SEEING THE WOOD FOR THE TREES: FOREST RESTORATION AT THE BUFFELSDRAAI REGIONAL LANDFILL SITE, DURBAN, SOUTH AFRICA.

ERROL DOUWES[1,2]*, NOKUPHILA BUTHELEZI[1,3], RICHARD WINN[1,4,5], FATIMA ALLI[1], KHULILE MAVUNDLA[1,6], BONGANI ZUNGU[1], KAREN MUIRHEAD[1]

[1] Environmental Planning and Climate Protection Department, eThekwini Municipality, Durban, 4001, South Africa.
[2] School of Life Sciences, University of KwaZulu-Natal, Westville Campus, Durban, 4000, South Africa.
[3] School of Agricultural, Earth and Environmental Sciences, University of KwaZulu-Natal, Scottsville 3209, South Africa.
[4] Buffelsdraai Landfill Site, Durban Solid Waste Department, eThekwini Municipality, Durban, 4001, South Africa.
[5] Wildlands Conservation Trust, PO Box 1138, Hilton, 3245, South Africa.
[6] Futureworks! Post: PO Box 2984, Knysna, 6570, South Africa.
*Corresponding author's postal address: PO Box 680, Durban, 4000, South Africa.

SUMMARY

The Buffelsdraai Landfill Site Community Reforestation Project (BLSCRP) is situated within the buffer zone of eThekwini Municipality's Buffelsdraai Regional Landfill Site (near Verulam). This paper outlines relevant background information, which led to the establishment of the project, as well as important planning and management drivers. Also discussed is the site's importance for research and evaluation of innovative climate change adaptation and sustainability initiatives.

ABSTRACT

The Buffelsdraai Landfill Site Community Reforestation Project (BLSCRP), situated within the buffer zone of eThekwini Municipality's Buffelsdraai Regional Landfill Site (near Verulam) was initiated in November 2008. The initial aim was to offset a portion of CO_2 emissions (declared as 307,208 tons CO_2 equivalent) associated with Durban's hosting of several 2010 FIFA World Cup™ soccer matches. However, whilst climate mitigation was the initial objective, the project quickly demonstrated substantive climate-change adaptation benefits, and this has subsequently come to take greater preference. Adaptation in this context refers to practical ways in which risks from climate impacts can be managed, including protection of communities and local environments as well as bolstering resilience of the economy. Specific socioeconomic benefits witnessed as part of the BLSCRP include increased food security and livelihoods opportunities for local community members, as well as better education options for local school children. The

enhanced ecosystem services, as will be delivered by the restored landscape, also show direct benefits to local communities. These ecological benefits include improved biodiversity refuges, water quality, river-flow regulation, flood mitigation, sediment control, visual amenity, and fire-risk reduction. Given its success, the project is now integral to the Municipality's local community ecosystem-based adaptation (CEBA) work-stream. This concept ensures that local communities are at the core of ecosystem-based climate change adaptation projects. It also ensures full ownership by communities of work done. The project is implemented as a collaborative effort with local communities, municipal departments, as well as external service providers. Local people collect and germinate indigenous seeds, then trade the tree seedlings for credit notes, which can be exchanged for food, basic goods, or used to pay for school fees. Trees are planted into a 580 hectare area, previously under sugarcane production for c. 100 years, within the 787 hectare buffer zone of the Buffelsdraai Regional Landfill Site. The balance of the buffer zone is comprised of existing grasslands, woodlands, wetlands and riparian areas, which also require ongoing management. The buffer zone also forms part of a newly registered Conservancy, which covers the entire extent of the Landfill Site. As a result of the innovative work done, the BLSCRP was nominated as one the United Nations "Momentum for Change" initiatives: projects which address climate change through climate-resilient and low-carbon mechanisms, while ensuring optimal benefits for local communities. The project has also been validated, by the internationally accredited Climate Community Biodiversity Alliance (CCBA), as delivering social, biodiversity and carbon sequestration benefits, at an international standard.

1. INTRODUCTION

During the course of the past five years, eThekwini Municipality (EM) has become a leader in the field of climate change adaptation (Roberts and O'Donoghue, 2013). One important pilot project, linked to Durban's innovation in this field, is the Municipality's flagship reforestation project, namely the Buffelsdraai Landfill Site Community Reforestation Project (BLSCRP) (Roberts et al., 2012; Douwes et al., 2015a). This paper outlines the establishment of this project, and subsequent work done at the site.

The Buffelsdraai Landfill Site (BLS), the largest regional landfill site in KwaZulu-Natal, is owned and managed by eThekwini Municipality's Plant and Engineering Section of the Department of Cleansing and Solid Waste, also known as Durban Solid Waste (DSW). The DSW undertakes and oversees all management of activities within the landfill footprint; whereas the EM's Environmental Planning and Climate Protection Department (EPCPD), in partnership with their appointed implementing agent Wildlands Conservation Trust (hereafter referred to as Wildlands), manage the buffer zone (Figure 1). Buffer zones around landfill sites are a requirement of South African law, as they help to screen nearby communities from views and odours associated with landfill operations. The installation of a forest in the buffer zone at Buffelsdraai was initiated in 2008 and took seven years to plant. Subsequently, in 2016, secondary reforestation activities began within the same area as a means to add additional biodiversity. The forest is intended sequester 307,208 tCO_2e (tonnes of carbon dioxide equivalent) as a means to offset the CO_2 emissions associated with the 2010 FIFA™ World Cup matches hosted in Durban.

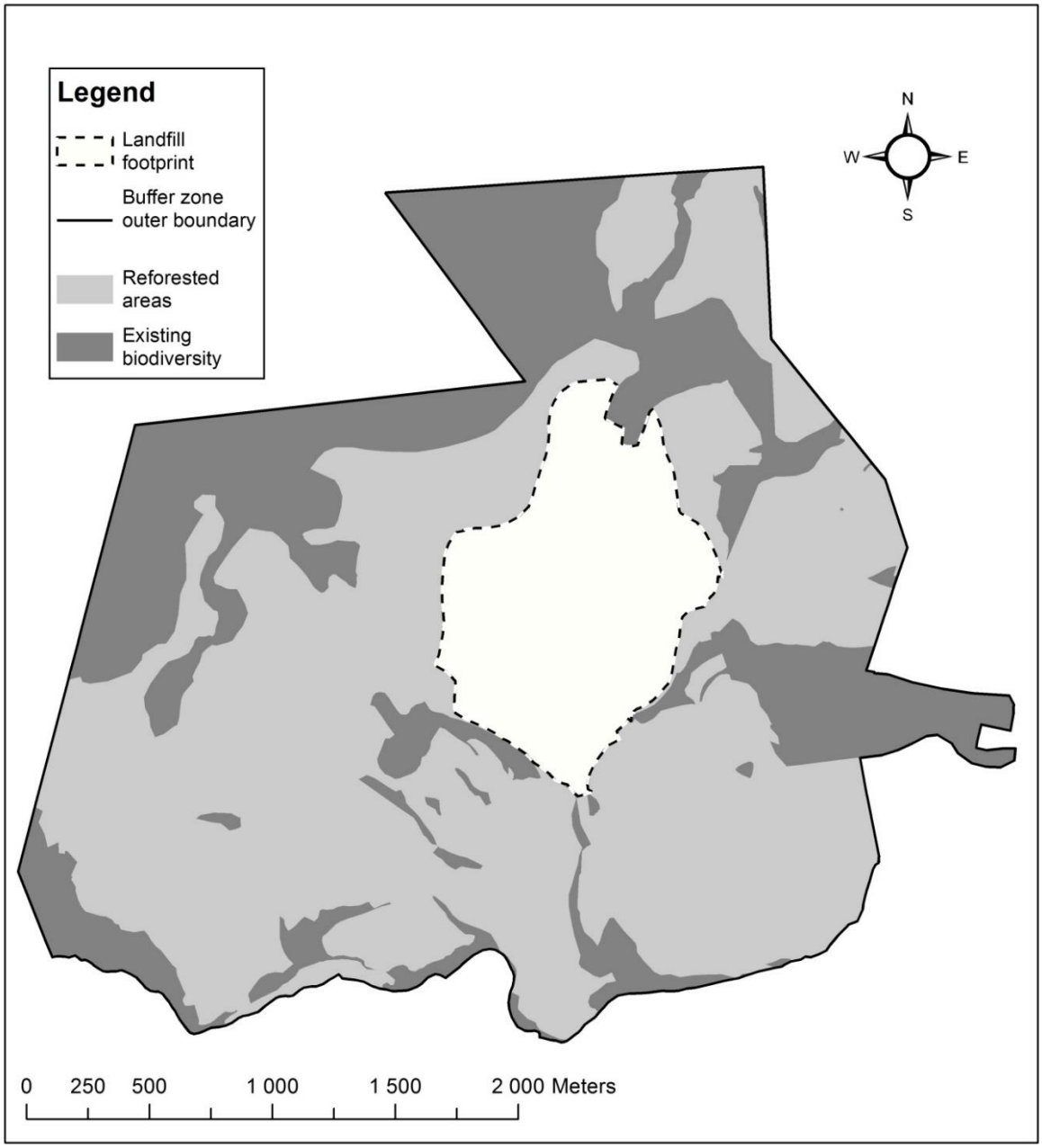

Figure 1 The Buffelsdraai Landfill Site (BLS), which comprises of a central landfill footprint area and an outer buffer zone where trees have been planted.

While offsetting CO_2 emissions (a climate change mitigation benefit) was a key target early on, the BLSCRP has also since delivered valuable climate change adaptation benefits. This is primarily due to the improved ecosystem services, delivered by the new forest, to local community members. The approach highlights the way in which natural ecosystems (whether in their pristine or restored states) can support and protect human communities. This project represents an important achievement for an African city such as Durban, as current predictions are that many African cities will face severe negative impacts as a result of climate change. For Africa's people and communities to understand what adaptation is, they must clearly perceive how it can be realistically achieved. Pilot projects such as the BLSCRP can demonstrate meaningful learnings,

and are important for showcasing how, with careful planning, a city can set relevant adaptation measures in place. Subsequent to the establishment of the BLSCRP, two other reforestation project sites have also been initiated, namely at iNanda Mountain and Paradise Valley Nature Reserve.

2. A NEW LANDFILL SITE FOR DURBAN

Prior to the formation of eThekwini Municipality in July 1996, the Metro region functioned under several Local Councils (Payne, 2005). Durban City Council, through its Solid Waste Disposal Department, DSW, operated only the Bisasar Road Landfill site at Springfield, while other Local Councils operated sixteen smaller sites. The democratization process of the 1990's led to the amalgamation of these Local Councils into eThekwini Municipality (eThekwini Municipality, 2007). DSW, which then inherited the smaller landfill sites, subsequently decided to shut fifteen of them down. Only two operational sites, at La Mercy and Springfield, were maintained (Payne, 2005). A new landfill, known as the Mariannhill Landfill Conservancy (MLC), was commissioned in Pinetown making a total of three operational sites in the Metropolitan area. Due to the short life span of the La Mercy Landfill, and its close proximity to the then proposed King Shaka International Airport (and being earmarked as a tourist/ residential area), public pressure resulted in its closure. This created a need for a new landfill in the north of eThekwini Municipality (Payne, 2005).

A rigorous site identification process resulted in three potential sites being investigated; and subsequently a site approximately 50km north-west of the city of Durban, situated between the Osindisweni and Buffelsdraai communities, was selected. The area, which was primarily under sugar cane production, had favourable geological conditions that contributed to its selection. Relevant studies indicated an intact tillite rock formation within two valleys divided by an east-west ridge. In addition, material suitable for construction and cover material could be sourced from the site (Payne, 2005). The land was purchased in October 2003 (Tongaat-Hulett Group Limited & eThekwini Municipality, 2003), and thereafter parts of the land was leased back to the prior owner - a sugarcane farmer. Subsequently, this farmer continued to cultivate sugarcane and also assisted in the management of the farm (e.g. through fire control within the buffer zone).

A full Environmental Impact Assessment (Reference: EIA/0726), which started in October 1996, culminated in a Record of Decision (ROD) issued in 2000 by the provincial Department of Agriculture and Environmental Affairs (DAEA). The ROD authorised the EM to proceed with plans to establish the landfill site (Lombard and Associates, 2000). The land was rezoned in October 2001 to "General Waste Landfill" (restricted to the land development area) as approved by the KwaZulu-Natal Development Tribunal (Judgement 2001/353) in terms of the provisions of the Development Facilitation Act No. 67 of 1995 (Moonsammy and Swart, 2001). A permit compliance certification was issued in May 2006 to DSW, by the Department of Water Affairs and Forestry (DWAF), for the official commissioning of the BLS as a Class B GLB^{+} landfill (Moodley et al., 2011); which permits domestic, business and garden waste (DEA, 2013). DSW was tasked to ensure permit compliance to the regulator through the submission of two external audits per year (Moodley et al., 2011).

The BLS is approximately 15km from the recently established King Shaka International Airport and serves the areas north of the Umgeni River through to Tongaat. The site is 937.7 hectares in extent, and is comprised of a central landfill footprint (116.2 ha in extent) and an outer buffer zone

(821.5 ha). The design life is estimated at 50-70 years, based on the airspace calculated at 45 x 10^6 m^3 (Payne, 2005), and an additional 30-year maintenance period, as required by legislation. Additional airspace is being created by removing the spurs, which are comprised of usable drainage rock, for construction purposes. Waste disposal rates are estimated at 3,500 tonnes per day (Moodley et al., 2011). The size of the buffer zone is in accordance with the level of effluence the landfill is estimated to have on the land (EPCPD and DSW, 2016).

Although landfill operations at Buffelsdraai officially began in mid-May 2006, only minimal waste was at first accepted from some areas previously serviced by Bisasar Road Landfill (Payne, 2005). This changed as of January 2017, when volumes increased as a result of the transfer of domestic waste from the Bisasar Road Landfill to Buffelsdraai.

3. A BUFFER ZONE REPURPOSED

All landfill sites are required by law, during the design phase (Lombard and Associates, 2000), to create a buffer zone that is situated between the active landfill area and adjacent communities; thus ensuring that the neighbouring communities are shielded from the impacts of the landfill. Wild and Mutebi (1996) define a buffer zone as:

> *Any area, often peripheral to a protected area, inside or outside, in which activities are implemented or the area managed with the aim of enhancing the positive and reducing the negative impacts of conservation on neighbouring communities and neighbouring communities on conservation.*

DSW, through previous experience at its MLC, had experimented with moving away from a purely “hard engineering” site management style, and had experimented with various “green engineering” approaches (Moodley et al., 2011). This included implementing a suite of environmental management tools/ systems within the landfill footprint and buffer zone that contributed to the vision of creating a conservancy. One example, namely the rescue and relocation of flora and fauna from a landfill into the buffer zone, had already been widely utilized in landfill conservancy management. Where such relocations were not possible, flora and fauna would be transplanted into the Plant and Rescue Unit (PRUnit) nursery (Moodley et al., 2011), and the same then occurred at the BLC where a PRUnit was also established. Other successful approaches that were also used at the BLC include the storage of quality top soil, removed from the landfill footprint, for later use in the potting of rescued trees and other plants. Rocks salvaged from blasting at the BLC were reused in the buffer zone as road edge protection and for creation of habitats for wildlife species (Moodley et al., 2011). An approach to minimise leachate and gas movement downstream, as well as to reduce erosion and wind scatter, involves the planting of trees in 32-metre wide belts on either side of drainage lines. This can also have a direct effect of improving the on-site groundwater quality (Moodley et al., 2011). The mind-set of green engineering also allowed for the development of like-minded partnerships. One such partnership, with the EPCPD, resulted from discussions in 2008 around the potential to initiate a carbon sink project within the BLS buffer zone (Roberts et al., 2012). This in turn led to the updating of the Buffelsdraai Constitution and Environmental Management Plan (EMP), which had initially been developed in the 2006/2007 financial year (Buffelsdraai Landfill Monitoring Committee, 2006a). The revised versions of these documents were finalised in 2014. Going forward, the EPCPD, in partnership with DSW and Wildlands, established the Buffelsdraai Landfill Site Community Reforestation Project (BLSCRP).

The BLSCRP would optimise the use of local communities for the growing of trees, while ensuring a systematic planting of indigenous forest into a 521.5 ha portion of the buffer zone. At the time of the project initiation in 2008, this 521.5 ha portion was comprised of sugarcane fields that had been cultivated for the past 160 years (Koen, 2015). The remaining 300 ha of buffer zone contained existing biodiversity areas (containing forest, grasslands and wetlands). The extent of the previous sugarcane farming practices made the site ideal for transformation into a large indigenous forest. Extant biodiversity areas within the BLS buffer zone had also been impacted on by regular fire occurrences, as sugarcane farmers' in the area typically harvest sugarcane by first burning the area as a means to optimise the volume of a harvested crop (Appleton, 2013). The subsequent removal of sugarcane farming on portions of the site has reduced the frequency of such fires, making restoration of natural vegetation easier, and has allowed for the return of native flora and fauna to the site. This trend may also assist DSW to achieve faster rehabilitation of the BLS footprint when it is eventually closed (Moodley et al., 2011), as the available levels of viable endemic seed available on site at that time are anticipated to be much higher.

The resulting enhanced ecosystem functioning around the BLS landfill site has contributed to the objectives of a local conservancy (Buffelsdraai Landfill Monitoring Committee, 2006a, updated 2014), which was established over the entirety of the landfill footprint and buffer zone. The conservancy operates in accordance with the Terms of Reference for the BLS compiled by the Monitoring Committee, which specifically set out to create a conservancy in accordance with requirements of the provincial government conservation authority, Ezemvelo KwaZulu-Natal Wildlife (EKZNW) (Buffelsdraai Landfill Site Monitoring Committee, 2006b). The receipt of conservancy status in October 2016 (Conservancy registration number C2016/006) elevates certain BLS management activities, associated with the landfill footprint and surrounding buffer, to a higher standard. These include a greater focus on species diversity, rapid response to fires and increased active fire control, increased management of and creation of awareness for illegal activities such as on-site hunting with dogs and on-site harvesting of traditional medicines. It also ensures a closer working relationship between the EM and the KZN Conservancies forum.

In order for the BLSCRP to formally be recognized as a 'carbon-offset project' with real benefits for the climate, communities and biodiversity, some level of accreditation was required. As such, an application for accreditation was made to the internationally recognised Climate Community and Biodiversity Alliance (CCBA). Such accreditation required compliance with the required CCBA standards, in terms of meeting required standards for benefits to communities, biodiversity protection, and in ensuring adaptation to or mitigation of climate change. Various on-site ecological baseline studies and detailed socio-economic assessments were undertaken (*viz*. Greater Capital, 2011; Macfarlane et al., 2011; Bertolli et al., 2013). Comparisons of the transformed areas (predominately sugarcane lands) with remnant patches of untransformed land, showed substantially less biodiversity in transformed areas (Macfarlane et al., 2011). Such ecological baseline studies are also important for long term research, as ecologists will be able to interrogate changes over time that reflect the gradual transformation from a landscape covered predominantly by sugarcane, to that of a forest. Soil surveys, to determine soil types and distributions (Macfarlane et al., 2011), helped to guide the tree-planting, given that soils play an important role in determining climax vegetation cover. It was anticipated that historical vegetation cover be replicated on the site, where feasible (Macfarlane et al., 2011).

3.1 Tree Planting

eThekwini Municipality adopted and pioneered an innovative forest restoration approach through the 'Indigenous Trees for Life' (ITFL) concept developed by Wildlands. This concept involves the establishment of Tree-preneurs within project beneficiary communities. The tree-preneurs are trained by 'facilitators', employed in each of the neighbouring communities, to encourage individuals to join the programme. Once local community members join, they are encouraged to grow indigenous tree seedlings in their 'home nurseries' until these reach a suitable height and are ready to be traded. Following collection of trees, the tree-preneurs are paid with credit notes. These credit notes can be used at 'Tree Stores' organised by the Wildlands to purchase groceries, bicycles, building materials, or to pay for school fees or vehicle driving lessons. Collected trees are kept in a holding nursery at the project site and are sorted according to size and species, ready to be hardened-off prior to planting.

In October 2008, Wildlands initiated tree planting on the 35.89 ha then available for reforestation at the BLSCRP. In July 2009, Wildlands was appointed as an implementing agent to undertake reforestation activities within the BLSCRP; following which trees were planted according to the lease of land from the Simamisa farmer who was cultivating sugarcane on the land within the buffer zone area (Winn, 2010).

In March 2010, a Memorandum of Understanding (MOU) drawn up between Simamisa (in partnership with Tongaat Hulett), DSW and EPCPD, included details of a lease notice period for the buffer zone management (Winn, 2010). Simamisa released 291.34 ha prior to March 2010 and thereafter, an additional 200.31 ha were released for immediate reforestation to occur. Sugarcane farming continued for a further one season and once cut, reforestation could occur. In March 2013, the 230.41 ha that had remained under the lease was released for the reforestation process to take place. Sugarcane regrowth would still occur in some areas from which the farmer would continue to harvest; however, prior burning of the cane was not practiced (Winn, 2010).

The first phase of the project involved tree planting and was undertaken from 2008 to 2015. Reforestation of the 580 ha area was undertaken using approximately 51 locally indigenous (sourced from within a 50km radius) tree species. The tree planting density was approximately 1,000 trees per hectare, except for riparian areas where this density increased to 2,000 trees per hectare. Tree planting was done mostly in spring and summer when rainfall is highest. Tree mortality was assessed some months after planting, and any dead trees were replaced with new saplings from the nursery stock on site. This nursery stock of 'insurance' trees is kept for instances when trees have died, usually due to either extreme drought or wild fires.

The second phase of the project resumed in 2016 and entails secondary reforestation; whereby a diversity of plant species (not only trees) would be planted to supplement the now established trees from the first project phase. A yearly target of 40,000 secondary reforestation species across 100 ha of land within the site is to be achieved. Furthermore, monitoring of natural succession and spreading of additional biodiversity enhancements (seedlings/ seeds/ rhizomes) where necessary will also be achieved. Climber and understorey species are planted where suitable gaps between already planted framework species are identified. Secondary reforestation is undertaken by a permanent planting team (26 people as at April 2017) employed from the local community. A separate team undertakes maintenance on the site.

The central BLS footprint (where active landfill activities were underway) was fenced to separate it from the surrounding buffer zone. In 2008, approximately 7,000 trees were planted

along this fenceline by the reforestation team. These trees were to act as a firebreak and screen the views and odours associated with the landfill operation. At the time, a fence was also proposed for the outer circumference of the buffer zone, as a means to minimise trespassing into the area by communities and their livestock (goats and cattle), as well as ensure that the boundary line was clearly recognised by all stakeholders. The high frequency of community members hunting with dogs, lighting unauthorised fires, and illegal dumping served to escalate the importance of a fence. As an alternative to fencing with wire, a 'Living Fence' was proposed and subsequently installed by the reforestation team. This included a suite of thorny tree species, planted in high densities (>2,000 trees per hectare, in a 15-metre wide belt) along the boundary. The Living Fence also included large truncheons planted at the edges of the 15-metre area. To date, more than 70,084 thorny tree species have been planted into this area.

3.2 Control of fires

On-site fire management is also undertaken to minimise the destruction of newly planted trees. For this reason, firebreaks are cut and maintained around all planted areas. This work is undertaken by the Municipality's Fire and Invasive Species Control (FISC) programme, in conjunction with Wildlands, which provides manpower to directly suppress unauthorised wild fires. Fuel loads are reduced through the application of prescribed burns, as well as through continuous control of invasive alien plants (IAPs) on the site. Together, these minimise the occurrence of wildfires. A periodic Veld Condition Assessment (VCA) aids in the identification of areas to be prioritised for prescribed burns (eThekwini Municipality, 2017) in a particular fire season (Trollope, 1990). Dissemination of fire related information, by crew members of the FISC programme, to community based schools helps to build awareness of the negative impacts of fires, as well as for approaches to deal with run-away fires. Fire management at the BLSCRP is largely seen as a protectionist activity, i.e. as a means to protect young trees, physical assets and people within the site (Vogler, et al., 2015). The risk of on-site methane (from the landfill footprint) contributing to fire-related disasters is accounted for by careful planning and management of, or reaction to, on-site fires (DEA, 2014).

3.3 Control of invasive alien plants

Regular and ongoing control of invasive alien plants (IAPs) within the BLSCRP is a high priority, as these plants threaten the successful establishment of the forest. IAPs most commonly found on-site include *Chromolaena odorata*, *Lantana camara*, *Melia azedarach*, *Solanum mauritianum* and *Tithonia diversifolia*. Wildlands, as part of their planting regime, clear IAPs systematically prior to planting and also through follow-up control. Between 2008 and 2016 (the initial tree planting phase), the Wildlands restoration team planted trees on land where sugarcane had recently been cut by the farmer. Follow-up control on these areas was undertaken by the maintenance team, who were tasked to clear any tall grasses, IAPs and remnant sugarcane. This also served to minimise the chances of IAPs setting seed. Post 2016, the dedicated restoration team tends to all reforested areas by clearing IAPs, primarily during the autumn and winter months when planting is halted (due to the dry soils), and to assist in reducing biomass fuel loads. IAPs pose a very high fire risk to the planted areas as they greatly increase biomass fuel loads; and this contributed to the decision to introduce a dedicated fire-control team from the FISC programme (discussed above).

In areas where IAPs established quickly, the restoration team remove and 'double-bag' IAP seeds prior to sending them to the landfill for disposal. During the secondary reforestation phase, the teams prepares the land by conducting initial and follow-up IAP control work before, during and after the planting period. Use of herbicides on the site are kept to a minimum, as a means to ensure that DSW is not held liable for any potential water contamination. Water quality tests are conducted quarterly (EPCPD & DSW, 2016). One exception, however, is Kaput (active ingredients: Picloram [pyridine carboxylic acid as potassium salt] and Triclopyr [pyridine carboxylic acid as triethylamine salt]) used to treat IAP woody species (e.g. *Casuarina equisetifolia*, *Eucalyptus grandis* and *Melia azedarach*) due to its high viscosity that minimises spillage.

Biological control, in the form of stem-borer weevils (*Lixus aemulus*) were released into an area of 2 ha (within the landfill footprint) in 2016 to assist in control of *Chromolaena odorata*. The initial release (320 weevils) occurred in February 2016 and a second release (234 weevils) occurred in September 2016. These weevils weaken the plants and their productivity, resulting in reduced management over time. No manual control of *Chromolaena odorata* plants within the release area will be undertaken for a 5-years period, as a means to facilitate the successful establishment of the weevils on the site.

4. FUNDING OF THE BLSCRP

The BLSCRP was initiated with seed funding sourced from the Danish Government in 2008, through a funding mechanism known as DANIDA (Danish International Development Agency). Thereafter, following the establishment of a Municipal Climate Protection Programme (MCPP), eThekwini Municipality successfully secured internal funds.

Shortly after COP17-CMP7, the Department of Environmental Affairs (DEA) announced the establishment of the National Green Fund, which was to be administered by the Development Bank of Southern Africa (DBSA). This fund was intended to boost the National Government's green economy objectives through the provision of grant funding to successful applicants. The EPCPD applied to the DBSA for funds, to boost the already successful Community Reforestation Programme and further scale up the climate change adaptation related work of the MCPP. As a result of an existing effective programme, as well as due to the proposed co-funding model, the DBSA in January 2013 pronounced the application as successful. The project was awarded Green Fund co-funding amounting to R 36,940,000.

5. HOW THE PROJECT HAS CHANGED PEOPLE'S LIVES

Socio-economic benefits resulting from the reforestation project have been significant (Figure 2), and include more than 540 employment opportunities generated since the start the project in 2008 (Douwes et al., 2015a). Benefits can be categorised into: a) household and b) community benefits (what can be termed multiplier effect). All people employed were from the surrounding communities and were previously unemployed. According to beneficiaries of the project, income gained from the project had significant impacts on their household livelihood (The Cirrus Group, 2014). All permanent, temporary and part-time workers are paid wages at the national minimum wage level in the construction sector (The Cirrus Group, 2014) and beneficiaries have reported higher income than the average income of the whole community.

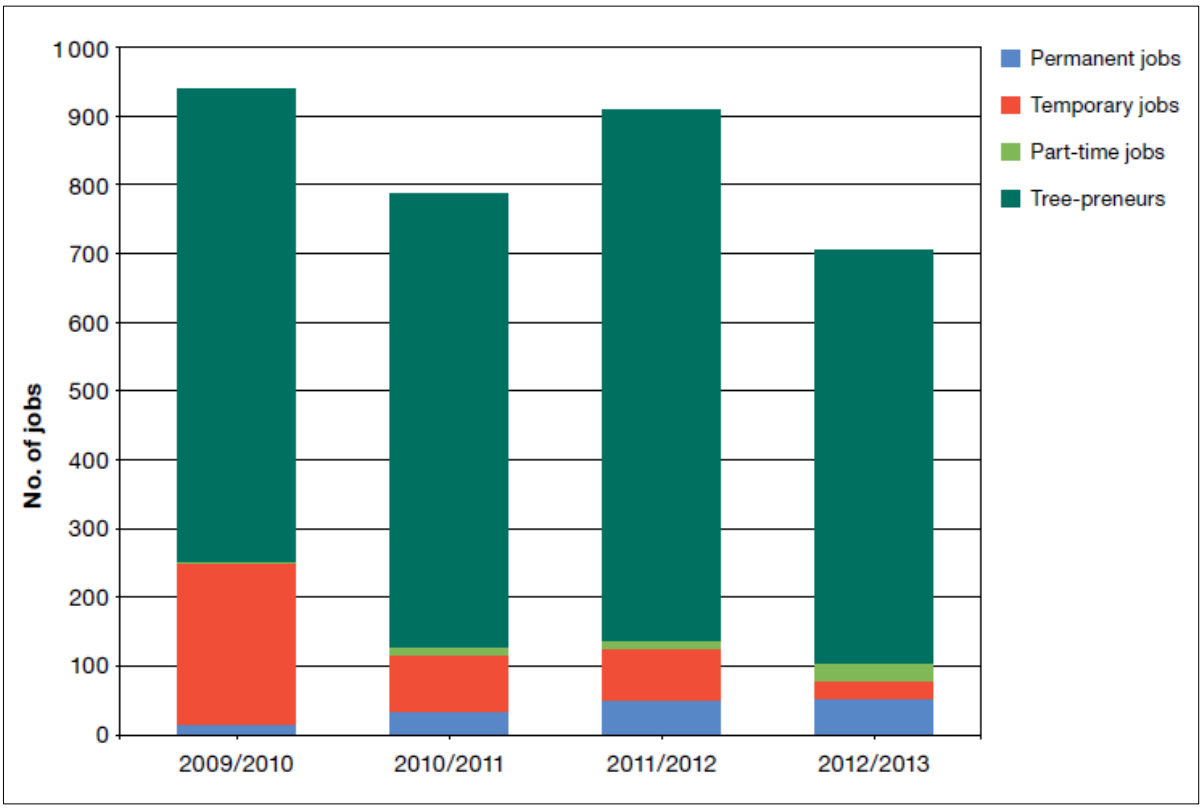

Figure 2 Jobs created through the BLSCRP between 2009 and 2013 (Source: Douwes et al., 2016)

Besides employment opportunities created, the development of tree-preneurs (as described above) led to the increase of household income and skills development. A study of 320 tree-preneurs (Greater Capital, 2011) indicated that majority (97%) of people traded trees for food (Figure 3), followed by educational expenses such as school fees and stationary (16%) and bicycles (5%). A small number of people reported that they spent their wages on building materials bought locally (The Cirrus Group, 2014), or on fees for driving lessons. Greater Capital (2011) compared food security levels before and during the initiation of the project. People who reported that they "sometimes go hungry the whole day" were reduced from 80% to less than 50%. Furthermore, households that were acquiring food through trading trees increased to 30%. Evidence indicates that people became less reliant on begging for food from relatives and extended families.

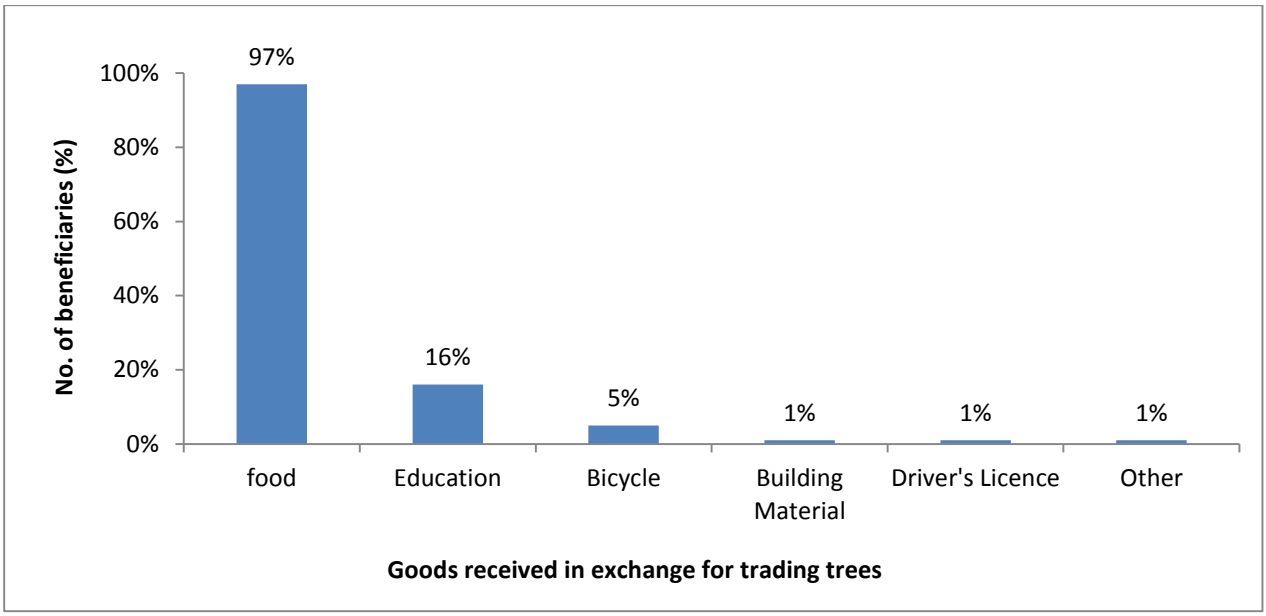

Figure 3 Composition of goods traded by tree-preneurs (Source: The Cirrus Group, 2014)

Another important finding was that the uptake of sustainable practices and use of natural resources results in other livelihoods benefits; for example, Group Capital (2011) found that communities living close to the BLSCRP relied heavily on natural resources to gather wild fruits, vegetables and medicinal plants. The above evidence indicates that natural resources, biodiversity conservation initiatives and socio-economic development are inextricably linked.

5.1 Sustainable Livelihoods Project

A “Sustainable Livelihoods” initiative, initiated soon after receipt of funding from the National Green Fund, sought to build local community entrepreneurs that engage in local food production. The initiative aims to build on, and further develop, the livelihood generation opportunities previously established and explored through the tree-preneur initiative. To date, benefits achieved exceed the 50 beneficiaries initially identified. This is due to the ‘pay it forward’ approach, whereby each beneficiary in turn assists and teaches a number of neighbours, thereby increasing the permaculture beneficiary numbers (Table 1) in an exponential manner.

Table 1 Number of nurseries constructed and beneficiaries reached at each of the Sustainable Livelihoods Project's development sites.

Activity	Project Site				
	Nazareth	Buffelsdraai	Osindisweni	iNanda (Matata)	iNanda (Maphephetheni)
No. nurseries constructed	1 (9m x 4m)	1 (6m x 6m)	0	0	Pending
No. beneficiaries trained	10	10	10	13	5
No. pay-it forward beneficiaries	18	30	26	7	9
No. Edamame herb beneficiaries	75	90	96	47	0
Total no. households impacted to date	103	130	132	67	14

5.2 Environmental Education

An environmental education initiative was piloted, over a two year period at the BLSCRP, using funds from the National Green Fund. The objective was to involve children and adults that were not necessarily direct participants in, or beneficiaries of, the BSLCRP. All participants gained important learning or educational experiences. Topics included: community climate adaptation approaches, carbon sequestration and storage as a form of climate change mitigation, biodiversity restoration ecology in practice, forest ecology, and community development or livelihoods models. Through this initiative, and the availability of the Education and Training Centre at the BLS, 3,200 learners from 24 local schools, and 60 ward councillors and committee members (from Buffelsdraai, iNanda and Paradise Valley) attended training. Furthermore, 320 ordinary community members attended community site-guides training and environmental training.

6. REFORESTATION RESEARCH

The uncertainty associated with the rapidly changing world ('Antropecene'), which is characterised by new challenges and complex problems, means that local governments require a more holistic and systematic approach to solving problems. As such, cities across the globe have increasingly partnered with research institutions in order to ensure that the latest science and problem-solving techniques are applied to real-world problems. In Durban, eThekwini Municipality and the University of KwaZulu-Natal (UKZN) initiated the Durban Action Research Partnership (D'RAP) (Roberts et al., 2012; Douwes et al., 2015b). This partnership focuses on advancing knowledge in biodiversity conservation and management within the context of global environmental change and further builds capacity of both institutions (Douwes et al., 2015b; Cockburn et al., 2016; Taylor et al., 2016). Through the partnership, principles of trans-disciplinary research are used to address real-world problems through collaborative research that is

conducted within a range of disciplines including environmental, biological, social science, governance and economics (Douwes et al., 2015b; Cockburn et al., 2016; Taylor et al., 2016).

A total of 15 UKZN students (13 MSc and 2 PhD) were involved at the BLSCRP through a Reforestation Research (RR) initiative, with topics ranging from communities' perspectives on the RR programme, to quantifying ecological restoration, to assessing climate change-related considerations and biodiversity outcomes (Douwes et al., 2016). The broad range of disciplines and trans-disciplinary research approach allowed students to gain experience in working in a collaborative way and promoted research across different disciplines and institutional boundaries. The long-term research relationships that students have built are improving their employability by engaging with practitioners beyond the academic context. These young graduates can now be employed by the Municipality and elsewhere which addresses a severe skills shortage in the environmental and biodiversity sector (Douwes et al., 2016).

The focus of the RR programme is to set up a robust monitoring framework for the reforestation program to continuously monitor any environmental changes taking place in the reforested area (Douwes et al., 2015b). The overall aim is to understand the system and to monitor changes. One important contribution will be to assess and put in place appropriate systems for the collation of baseline data. Another important contribution will be to identify suitable indicators and to establish a monitoring framework for biodiversity and ecosystem services (e.g. species, carbon sequestration, water quantity and quality) (Douwes et al., 2016).

Registering the entire BLS as a 'Protected Area' with the Birds in Reserves Project (BIRP) was undertaken in 2016. The primary aim of BIRP is the collection of bird occurrence data (BIRP, 2017), specifically inside South African Protected Areas (SAPAs). This citizen science project (ADU, 2017) of Cape Town University's Animal Demography Unit (ADU) is supported and endorsed by both the South African National Biodiversity Institute (SANBI) as well as Birdlife South Africa (BLSA). The BIRP information can be used for personal or recreational use; including education, research and conservation purposes. It will serve as an avifaunal baseline monitoring tool for the CRP and BLC. Interested people/ birders can access the information from the BIRP website (BIRP, 2017). Background information of the BLSCRP project and GIS shape files of the project boundary were submitted to the Animal Demography Unit (ADU). The BLSCRP was added to the list of reserves in BIRP in April 2017.

7. CONCLUSION

In November 2014, the Reforestation Project was validated by the Community, Climate and Biodiversity Alliance (CCBA) (Douwes et al., 2015a). It received a Gold Standard for ensuring exceptional climate change adaptation benefits and for benefits to local communities and biodiversity (Douwes et al., 2015a). In addition, on 16 July 2015 the 'Buffelsdraai Landfill Footprint and Buffer zone Project' won the "Best Public Service Implemented Programme or Project of the Year" from the KwaZulu-Natal Premier's Service Excellence Awards (Douwes et al., 2015a).

The project has highlighted the importance of how natural ecosystems support and protect human communities, and the role that human communities can play in supporting, restoring and protecting local ecosystems. Apart from the subsistence contributions, forests support livelihoods through income earning opportunities.

As a means to ensure continuity of the many benefits of the BLSCRP, the EPCPD initiated, with funds from the National Green Fund, a Reforestation Hub Centre of Excellence at the nursery site. The centre will target researchers, scholars, community members and tourists that come to learn about climate change adaptation. The centre will showcase the extensive plant nursery and a new building that demonstrates innovative sustainability technologies. These include solar panels, the capture, storage and re-use of water, efficient lighting, etc. A derelict farm building, adjacent to the nursery, is being renovated to form the core of the new structure, again as a means to showcase the principles of re-use, recycling and sustainability. Green design principles are used throughout the centre, in order to showcase climate-smart construction methods and materials. The construction process has already generated many local job opportunities.

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