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ETHEKWINI MUNICIPALITY

GREEN ROOF PILOT PROJECT

MUNICIPAL climate protection PROGRAMME

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Local Action for Biodiversity

Information Pamphlet

GREEN ROOF PILOT PROJECT

MUNICIPAL
climate protection
PROGRAMME

THIS PROJECT AIMS TO:

- Reduce temperatures and stormwater runoff;
- Mitigate and adapt to climate change; and
- Promote inner city biodiversity.

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WHAT IS A GREEN ROOF?

A green roof is a roof with a suitable gradient that is planted with low growing, drought resistant, indigenous vegetation in a shallow, lightweight growing medium. Green roofs do not require structural supports and hence can be established on existing roofs that have not been specifically constructed to carry an additional structural load such as an intensive rooftop garden does (with larger, heavier plants and soils).

WHY A GREEN ROOF PILOT PROJECT?

The Green Roof Pilot Project is part of **eThekwini Municipality's Municipal Climate Protection Programme**. This Programme was initiated in 2004 and focused initially on understanding the vulnerability of the city to climate change impacts e.g. increased temperatures, changes in rainfall, rising sea levels and an increase in the severity and frequency of extreme weather events. This knowledge is being used to inform the development of appropriate **adaptation and mitigation**[1] **responses** and strategies at the municipal and community level. A strong emphasis has been placed on identifying climate change adaptation projects that will improve the resilience of the city to future developmental, social and environmental challenges. They will also assist in mainstreaming of climate protection into municipal city planning and development.

The **Green Roof Pilot Project** is a response to the higher temperatures and increase in the frequency and severity of floods and droughts that are expected as the result of climate change. In the urban environment these changes will exacerbate the already high temperatures experienced as a result of the "urban heat island" and the high levels of surface run-off and flooding that result from the hardening of permeable surfaces. Green roofs are currently being used around the world to reduce temperatures and stormwater runoff. Green roofs also offer an opportunity to promote inner-city biodiversity on underutilized, empty roofs and to address food security issues through the production of food.

[1] Climate Change Mitigation: this refers to measures to reduce greenhouse gas concentrations in the atmosphere, and thus ultimately the magnitude of climate changes.

Climate Change Adaptation: this acknowledges that no matter what level of mitigation is achieved, a certain level of climate change is now unavoidable. Adaptation refers to the adjustment in natural and human systems which moderate harm or exploit the beneficial opportunities associated with climate change.

LOCATION OF THE GREEN ROOF PILOT PROJECT

The Green Roof Pilot Project is located on one of the buildings in the City Engineer's complex. The choice of this location was informed by the following facts:

- the roof is flat and has easy access
- it is a secure location where scientific analyses can be undertaken,
- the roof was assessed by a structural engineer and found to be suitable in terms of its loading capacity, and
- the roof is visible to municipal staff and the public visiting the City Engineer's building.

WHAT ARE THE BENEFITS OF GREEN ROOFS?

- Large scale roof planting will **reduce the "urban heat island effect"** (caused by the higher heat absorption of city surfaces such as concrete and tarmac) through shading, absorption of heat in plant thermal mass and evaporational cooling.
- **Reduced surface run-off** by reducing the amount of hard surfaces in the city and through the absorption of water by the soil media and plant roots. This reduces overall **surface run-off** as well as **attenuating storm water run-off**. The latter is beneficial from a storm water infrastructure perspective.
- **Improved air quality** through the reduction of airborne particulate pollutants, heavy metals and volatile organic compounds as they are deposited on the soil, on the leaf surfaces of the plant layer, and onto the moist internal surfaces of the leaves.
- **Positive climate change impacts** via the absorption of carbon dioxide (a greenhouse gas) as plants absorb carbon dioxide and release oxygen as they photosynthesize.
- **Reduced use of air conditioners** in buildings due to shading and evapotranspirational cooling[2].

- **Reduced maintenance and replacement costs for roofs**, prolonging of roof life by two to three times.
- **Reduction of noise pollution**.
- **Increased biodiversity**.
- **Food production**.
- **Aesthetic benefits**.
- **Fire resistance**.
- **Electromagnetic insulation**.

[2] Cooling due to the evaporation of water from the surface of the green roof as well as evaporation of water from the aerial parts of the plants (transpiration).

HOW DO YOU CONSTRUCT A GREEN ROOF?

There are two construction methods. The **direct method** involves placing the growing medium directly onto the underlay required for green roofs. The second involves placing the growing medium in trays. This is referred to as the **modular method**. The modular method is best for difficult applications, such as corrugated roofs or where roof access is difficult. This method also works well when instant effect and mobility are necessary. Both the direct and the modular methods of green roof construction are being used in the pilot project and both require that:

- The roof is checked by a **structural engineer** to ensure that the existing roof can take the additional loading.
- A **green roof specialist** is consulted to establish which method is most suitable and which plant species should be used.
- An additional **protection layer** is applied on top of the existing roof membrane (usually a layer of geotextile bidum and a layer of 1000 micron plastic).
- A **drainage layer** is placed on top of the protection layer: For direct method construction another layer of **geotextile fabric mesh** is placed on the roof. For the modular method **recyclable plastic containers** are placed on the roof.
- A **specialised soil layer** is then either placed on top of the layers (direct method construction) or in the containers (modular method construction). The soil layer for a green roof may be as much as 60 % lighter than a conventional soil type. Normally a lightweight, well drained, high moisture retention soil layer compiled of vermiculite, perlite and well composed growing medium or potting mix is used.
- **Indigenous vegetation** is then planted in the soil layer.

THE DIRECT METHOD OF PLANTING

THE MODULAR METHOD OF PLANTING

WHAT KIND OF PLANTS SHOULD BE PLANTED ON THE GREEN ROOF?

Plants in the vegetative layer should be:

- drought resistant,
- heat tolerant,
- low growing,
- self seeding (so as to replace themselves from seed when stressed by heat and water fluctuations),
- wind resistant, and
- able to survive and even thrive under extreme growing conditions.

TIP: When selecting plants, ensure that the plants have been hardened off or acclimatized to withstand dry, hot conditions.

The Green Roof Pilot Project has used **only indigenous plants** (except for the food plants that will be tested) in support of the Municipality's policy of protecting the city's **internationally significant biodiversity**.

WHAT PLANT SPECIES SHOULD BE USED?

The pilot project has only used **indigenous plants** and this approach is recommended for any **green roof** in Durban in order to promote **biodiversity** and the viability of the city's natural ecosystems.

Over **100 indigenous plant species** are being used in this pilot project. The intention is to determine which indigenous species are most suitable for green roof applications in Durban.

The planting palette for the pilot project has been inspired by the plant associations that occur naturally in the wild, such as those that grow on extremely hot and dry granite and sandstone rocky outcrops and cliffs (cremnophytes or cliff dwellers) and in shallow humus rich soils.

EXAMPLES OF THE SPECIES USED IN THE PILOT PROJECT	
Aeollanthus parvifolius	*Asparagus densiflorus*
Aptenia cordifolia	*Aloe arborescens*
Aloe maculata	*Aloe rupestris*
Bulbine abyssinica	*Bulbine inflata*
Bulbine natalensis	*Cissus fragilis*
Cissus quadrangularis	*Cotyledon orbiculata*
Crassula multicava	*Crassula obovata*
Crassula ovata	*Crassula perfoliata*
Crassula sarmentosa	*Crassula vaginata*
Crinum macowanii Delosperma rogersi	
Justicia flava	*Hibiscus calyphyllus*
Huernia hystrix	*Kalanchoe thyrsiflora*
Kleinia fulgens	*Nymphoides thunbergiana*
Pelargonium capitatum	*Portulacaria afra*
Senecio barbetonicus	*Stapelia gigantea*

MAINTAINING A GREEN ROOF

The green roof requires **regular irrigation** until the plants have become **established**. Thereafter the plants need to be irrigated as and when necessary, which is determined by the type of vegetation, the depth and drainage characteristics of the soil and the prevailing atmospheric conditions. Opportunities exist for irrigation using water collected in the gutters of the roof and adjacent roofs and grey water from kitchens and bathrooms.

Occasionally green roofs need to be **weeded**, as a common problem is the germination of wind and bird dispersed seed.

WHAT IS THE PILOT PROJECT TESTING?

The pilot study tests:

- Both the **direct and modular methods** of green roof construction.

- **Different growing media** across a range of nutrient levels, textures, composition, depths, weights and drainage characteristics.

- A range of **different plant species**.
- Some containers are also being used as "ponds" to see which **submerged aquatic and wetland plants** will survive under roof top conditions.

- **Different watering rates** taking into account the variations in location, plant species, soil medium and rainfall.

Scientific analyses are also being undertaken to assess:

- the **temperature reduction** that the green roof affords both the ambient atmosphere and the building itself (resulting in the reduction of the "heat island effect" and the reduction of air conditioner use respectively);

- the quantity and quality of the **surface run-off** from the roof; and

- the increase in **biodiversity** of the roof.

Results to date show up to a **25°C difference** between the green roof's ambient temperature and the control roof's ambient temperature.

A comparison of the direct and modular methods is provided in the table below.

OPTIONS	DIRECT	MODULAR
Installation	Various protective layers must be installed on the roof prior to planting.	Trays can be pre-planted, thus offering quick installation. The container system can be put in place on the roof rapidly and in accordance with design requirements.
Maintenance and repair	Layers need to be lifted until the problem is found, resulting in the growing medium and plants being disturbed.	Containers can be moved easily without disturbing the growing medium and plants.
Alterations and additions	Often difficult and expensive to change or add-on to due to edge design requirements.	Allows for the installation of green roofs in sections, thus offering the opportunity for future add-ons and alterations.
Lightweight	Direct systems are often heavy and may require roof surface replacement or additional support.	Trays can be installed on almost any existing roof surface in good condition and with appropriate structural capacity.
Plants	Plant roots have less space restrictions allowing for deeper and more extensive root systems and greater interactions between plants.	Some plants may struggle as their roots systems are restricted.
Cost and materials	Cheaper, fewer materials needed and therefore reduced impact on the environment.	More expensive and more materials needed, but if recyclable plastic containers are used, environmental impact is significantly reduced.

In the pilot project eight areas of ±50m^2 have been planted, five of these are planted using the modular method and three using the direct method.

The reason both the **direct and modular** methods were used with varying soil media was to measure the following:

- The difference in growing **medium weight and fertility**.
- The ability of both techniques to **minimise surface run-off** and their **rainfall retention capacity**.
- The difference in **temperature reductions** between the two methods.

WHERE TO FOR THE GREEN ROOF PILOT PROJECT?

There is an increasing need to promote **urban greening and agriculture** and rooftops offer an easily accessible urban space. Future research options include testing the suitability of different **food plants**, testing the growth of plants on **non-flat roofs**, circulating **grey water** and rainfall run-off back onto the green roof (especially when growing crops which require more water for survival).