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The Buffelsdraai Landfill Site Community Reforestation Project

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Members of a local community plant trees as part of the Buffelsdraai Landfill Site Community Reforestation Project

A project in Durban, South Africa, is pursuing a new form of urban biodiversity conservation using structured interventions to provide wider benefits for communities.

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Cities have a crucial role to play in climate-change adaptation and mitigation. The majority of the world's people now live in urban areas (UNDESA, 2014), with the result that cities form centres of intense greenhouse gas emissions related to transport, energy and industry. Addressing climate-change mitigation at the city scale is evidently important, but the risks that cities face due to climate change are arguably even more so. Where the impacts of climate-change-related disasters are not planned for appropriately, the combination of high settlement densities, the location of infrastructure in vulnerable places, and urban poverty can have very negative consequences for people. This is particularly true of cities in many African countries, where informal settlements – which lack many basic services – form a large proportion of residential areas. It is imperative that development in these cities is aligned appropriately with projected changes in climate.

To this end, various mechanisms are being pursued globally to address climate-change mitigation and adaptation in urban areas. These include nationally coordinated mitigation policies to, for example, develop renewable-energy and energy-efficiency building retrofits, as well as local-scale adaptation planning initiatives. Two of the latter considered of high importance for African cities are community-based adaptation (CBA) and ecosystem-based adaptation (EBA). CBA refers to the participatory identification and implementation of community-based development activities that strengthen local people's capacity to adapt to climate change. CBA also builds on the expressed needs and perceptions of communities to address the local development concerns underlying vulnerability (Ayers and Forsyth, 2009; Reid *et al*., 2009; Archer *et al*., 2014). EBA refers to "the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change" (AHTEG, 2009). Both CBA and EBA allow the delivery of climate-change adaptation interventions that support economic development, promote poverty alleviation, enhance water and food security, and boost biodiversity conservation (Lykke *et al*., 2009; Cartwright *et al*., 2013; Munang *et al.,* 2013). Such benefits can foster much-needed political buy-in; moreover, the integration of CBA and EBA into local decision-making processes (e.g. municipal land-use planning) increases opportunities for risk reduction (Archer *et al*., 2014).

This article discusses the key benefits arising from and lessons learned in a reforestation project implemented by the eThekwini Municipality (the local government responsible for the city of Durban, South Africa) in partnership with local communities and organizations. Although established as a mitigation initiative to help offset greenhouse gas emissions associated with 2010 FIFA World Cup™ matches held in Durban, the Buffelsdraai Landfill Site Community Reforestation Project ("the project") has provided crucial co-benefits, including climate-change adaptation, poverty alleviation and ecosystem restoration. The project builds on a combination of the local economic development and ecosystem service delivery aspects of South Africa's national Working for Water programme (van Wilgen, Le Maitre and Cowling, 1998; Turpie, Marais and Blignaut, 2008) and the eThekwini Municipality's Working for Ecosystems programme (Douwes, 2010).

CLIMATE-CHANGE MITIGATION AND ADAPTATION STRATEGIES IN DURBAN

Durban has a portfolio of synergistic adaptation and mitigation responses that form part of its Municipal Climate Protection Programme. Reviews of this

Tree-preneurs sort saplings received from the community at a "holding nursery" as part of the Buffelsdraai Landfill Site Community Reforestation Project. Seedlings are grown in people's backyards and placed in holding nurseries at the site for hardening before planting

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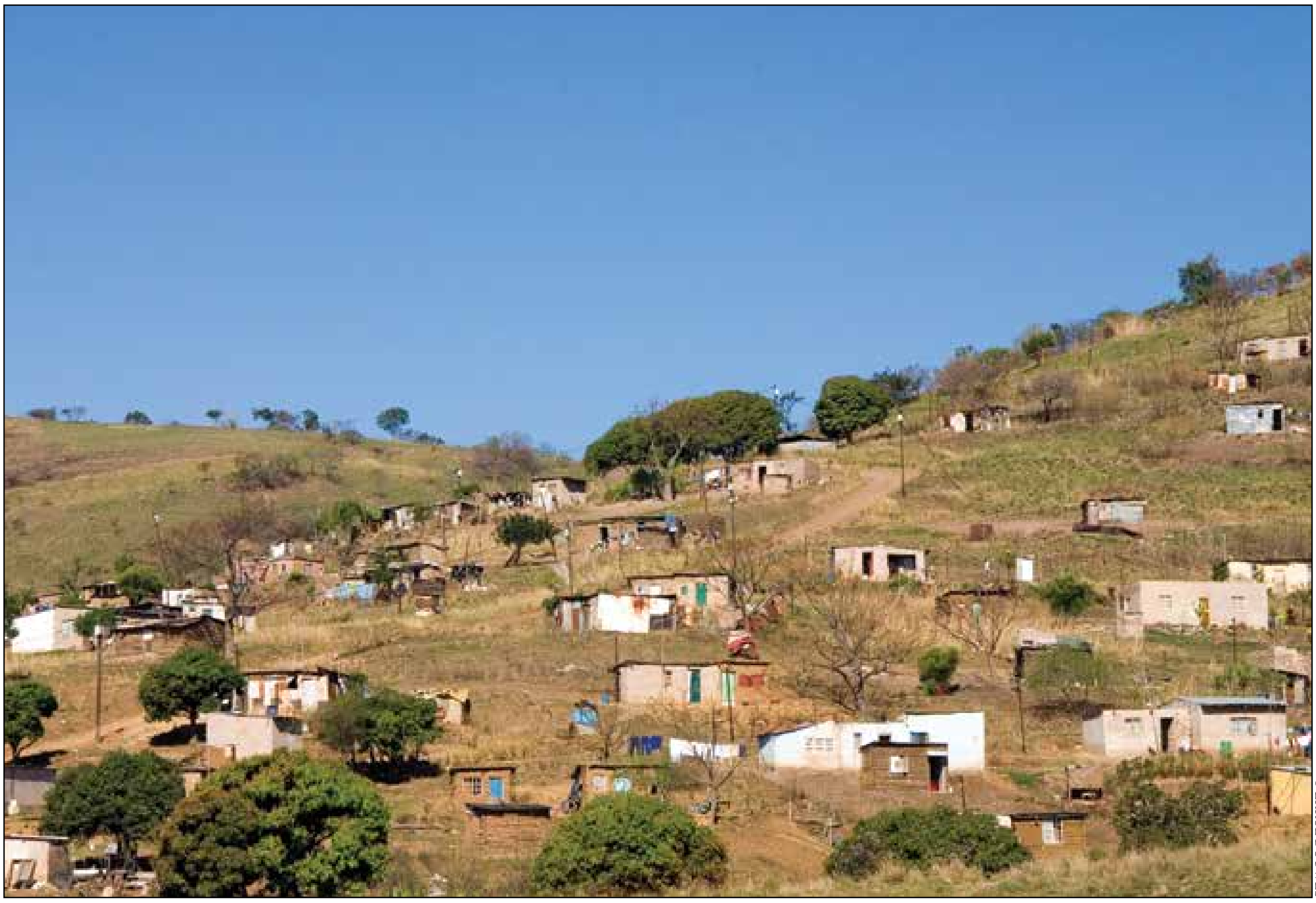
programme (Roberts *et al*., 2012; Roberts and O'Donoghue, 2013) suggest that while adaptation is the immediate priority, mitigation interventions are also crucial for enhancing the city's adaptive capacity through the avoidance of climate change while reducing existing high levels of per capita emissions. In this sense, mitigation may even be viewed as the "surest form" of adaptation. EBA is considered a strategic approach to adaption that maximizes the prospects for long-term sustainability and reduces the vulnerability of impoverished urban communities, which remain dependent on natural capital for survival (Roberts *et al*., 2012).

A practicable community EBA initiative has emerged recently in Durban in response to the recognition that climate-change adaptation needs to involve and benefit local communities for it to be sustainable and meaningful. Natural habitat restoration projects have the advantage of not only achieving climate-change mitigation aims but also increasing climate-change adaptation capacity and reducing the vulnerability of ecosystems and communities. It is acknowledged that mitigation gains are low in Durban's urban-based ecological restoration projects in comparison with gains in adaptive capacity. Preferably, therefore, investments in ecosystem restoration should not seek solely to deliver carbon sequestration but should also prioritize the supply of other ecosystem services (e.g. flood attenuation, sediment regulation, biodiversity refuge conservation and river-flow regulation), thereby increasing and broadening the resilience and adaptation capacity of regional ecosystems, including river catchment systems, with clear benefits for local communities that depend on natural resources.

ESTABLISHMENT OF THE BUFFELSDRAAI LANDFILL SITE COMMUNITY REFORESTATION PROJECT

Following Durban's selection as one of nine South African host cities for the 2010 FIFA World Cup™, the eThekwini Municipality established a target to host a climate-neutral event. The total unavoidable carbon footprint for the Durban component of the event was declared at 307 208 tonnes of carbon dioxide equivalent (CO_2e). A portion of this footprint was to be mitigated through local natural forest restoration that also enhanced the adaptive capacity of local ecosystems and communities. The project was initiated within the 757-hectare buffer zone of

The Buffelsdraai Landfill Site Community Reforestation Project has generated significant socio-economic benefits for the local community



the municipality's Buffelsdraai Regional Landfill Site in the north of Durban in November 2008. Initial small-scale tree-planting was undertaken in 2009, followed by a larger-scale effort from 2010. All land earmarked for reforestation was previously either under sugarcane production, with limited productive capacity, or infested with invasive alien plants. The carbon to be captured by the project over a 20-year period was estimated initially at some 45 000 tonnes of CO_2e (eThekwini Municipality, 2011).

The eThekwini Municipality appointed a local non-profit organization, the Wildlands Conservation Trust, to implement the project through its Indigenous Trees for Life programme, which assists unemployed people, subsequently known as "tree-preneurs", to set up small-scale indigenous tree nurseries at their homes. Facilitators in relevant communities are appointed to recruit, train and support the tree-preneurs, who trade their trees (at a minimum height of 30 cm) for credit notes, which can be exchanged for food or basic goods or used to pay school fees.

A holding nursery at the reforestation site allows the storage and sorting of trees received from tree-preneurs. Trees are hardened off in the nursery to increase their chances of survival once planted out; this involves the use of local soils without fertilizer or mulch, and watering is minimized. Teams of local people are employed to plant the hardened-off trees and then maintain the forest (including through the control of invasive alien plants). Planting takes place predominantly in the wet season to help increase tree survival. Planted areas are inspected regularly, and dead trees are replaced with new saplings. A stock of "insurance" trees is stored in the on-site nursery to replace trees that have succumbed to wildfire or drought.

The Municipality's Environmental Planning and Climate Protection Department oversees the project, but partnerships with other municipal agencies are also vital. These agencies include the Durban Solid Waste Department, which owns the land; the Coastal, Stormwater and Catchment Management Department, involved in water monitoring; and the municipality's Energy Office, which provides photovoltaics and solar geysers for offices and ablutions. Other partners include the University of KwaZulu-Natal (UKZN) as part of a research partnership, and the Wildlife and Environmental Society of South Africa as part of an environmental education partnership. Members of the local community are considered crucial partners for implementation success.

ASSESSMENT OF BENEFITS

The multiple socio-ecological benefits achieved by the project have resulted in Gold Standard validation by the Climate Community and Biodiversity Alliance, following the regular monitoring of carbon stock, increases in biodiversity, and socio-economic surveys of neighbouring communities. Conformance with the Climate Community and Biodiversity (CCB) Standards is determined through a two-stage process involving validation and verification (CCBA, 2015), which is undertaken by independent accredited auditors. The validation phase, already completed for the Buffelsdraai project, entailed an assessment of the design of the land-based carbon project against each criterion of the CCB Standards. Verification (scheduled for 2017) is to be performed after initial project implementation (and then at approximately five-year intervals) to confirm whether the project has delivered benefits in line with its validated design and monitoring plan. Table 1 lists the various indicators used to monitor the implementation and effectiveness of the project.

The estimated carbon to be sequestered each year was calculated before planting, based on the anticipated accumulation of woody biomass arising from the phased plantings in initial years and growth over a 20-year period. Knowles (unpublished) modelled carbon accumulation rates using the Century Ecosystem Program for the

TABLE 1. Indicators used to monitor carbon stocks, biodiversity and the socio-economic benefits of the Buffelsdraai Landfill Site Community Reforestation Project

Indicator type	Measurement	Frequency	Notes
Carbon stock	Area planted (ha)	Annually	Calculated for areas previously under sugarcane
	Number of trees	Annually	Trees planted in the living fence were not included in initial carbon calculations
	Accumulated carbon sequestered to date (tonnes CO_2e)	Annually	These values were calculated before project inception
Biodiversity	Indigenous trees (species richness)	Annually	Only woody tree species sampled
	Invertebrates (species richness)	Every five years	Limited to snails and millipedes
	Vertebrates (species richness)	Every five years	Small mammals, birds and reptiles were sampled
Socio-economics	Number of temporary jobs	Annually	Measured for people directly employed
	Number of permanent jobs	Annually	Measured for people directly employed
	Disposable income	Every five years	Within families of tree-preneurs or employees
	Food availability	Every five years	Within families of tree-preneurs or employees

various vegetation types sampled by Glenday (2007). Field surveys of extant forest and woodland patches (Macfarlane, Harvey and Hamer, 2011) were undertaken early in the project. The resulting inventories and associated data allowed the calculation of importance values (IV) for each tree species as a way of guiding future selections of species for planting (Macfarlane, Harvey and Hamer, 2011). The IV methodology (see DWAF, 2005) uses the relative abundance, relative frequency and relative basal area (biomass) of each species in each habitat type. The exercise was repeated four years after the initial survey and calculation (Bertolli, Teixeira-Leite and Macfarlane, 2013) to confirm the targets set for species richness. Macfarlane, Harvey and Hamer (2011) also collected baseline data on vertebrate and invertebrate species richness. Roy (2015) determined the species richness, diversity and composition of the newly planted areas at Buffelsdraai through extensive sampling of 60 plots (each of which was 200 m^2 in area). These plots were compared with an established forest in Durban to determine whether the project was on a trajectory that would allow the establishment of a phytosociological assemblage similar to that of a natural forest.

A socio-economic baseline study of project beneficiaries (Greater Capital, 2011) was undertaken to help the eThekwini Municipality understand the long-term benefits of the reforestation process that would accrue to the 6 309 households in the Buffelsdraai, Osindisweni and KwaMashu settlements. These areas are acknowledged to suffer from poverty and unemployment.

TABLE 2. Anticipated greenhouse gas removals to date, through woody biomass accumulation, during phased planting at Buffelsdraai

Year	Cumulative area planted (ha)	Carbon sequestration rate per unit area (tonnes of CO_2e/ha/year)	Carbon sequestration rate per year (tonnes of CO_2e/year)	Accumulated carbon sequestered to date (tonnes of CO_2e)
2008	1.1	1.4	5.6	5.6
2009	44.1	1.4	226.4	232.0
2010	82.1	1.4	421.4	653.5
2011	182.1	1.4	934.8	1 588.3
2012	282.1	1.4	1 448.1	3 036.4
2013	382.1	1.4	1 961.4	4 997.8
2014	482.1	1.4	2 474.8	7 472.6

Source: eThekwini Municipality (2011).

RESULTS

The results presented below are for the first five years of tree-planting (2010–2014) and relate broadly to the indicators listed in Table 1.

Carbon stock

Table 2 shows the carbon anticipated to be sequestered in each year from inception. This is an estimate based on the cumulative area planted; actual measurements are being conducted through the research partnership with UKZN.

Biodiversity

A total of 51 locally indigenous tree species were recorded at Buffelsdraai in 2013, including species found in newly reforested areas as well as in extant forest patches at the site (Bertolli, Teixeira-Leite and Macfarlane, 2013). As of January 2015, 442 hectares had been reforested at Buffelsdraai at a rate of about 100 hectares per year and an average density of 1 000 trees per hectare (certain riparian areas were planted at an average of 2 000 trees per hectare). A total of 595 476 trees had been acquired since project inception through the treepreneurs programme, as of January 2015 (Douwes *et al*., 2015). The planted trees include 46 locally indigenous species, of which the most common are *Acacia natalitia*, *Erythrina lysistemon* and *Bridelia micrantha* (Roy, 2015).

The Buffelsdraai landfill site in 2015

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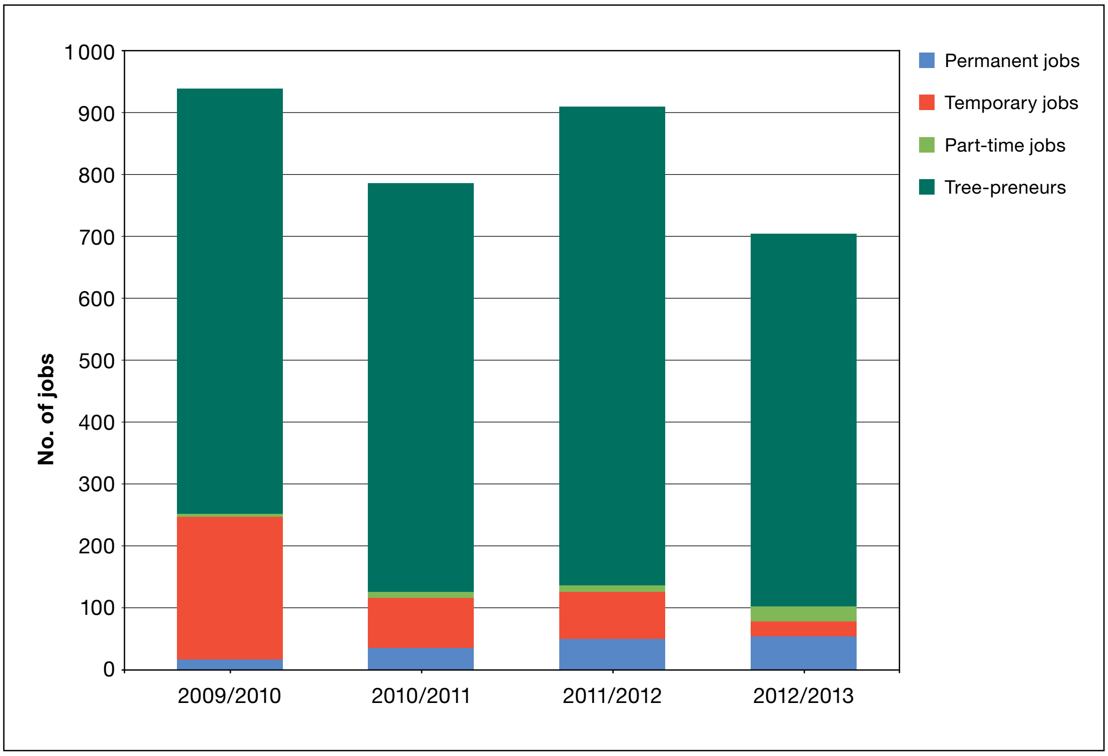

1
Socio-economic upliftment of neighbouring communities through job creation (2009/2010–2012/2013)

Compared with a forest reference site, the planted areas at Buffelsdraai had lower species richness (an average of 28 species per 0.4 hectares at Buffelsdraai compared with 37 species per 0.4 hectares at the reference site) and lower species diversity (a Shannon exponential mean of 21.6 effective species per 0.4 hectares at the reference site and 12.3 at Buffelsdraai) due to the dominance of a few pioneer nitrogen-fixing species that are generally quick and easy to grow (Roy, 2015).

Eighty bird species were recorded at the Buffelsdraai site at project inception (Macfarlane, Harvey and Hamer, 2011); ongoing quarterly records indicate that the number was 145 in December 2014 (Spence and Wood, 2014). Although the number of bird species appears to have increased, Spence (personal communication, 2015) has suggested that 145 might be a more realistic baseline, given that all species cannot be confirmed in one count, and species lists must cover all seasons. Nine millipede and 22 mollusc species were recorded at the site (Macfarlane, Harvey and Hamer, 2011).

Socio-economics

The project has generated more than 50 full-time, 16 part-time and 389 temporary jobs for local community members, and more than 600 active tree-preneurs have been engaged (Figure 1). Local people who gained employment in the project were found to have higher disposable incomes and increased availability of food, and many families reported improved educational opportunities for their children. All communities demonstrated a high reliance on the use of natural resources for food, energy, water and primary health care (Greater Capital, 2011).

DISCUSSION

This case study provides a number of lessons that could inform the development of community-based reforestation elsewhere. The project inclines heavily towards local job creation and the active upskilling of community members, achieved primarily through ongoing interactions between facilitators and tree-preneurs. The development of entrepreneurial skills is also a focus, and tree-preneurs who produce large quantities of trees are rewarded with additional training courses and experiential learning opportunities. An education and outreach initiative has been established to help local communities develop an understanding of climate change, as well as of how forests and ecosystems deliver beneficial ecosystem services.

The project has demonstrated some measure of climate-change mitigation and adaptation, although the adaptation benefits (especially with respect to biodiversity and socio-economic aspects) are far more tangible than originally envisaged. The composition of planted trees indicates a likelihood of high resilience to climatic change due to the prevalence of generalist species (Roy, 2015); socio-economic benefits include the increased availability of food and improved education opportunities for schoolchildren (Greater Capital, 2011).

The benefits generated by the project led to its nomination and selection in 2011 as one of the UN's "Momentum for Change" initiatives, which recognize projects for addressing climate change through climate-resilient and low-carbon mechanisms while ensuring optimal benefits for local communities (UNFCCC, 2015). It is acknowledged, however, that, while initial results hold promise, further interrogation of the project benefits is required. For example, the full extent of ecological and ecosystem service benefits – such as increases in biodiversity refuges, water quality, river-flow regulation, flood mitigation, sediment control, visual amenity, and fire-risk reduction – is unknown.

Another aspect in which the project has shown promise is in the engagement of a broad spectrum of stakeholders, which has ensured widespread buy-in and transparency and, in the case of a research partnership with UKZN, created opportunities for investigating the impacts of the project on ecosystem services. Buy-in and support for the project from local leaders has helped drive the establishment of two additional reforestation projects in Durban – iNanda Mountain and Paradise Valley – using the same model.

This project emerged opportunistically as a result of the 2010 FIFA World Cup™, pointing to the need for cities and countries to exploit such moments because they have the potential to provide long-lasting legacies (Diederichs and Roberts, 2015). This is especially relevant for projects implementing green economy principles, as seen in the example discussed here. The combination of local economic development and the delivery of ecosystem services, which is also used in South Africa's national Working for Water programme (Buch and Dixon, 2009), could feasibly be replicated in other parts of Africa, especially in cities, as a way of mainstreaming climate-change adaptation measures (Bourne *et al*., 2016). The goal of low-carbon-emissions development (UNDP, 2011) can also be addressed in parallel with the development of socio-ecological needs. The Indigenous Trees for Life model has already been extended to other environmental sectors, such as solid waste control, at Buffelsdraai and other sites (Bender, 2016), providing opportunities to implement a range of transformative programmes that target vulnerable communities. Such opportunities, if sensitive to local ecosystem threats and needs, could be pursued in cities throughout Africa with the potential to put African countries on a development path in keeping with the Sustainable Development Goals.

The above-mentioned partnerships and project components all aim to yield positive co-benefits and outcomes, but they also highlight the vulnerability of the project, which could fail if long-term management commitments from local government are not forthcoming. There is a clear need for a systematic risk management approach that highlights positive interdependencies and evaluates and exposes problematic trends over time.

CONCLUSIONS

Although initiated to offset the local carbon footprint of the Durban 2010 FIFA World Cup™, the benefits achieved by the Buffelsdraai Landfill Site Community Reforestation Project have already far exceeded the single objective of creating a tree-based carbon sink, including the enhanced restoration of biodiversity and the delivery of ecosystem services, a range of social upliftment and economic opportunities for local communities, and important research efforts. The project is indicative of a new form of urban biodiversity conservation, in which structured and deliberative interventions in biodiversity management can create new socio-ecological systems. Going forward, it is recommended that the project builds on the partnership and research platform approach. This will help optimize co-benefits and grow the portfolio of coordinated, synergized and constantly re-evaluated responses to the need for climate-change adaptation and mitigation.

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