien invasive species and the reduced potential for use for leisure purposes.

Arteries serve as corridors that allow for the movement of materials between components of urban sprawl such as traffic (grey) and water (blue) systems. The basic function of arteries is to implement measures which distribute urban ecological corridors throughout social and economic developments while maintaining functional networks of circulation for people, materials and nature (Li et al., 2005). The implementation of effective arteries encourage practical connectivity of traffic hubs, transfer sites and disconnected river segments which might reduce issues of traffic congestion, air pollution and the heat island effect (Li et al., 2016).

Arguably, green areas require management and maintenance through the implementation of social enterprise models to ensure effective collaboration amongst authorities and the benefiting community. Thus, it is necessary to build a level of local capacity to identify technical, managerial and business skills within local communities that can help manage and maintain significant green areas (Crowe et al., 1996). Indeed, Hostetler et al. (2011) suggests that the incorporation of local initiatives will address the knowledge gap by encouraging interaction between developers and residents by discussing innovative design to ensure successful management of projects and greater understanding of environmental services such as the intrinsic value associated with improved health of the environment (Connop et al., 2016). Teng et al. (2011) present a framework which allows for the integration of an approach toward green space planning by analysing factors such as animal conservation, human recreation and water protection objectives. Overall, the development of a framework within Urban Green Infrastructure (UGI) aims to emphasise the complex interconnected links associated with people, places, ecosystem services and policy implementation, to encourage urban resilience and identify sustainability strategies (Vandergert et al., 2015). Overall, the making of successful urban green infrastructure initiatives can enhance local leisure assets.

Although in the global North the discourse about urban green infrastructure is well-established, in growing cities of the global South the take up of these concepts of green infrastructure and biodiversity corridors in recalibrating urban spaces has been limited. This limited take-up and development of ecological corridors thus reduces the potential recreational and leisure spaces for city residents and visitors. Several analysts argue, however, that the utilisation of urban green landscape development can be considered as ‘soft engineering’ which could be appropriate in a developing world context (Kitha & Lyth, 2011). In addition the application of models using Geographical Information Systems could serve to guide the urban planning of green spaces and conserve high biodiversity levels (Govindarajulu, 2014).



Green Urban Infrastructure in South Africa

In the case of South Africa the development of urban ecological research is still relatively limited. The existing literature mainly highlights the different approaches taken by various South African cities in an attempt to address ecology within urban areas. For example, the approach taken by Cape Town is driven by the need to conserve natural areas, habitats and biodiversity in and around the city, including for recreation and leisure enhancement purposes (Rebelo et al., 2011). Likewise, in the context of Durban, the development of urban environmental management serves as the environmental driver for the city which attempts to protect key environmental goods and services available within urban open spaces (Roberts, 2008).

Building upon these studies the focus of this research was to determine the growth and application of an ecological corridor initiative as a source of urban upliftment and ecological expansion in the south of Johannesburg. The research applied a qualitative approach using key stakeholder interviews as well as participant observation. Primary data was collected through semi-structured interviews with significant stakeholders involved in the Kliprivier Urban Biodiversity Project (KUBiC). Five detailed semi-structured interviews were conducted with expert stakeholders between July and September 2016. The parameters of the research were influenced by the limited amount of stakeholders and specialists who were directly involved in the KUBiC project. All interviews were conducted in person and recorded for the ease of transcription. The use of detailed semi-structured interviews allowed the utilisation of grounded theory in an attempt to derive a general theory through the views of participants within the study (Creswell, 2003). For ethical reasons the names of interviewees are not disclosed.

The five interview respondents were as follows. Respondent 1 is a development consultant whose skills were utilised to develop a framework for the KUBiC project and also Chairperson of the Klipriviersberg Sustainability Association (KlipSA). Respondent 2 is the CEO of the South of Johannesburg's Business and Tourism Forum (SOJO) and main organiser or representative of the KUBiC project. Respondent 3 is a botanist who was significantly involved at the initial stages of the KUBiC project, including the production of an ecological report regarding the road verges situated along Kliprivier Drive. Respondent 4 is a representative from Johannesburg City Parks (JCP) who served as a liaison and consultant for the project organisers during the inception of the KUBiC project. Respondent 5 is one of the managers of the Wildlife and Roads Project for the Endangered Wildlife Trust (EWT). In addition to the results from the five expert interviews, participant observation was used to examine the role that KUBiC serves within the community. The method of participant observation involves the spending of time within the environment (whether personal or business) of an individual or a community in order to understand their circumstances (Laurier, 2010). The premise of the approach, however, involves remaining as close to the spatial phenomenon as possible without directly influencing any actions. The use of this research method involved attending multiple planning meetings for KUBiC's annual event as well as attendance at the annual event on 15th October 2016.

The making of green spaces and green urban infrastructure fits within the policies of the City of Johannesburg (CoJ) and Johannesburg City Parks. This said, the establishment of an ecological corridor was innovative within Gauteng due to its location along a major arterial transport route situated within the south of Johannesburg and engaging the collaboration of a conservancy, Klipriviersberg Sustainability Association (KlipSA) and a business and tourism forum, the South of Jo'burg Business and Tourism Forum (SOJO). The Kliprivier Urban Biodiversity Corridor (KUBiC) project serves a range of roles within its community. It focuses on developing ecology through the promotion, protection and enhancement of biodiversity and urban upliftment. The inception of developing a green corridor, along a 12-13km route, situated on Kliprivier Drive, can be attributed to the co-owner of Thaba Eco Hotel. During 2011, the co-owner of Thaba Eco Hotel was touring in Singapore and was intrigued by the development of a green belt situated along the highway between the airport and his hotel. The co-owner of Thaba Eco Hotel envisioned utilising a similar concept within the South of Johannesburg, in an attempt

to link the characteristically hard industrial sector in the North with the softer green spaces situated in the South. Thus, the development of a tree planting scheme would suffice in beautifying the areas situated along the road while providing an attractive route both into and out of the city.

Kliprivier Drive serves as a major arterial route which links the centre of Johannesburg to the southern periphery of the City's municipality, allowing for movement along the beautifully vegetated road which serves as a major introduction to various nodes. According to Respondent 1, the implementation of a "corridor" would serve as a significant factor for areas situated along Kliprivier Drive providing a further link between the New South and the Old South as described by Harrison and Zack (2014). The development of the Panorama improvement area and Klipriviersberg precinct, situated south of the N12, is characterised by middle-to-high income residential areas as well as employment nodes and retail centres, which is commonly referred to as the New South (Figure 1). In contrast, areas such as Booyens Reserve and Southdale, situated north of the N12, is characterised by low-income residential areas and light industry which is commonly referred to as the Old South (Figure 2). Therefore, Respondent 1 described the development of a throughway as an "important link" between these nodes characterised by the development of biodiversity.

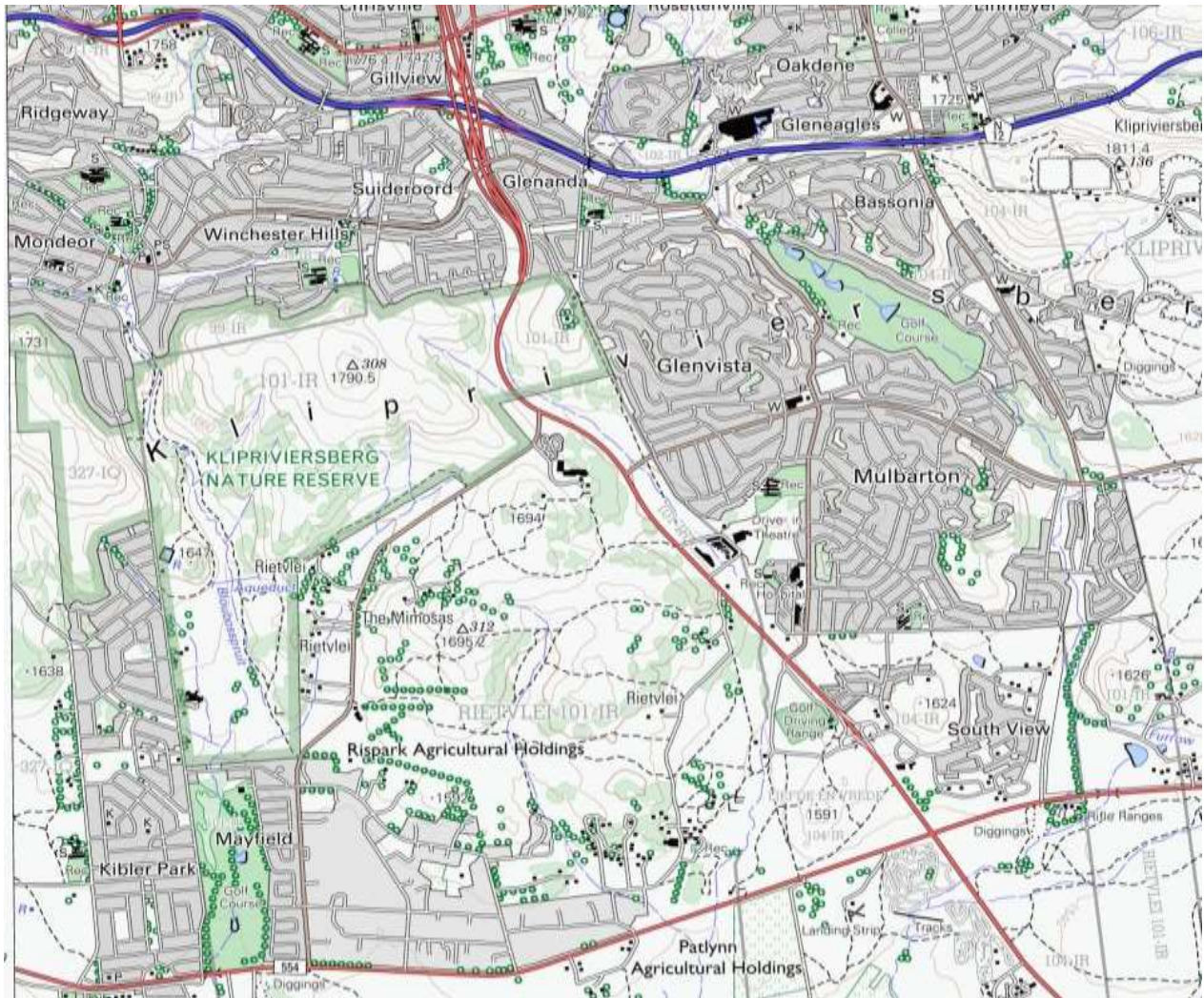


Figure 1. New South. Source: Chief Directorate: Surveys and Mapping (2005)

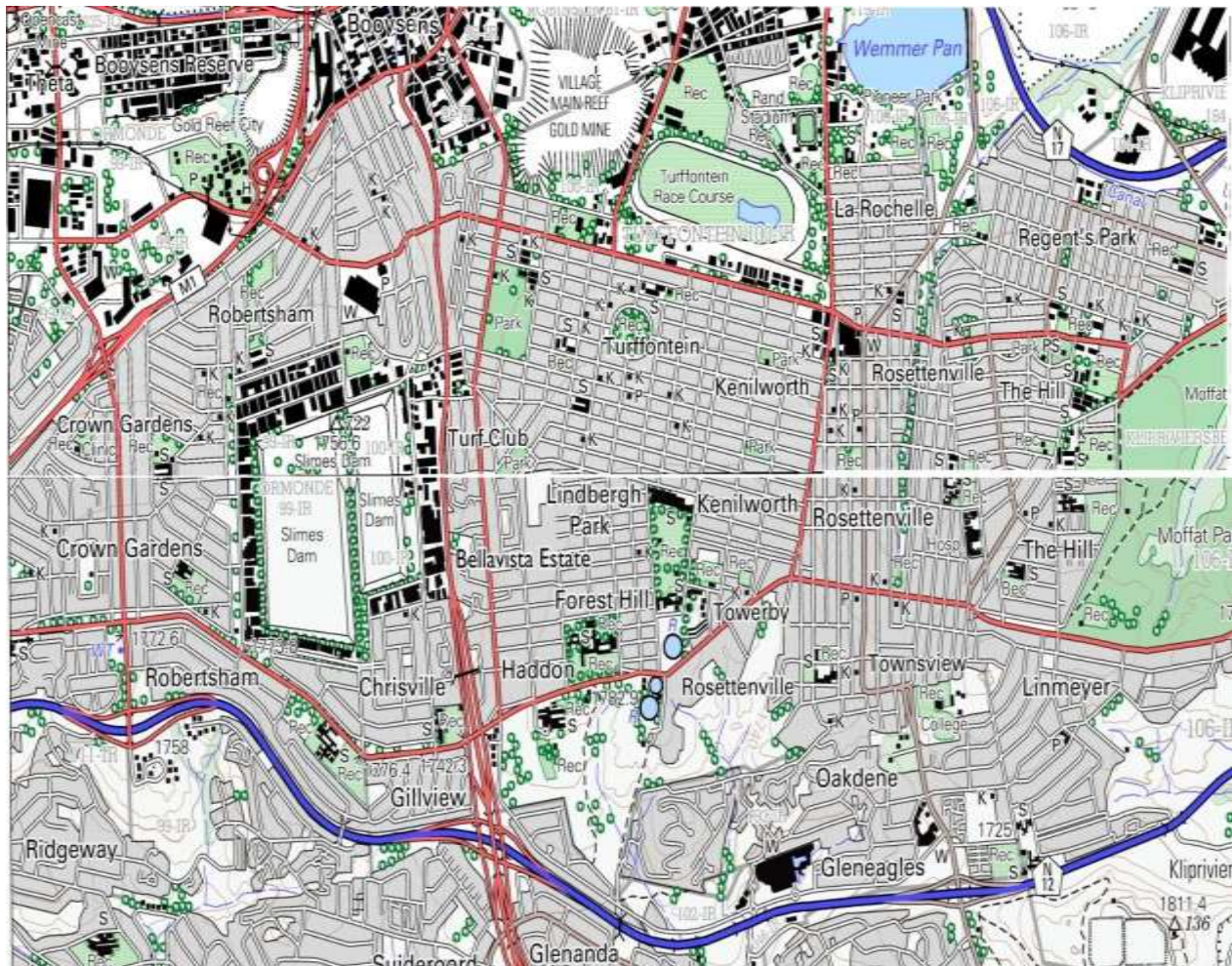


Figure 2. Old South. Source: Chief Directorate: Surveys and Mapping (2005)

The utilisation of the term Urban Biodiversity Corridor aimed *“to create a green atmosphere”* and was applied to emphasise the role the corridor would serve (Respondent 2). Indeed, Respondent 2 believes that due to the northern suburb’s (the Old South) *“very busy, light industry of hardcore business and the types of residential entities, it doesn’t leave a lot of space to create a green atmosphere.”* In contrast, the southern suburbs (the New South) were described as characterised by *“land which is quite mixed between business and residential and there isn’t one particular pocket which can be identified as purely business or residential”*. The incorporation of the biodiversity aspect was implemented through the planting scheme and, as suggested by Respondent 3, the development of *“ecologically functional areas”* would ensure that the road could serve as a green, aesthetically pleasing route for residents, employees and tourists who commute to and from work, to leisure sites or entertainment venues. Therefore, the need for effective urban management should ensure that the area is protected and by-laws are enforced before the introduction of a green element. This would suggest that the term Urban Biodiversity Corridor is defined by the incorporation of effective urban management and the development of biodiversity through planting schemes.

Overall, the focus of the KUBiC project is to introduce a sustainable approach which builds upon the development visions for the southern areas of Johannesburg. These visions were made clear at the 2012 launch of the project. The following visions were set forth:

- Future development founded in protecting, promoting and adding value to the unique natural assets through sustainable economic and social development.



- Key economic growth drive in tourism and agriculture associated with ecotourism and agro-tourism.
- Creating a unique lifestyle for people to live, work and play ((KUBiC Launch Presentation, 2012).

At the launch of the KUBiC project on the 31st of October 2012 it was stipulated that the project's vision aimed to create a unique experience when entering and leaving Johannesburg along a major green corridor (KUBiC Launch Presentation, 2012). This would be achieved through the development of three major elements, namely: environmental elements, economic elements and social elements. The three dimensions of the project are presented on Table 1.

Table 1 - The objectives of KUBiC

Elements	Description
Environmental	Establish self-sustaining attractive habitats adding to the biodiversity
	Improve the linkages between fragmented formal, informal and natural areas of open space areas
	Promote biodiversity in the mixed use developed urban areas
	Improve aesthetics along the corridor and into surrounding urban areas
	Mitigate carbon emissions and air pollution
Economic	Promote tourism and investment
	Improve the visual experience and impression of the south and along Kliprivier Drive
	Improve property value and increase investment opportunities
	Reduced costs of maintenance and urban management along the road side
	Improve accessibility experience into and out of the city from the south
	Improve the environment for business to do its business
Social	Improve living conditions of those living next to Kliprivier Drive
	Improve working conditions of those working along Kliprivier Drive
	Provide job creation and employment opportunities
	Reduce social problems and costs
	Improve open space areas for active and passive recreation
	Strengthen civic identify and pride of communities

(Source: KUBiC Launch Presentation, 2012)

Together these three sets of elements suggest the project would seek to serve a sustainable approach toward developing and maintaining the corridor within the South of Johannesburg. This said, Respondent 2 contends the ultimate goal of the project includes the desire *“to create this wonderful green forest”* due to the road verges having *“a lot of green pastures, so we can plant things along that road and stretch of pavement because they are nicely wide.”* This would allow for *“us to see the whole corridor changing face as we give it a face lift.”* Further, Respondent 2 described the project as also trying to encourage *“the community to get together with the businesses to work on projects with the city”*. Indeed, this aspect of the project would



ensure that *“the south of Johannesburg is not forgotten as a lot of the attention goes to the inner city and gets driven North”* to areas such as Rosebank and Sandton. Therefore, due to the amount of space for vegetation situated along the road, the main focus of the KUBiC project is to clean the area, manage the waste and plant trees and shrubs with the majority of the focus being on the Old South. Nevertheless, KUBiC has a unique characteristic, unlike many projects, which could enhance their chances of success. This characteristic is the effective management of the project through the partnership between a conservancy and a business and tourism forum.

SOJO or the South of Jo’burg Business and Tourism is a voluntary association established to act as an interface between business and the municipality. SOJO will handle any issues such as leaky pipes, burst sewers, potholes and so forth by approaching the council on behalf of the businesses. Respondent 1 described the primary focus of SOJO as wanting to provide “a sustainable business sector within the south of Johannesburg by working on a process of city improvement districts.” This would allow for the creation of economic nodes in the South of Johannesburg as well as linkages between them. SOJO was established through the development of a tourism trail within the South of Johannesburg and promoted by Gold Reef City. Thus, the objective of SOJO is to create a healthy and safe environment for business and tourism development within the South of Johannesburg.

Its partner organisation is a conservation association, namely the Klipriviersberg Sustainability Association. This organisation is focussed upon the Klipriviersberg Nature Reserve (KNR) along the green corridor which serves as a major focus for the biodiversity aspect of the project. Respondent 1 argues that this nature reserve is “the Jewel of the South” suggesting the need to preserve its integrity through sustainable development. Thus, the focus of KlipSA is “finding suitable and appropriate social and economic developments which will protect, promote and enhance the value of the natural asset as well as other natural assets such as the ridges, grasslands and wetlands” (Respondent 1). This approach tries to proactively engage with developers to avoid resistance and encourage preservation or enhancement of the natural environment while remaining within the spatial development framework and integrated development plan of the city of Johannesburg. Overall, this collaboration between a tourism and business forum and a conservancy serves as the unique characteristic for the KUBiC project.

A key and necessary underpinning for the KUBiC project is an effective policy framework. It is argued that the consideration of various legislations (such as the IDP 2013/14, City Growth Management Strategy and many others) ensured the project complied with regulations and enhanced its environment. The specific section relating to SOJO and KlipSA, within the city’s Growth and Development Strategy 2040 are in line with encouraging partnerships that serve as a critical mechanism through community safety and the quality of open spaces. The GDS 2040 highlights the role of SOJO with regard to improved management and maintenance of urban areas through arrangements between the City, its entities and other parties, as mentioned earlier. This role relates to the focus of the City Improvement/Management Districts but encourages businesses and community participation through forum discussions and projects. KlipSA has also served a range of roles but focuses on ensuring the sustainable development of biodiversity, natural and cultural assets.

The development of KUBiC’s framework involved a discussion with all relevant parties of the City of Johannesburg (CoJ) to ensure the effective management of the dual-carriage motorway. These parties include City Power (electricity), Jo’burg Roads Agency (JRA) (servitudes), Johannesburg City Parks (JCP) (road verges) and Rand Water (water pipes). Each party serves an important role within the project’s development and maintenance of the road. The majority of the project utilises the regional offices of Region F, which serves as the representative office for the majority of Kliprivier Drive. This faction of the CoJ, provides service delivery and manages



different municipal entities within the various suburbs of Region F. It was stated by Respondent 2 that SOJO *“deals directly with the regional director of region F as they are familiar with our project.”*

The KUBiC project has two main role players, namely: Johannesburg City Parks (JCP) and Pikitup. JCP serves its role through maintaining the natural areas by supporting biodiversity while Pikitup serves a vital role in maintaining urban management through refuse removal. This required the involvement of various stakeholders to become involved in assisting with the implementation of the idea. JCP serves as the largest role player within the project as they provide the trees for planting and ensure effective maintenance of the trees. Once trees have been planted on council land, such as road verges, the watering, cutting of the grass and maintenance of the ring around the tree ensures it does not get choked by the grass. However, the planting of trees on council land is not a simple procedure. It is required of the organiser to apply for various wayleaves with different departments, which only grants permission to plant the trees if no department has an objection. The management of the road islands is also the responsibility of JCP, however, and according to Respondent 2 *“there are always challenges associated with the need for continuous communication with the different departments to ensure those things get done.”* After the project has been initiated and is running SOJO needs to ensure the maintenance is continued or *“else it may it will look shoddy and poorly kept”*. It often serves common debate that if vegetation expands into the road it is the responsibility of the JRA to remove those intrusive growths. The skills of a botanist were necessary to ensure that the biodiversity aspect of the project was effectively implemented (Respondent 3). This specialist voluntarily provided ecological guidelines for the development of the project, in which he produced an intensive ecological report to distinguish areas of biological strain situated along the corridor.

Respondent 3 argues that biodiversity corridor can provide an area of effective management which encourages animal migration and utilisation of the corridor. It was urged that this corridor should not be described as a link between the north and the south, but should rather encourage the development of creating biodiversity zones within highly developed areas. These biodiversity zones would promote energy flows and the movement of biodiversity back and forth along the corridor, which were described as exits at an ecosystem scale by Li *et al.* (2016). The land being utilised by the KUBiC project is government owned and it is argued that approaching *“the road reserve and adjacent land owners would encourage the expansion of the project’s boundaries rather than confining it to a narrow corridor”* (Respondent 3). In addition, the utilisation of habitat gardens could serve as a further opportunity to expand the current size of the KUBiC project, while promoting the development of it as a functional corridor. It was revealed that the development of a model for the management of open spaces and parks would serve a significant value to the JCP.

The management of roadside verges along an ecological corridor would require different grass cutting methods to ensure both commuter safety and habitat availability for the biodiversity. One interviewee confirmed that currently grass is cut to a low level on a quarterly cycle (Respondent 4). This practice is not conducive to supporting biodiversity living within the grass. The views of Respondent 3 match that of Bolger *et al.* (2001), by suggesting the interspersed grass cutting of low sections and high sections, would allow motile biodiversity living within the grass to migrate an adjacent patch to avoid being disturbed by the mowing of the grass. However, the reality of implementing such a scheme is challenged by aspects of crime and issues of it being a potential fire hazard, which is similar to the views of Clarke *et al.* (2010). Indeed, grass cutting along road verges acts as a key security aspect for the safety of commuters on the road that can be put in place and integrated but as previously mentioned the trimming of grass to such short lengths results in a loss of habitat for certain species which is problematic in the creation of an ecological corridor.

In contrast to the previously mentioned ecological aspects of the corridor which has promoted species migration and movement, it was stressed that the corridor can only serve “birds, insects



and plants” as the large mammals situated within the KNR, “*are restricted within that particular area as a tourist attraction*” which is “*managed and controlled by the City of Johannesburg*” (Respondent 2).

For local communities a special focus in the KUBiC is upon improving refuse removal and environmental health. The interviewees argued that engagement with the community was important to ensure that “*they take ownership of the area as well as see what are the challenges they are facing*” which enables SOJO to support the community’s needs. Respondent 2 emphasised that SOJO is “not an organisation which will tell them what to do” but rather “we want to find out from them how they would like to see change and help improve their surroundings.” SOJO aims to “*create an atmosphere of sustainability*” which emphasises the importance of “*ownership and awareness.*” Therefore, the role of the project is not just to plant trees, remove graffiti and illegal advertising as well as involving the community in an annual clean-up day once a year, but it aims to encourage community pride through ownership of the area whereby they will look after the trees which are planted, be encouraged to recycle at source and try identify potential job opportunities for the local residents. Finally, the framework developed for the KUBiC project also incorporates opportunities for enhanced recreation through the creation of pathways for cyclists, runners and pedestrians.

Conclusion

The continued advance of urbanisation serves as a threat to the preservation of ecosystems through the fragmentation of environments. This has resulted in the development of isolated green spaces in urban areas which segregates populations of different species. Therefore, the development of ecological corridors has become commonplace within policy environments of countries in the global North, most especially in the European Union. Ecological corridors are attracting a growing scholarship in the context of cities in the global North. In the developing world, however, scholarship around the greening of urban infrastructure in general is relatively scarce.

This article contributes to a knowledge gap by investigating the planning and development of an ecological corridor within South Africa’s major city. The KUBiC project aims to deliver a forested corridor targeted to beautify, uplift and link the south of Johannesburg to its more developed northern areas. The term “Urban Biodiversity Corridor” is applied in an attempt to distinguish between the project’s two major functions, namely: the development of a functional ecosystem which allows for species migration as well as the implementation of an effective urban management plan which attempts to alleviate poverty. Accordingly, the project has taken into consideration various aspects of social, economic and environmental responsibilities in an attempt to encourage sustainable development. Of interest is that core drivers of the project are a partnership between a conservation agency (KlipSA) and a local business and tourism forum (SOJO). This unique collaboration served to implement a range of projects which address challenges in the urban environment of Johannesburg South. The enhancement of leisure and recreation opportunities in the project area can be an output of this unfolding innovative development project.

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References

Antrop, M. (2004). Landscape change and the urbanisation process in Europe. *Landscape Urban Planning*, 67: 9-26.



Beier, P., W., Spencer, R.F., Baldwin & B.H., McRae (2011). Toward best practices for developing regional connectivity maps. *Conservation Biology*, 25: 879-892.

Bennett, A.F. (2003). *Linkages in the landscape: the role of corridors and connectivity in wildlife conservation* (2nd ed.). Cambridge: IUCN.

Bernazzani, P., Peterson, G.D. & Gordon, L.J. (2009). Understanding relationships among multiple ecosystem services. *Ecological Letter*, 12: 1394-1404.

Chief Directorate: Surveys and Mapping (2005). 2628AA *Johannesburg*. 1:50 000. Pretoria: Government Printer.

Cimon-Morin, J., Darveau, M. & Poulin, M. (2013). Fostering synergies between ecosystem services and biodiversity in conservation planning: a review. *Biological Conservation*, 166: 144-154.

Clarke, D.J., Pearce, K.A. & White, J.G. (2006). Powerline corridors: degraded ecosystems or wildlife havens? *Wildlife Restoration*, 33: 615.

Clergeau, P., Jokimaki, J. & Snep, R. (2006). Using hierarchical levels for urban ecology. *Trends in Ecological Evolution*, 21: 660-661.

Connop, S.P., Vandergert, B., Eisenberg, M.J., Collier, C., Nash, J., Clough & Newport, D. (2016). Renaturing cities using a regionally-focused biodiversity-led multifunctional benefits approach to urban green infrastructure. *Environmental Science & Policy*, 62: 99-111.

Creswell, J.W. (2003). (2nd ed.) *Research Design: Qualitative, Quantitative and Mixed Methods Approaches*. London: SAGE Publications.

Crowe, P., Foley, K. & Collier, M. (1996). *Exploring the implication of socialecological resilience thinking: innovations for urban planning and policy*. Department of the Environment – Potential Effects of Climate Change in the United Kingdom. London: DOE.

European Commission (2012). Our life insurance, our natural capital: an EU biodiversity strategy to 2020.

European Environmental Agency (2014). Spatial analysis of green infrastructure in Europe. Technical report 2

Gerlach, G. & Musolf, K. (2000). Fragmentation of landscape as a cause for genetic subdivision in bank voles. *Conservation Biology*, 14: 1066-1074.

Gilbert-Norton, L., Wilson, R., Stevens, J.R. & Beard, K.H. (2010). A meta-analytic review of corridor effectiveness. *Conservation Biology*, 24: 660-668.

Govindarajulu, D. (2014). Urban green space planning for climate adaption in Indian cities. *Urban Climate*, 10: 35-41.

Hanski, I. (2011). Habitat loss, the dynamics of biodiversity, and a perspective on conservation. *Ambio*, 40: 248-255.

Harrison, P. & Zack, T. (2014). Between the ordinary and the extraordinary: socio-spatial transformations in the 'Old South' of Johannesburg. *South African Geographical Journal*, 96(2): 180-197.

Hess, G.R. & Fischer, R.A. (2001). Communicating clearly about conservation corridors. *Landscape Urban Planning*, 55: 195-208.



- Hostelter, M., Allen, W. & Muerk, C. (2011). Conserving urban biodiversity? Creating green infrastructure is only the first step. *Landscape Urban Planning*, 100(4): 369-371.
- Kai-ran, L. (2010). The Greenway Network as Ecological Corridors and Associated Planning Principles. *Chinese Landscape Architecture*, 3: 6-11.
- Keller, I., Nentwig, W. & Largiader, C.R. (2004). Recent habitat fragmentation due to roads can lead to significant genetic differentiation in an abundant flightless ground beetle. *Ecology*, 13: 2983-2984.
- Killeen, T.J. & Solorzano, L.A. (2008). Conservation strategies to mitigate impacts from climate change in Amazonia. *Philosophical Transitions of Societies*, 363: 1881-1888.
- Kitha, J. & Lyth, A. (2011). Urban wildscapes and green spaces in Mombasa and their potential contribution to climate change adaptation and mitigation. *Environmental urbanisation*, 23(1): 251-265.
- Kopperoinen, L., Itkonen, P. & Niemela, J. (2014). Using expert knowledge in combining green infrastructure and ecosystem services in landuse planning: an insight into a new place-based methodology. *Landscape Ecology*, 29: 1361-1375.
- KUBiC Launch Presentation (2012). *KUBiC (Kliprivier Urban Biodiversity Corridor) – Launch of the Vision and Concept*. PowerPoint presentation. Johannesburg: SOJO.
- Laurance, W.F., Clements, G.R., Sloan, S., O'Connell, C.S., Mueller, N.D. & Goosern, M. (2014). A global strategy for road building. *Nature*, 513: 229-232.
- Laurier, E. (2010). Participant Observation. In Clifford, N., French, F & Valentine, G. (Eds.). *Key Methods in Geography*. London: SAGE Publications, 116-130.
- Li, F., Wang, R.S., Paulussen, J. & X Liu, X.S. (2005). Comprehensive concept planning of urban greening based on ecological principles: a case study in Beijing, China. *Landscape Urban Planning*, 72: 325-336.
- Li, F., Liu, X., Zhang, X., Zhao, D., Liu, H., Zhou, C. & Wang, R. (2016). Urban ecological infrastructure: an integrated network for ecosystem services and sustainable urban systems. *Journal of Cleaner Production*, 1-7.
- McDonnell, M.J. & Pickett, S.T. (1990). Ecosystem structure and function along urban-rural gradients: an unexploited opportunity for ecology. *Ecology*, 1: 1232-1237.
- Munoz, P.T., Torres, F.P. & Meglas, A.G. (2015). Effects of roads on insects: a review. *Biodiversity Conservation*, 24: 659-682.
- Pauleit, S.L., Liu, L., Ahern, J. & Kazmierczak, A. (2011). Multifunctional green infrastructure planning to promote ecological services in the city. *Urban Ecology*, 1: 272-285.
- Qiang, Z., Kong-Jian, Y. & Di-Hua, L. (2005). The width of ecological corridor in landscape planning. *Acta Ecologica Sinica*, 9: 2406-2412.
- Rathore, C.S., Dubey, Y., Shrivastava, A., Pathak, P. & Patil, V. (2012). Opportunities of habitat connectivity for tiger (*Panthera tigris*) between Kanha and Pench National Parks in Madhya Pradesh, India. *PLoS*, 7:7.
- Rebelo, A.G., Holmes, P.M., Dorse, C. & Wood, J. (2011). Impacts off urbanisation in a biodiversity hotspot: conservation challenges in Metropolitan Cape Town. *South African Journal of Botany*, 77: 20-35.



Roberts, D.C (2008). Thinking globally, acting locally – institutionalising climate change at the local government level in Durban, South Africa. *Environment & Urbanisation*, 20(2): 521-537.

Schwoertziga, E., Poulinc,N., Hardiona, L. & Tremolieres, M. (2016). Plant ecological traits highlight the effects of landscape on riparian plant communities along an urban-rural gradient. *Ecological Indicators*, 61: 568576.

Snall, T., Lehtomaki, J., Arponen, A., Elith, J. & Moilanen, A. (2016). Green infrastructure design based on spatial conservation prioritisation and modelling of biodiversity features and ecosystem services. *Environmental Management*, 57: 251-256.

Teng, M., Wu, C., Zhou, Z., Lord, E. & Zheng, Z. (2011). Multipurpose greenway planning for changing cities: a framework integrating priorities and a least cost path model. *Landscape Urban Planning*, 103(1): 1-14.

Van Der Windt, H.J. & Swart, J.A.A. (2007). Ecological corridors, connecting science and politics: the case of the Green River in the Netherlands. *Journal of Applied Ecology*, 45: 124-132.

Vandergert, P., M., Collier, S., Kampelmann & Newport, D. (2015). Blending adaptive governance and institutional theory to explore urban resilience and sustainability strategies in the Rome Metropolitan Area, Italy. *International Journal in Urban Sustainable Development*. DOI: 10.1080/19463138.2015.1102726.

Vos, C.C. & Chardon, J.P. (1998). Effects of habitat fragmentation and road density on the distribution pattern of the moor frog *Rana arvalis*. *Journal of Applied Ecology*, 35: 44-56.

Williams, N.S., Schwartz, M.W., Vesk, P.A., McCarthy, M.A., Hahs, A.K., Clemants, S.E., Corlett, R.T., Duncan, R.P., Norton, B.A. & Thompson, K. (2009). A conceptual framework for predicting the effects of urban environments on floras. *Journal of Ecology*, 97: 4-9.

Zachos, F.E., Althoff, C., Steynitz, Y.V. Eckert, I. & Hart, G.B. (2007). Genetic analysis of an isolated red deer (*Cervus elaphus*) population showing signs of inbreeding depression. *European Journal of Wildlife Restoration*, 53: 61-67.