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# *“Mitigating the climate impacts of the waste sector”*

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SARCHI Chair in Waste and Climate Change

CSIR, Pretoria  
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EDGEWOOD CAMPUS

HOWARD COLLEGE CAMPUS

NELSON R MANDELA SCHOOL OF MEDICINE

PIETERMARITZBURG CAMPUS

WESTVILLE CAMPUS

INSPIRING GREATNESS

# Acknowledgments



science  
& technology

Department:  
Science and Technology  
REPUBLIC OF SOUTH AFRICA



National Research  
Foundation

RISA

Research and Innovation  
Support and Advancement

CSIR

our future through science



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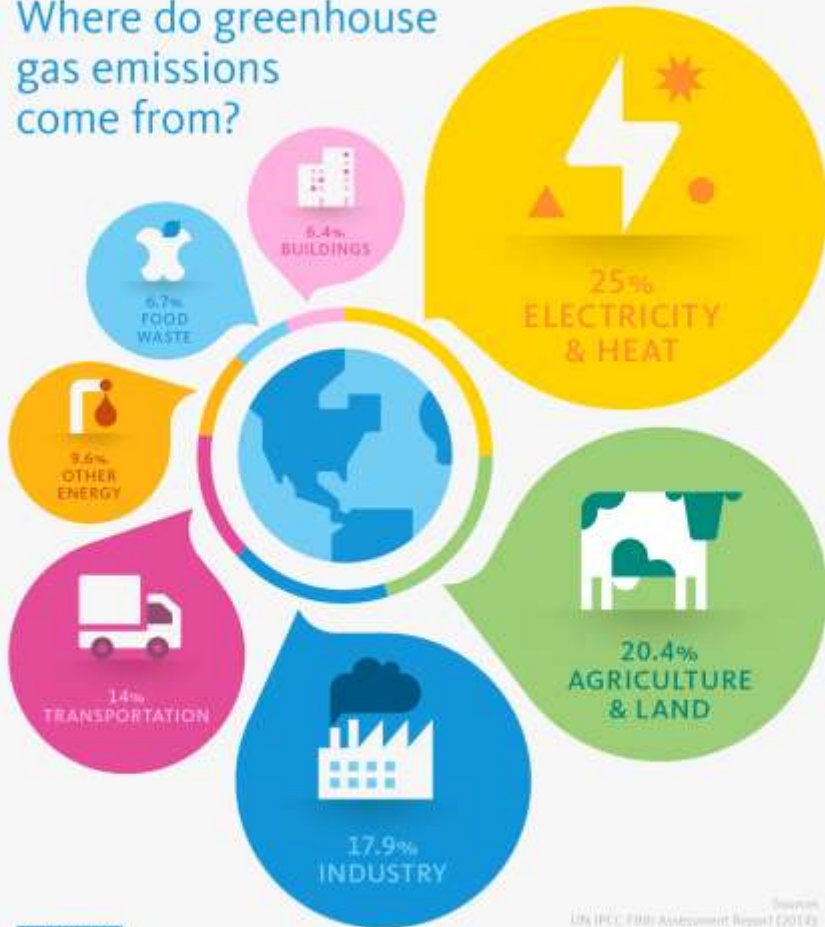
## A WASTE RDI ROADMAP FOR SOUTH AFRICA

The importance of research, development and innovation (RDI)  
in transforming the South African waste sector



# Our Grand Challenge

Where do greenhouse gas emissions come from?



UNIVERSITY OF CALIFORNIA

Learn more at [climate.universityofcalifornia.edu](http://climate.universityofcalifornia.edu)

Source: UN IPCC Fifth Assessment Report (2014); UN FAO Food Waste Footprint (2013)

Percent of global greenhouse gas emissions.

## GRAND CHALLENGES



# Waste and Climate Change in SA - GHG



CH<sub>4</sub> from landfills represents **12%** of total global CH<sub>4</sub> emissions (USEPA, 2006; World Bank, 2012)

GHG emissions in the EU have more than halved from 1999 to 2007.

CH<sub>4</sub> has increased by **11.3%** and GHG emissions have increased of almost **60%** from waste sector in SA in past 15 years.



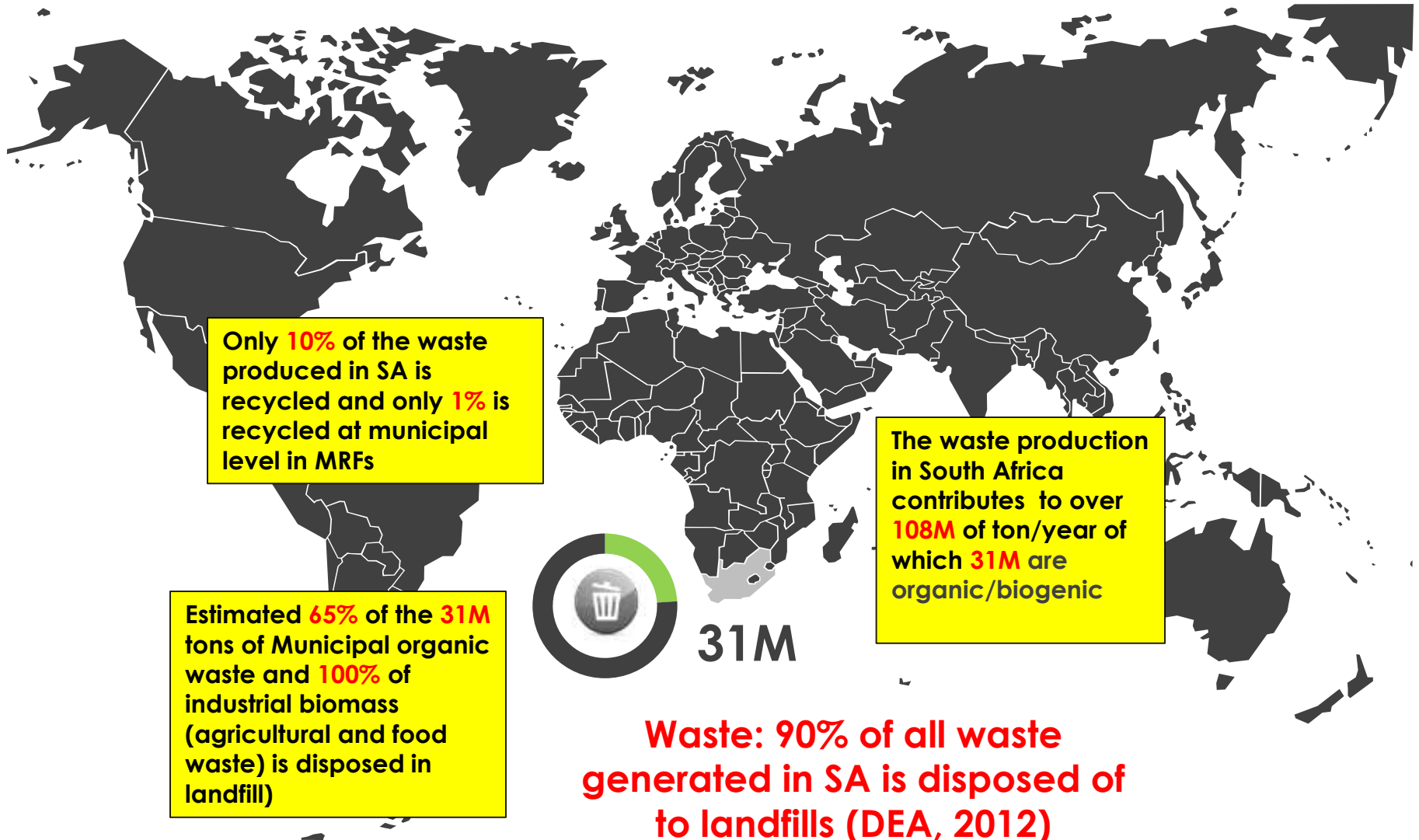
**4,3%**

The waste sector in South Africa contributes to **4.3%** of GHG emissions and **37.2%** of total CH<sub>4</sub> (DEA, 2014)

**Emissions: 9 million tons of CO<sub>2</sub> equivalent (2016)**



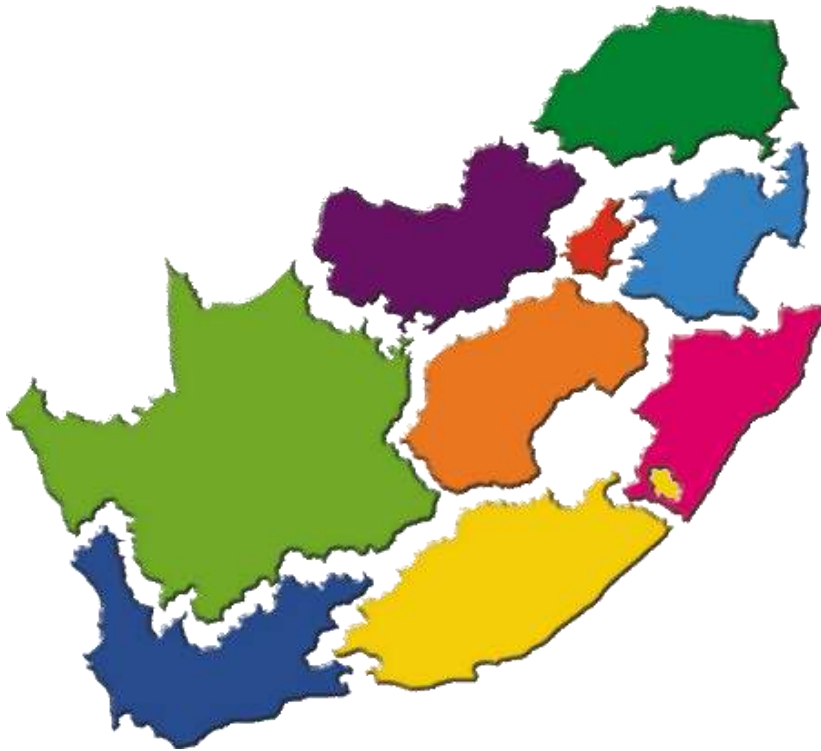
# Waste and Climate Change in SA - WASTE



Waste management in an emerging economy is a complex socio-technical challenge...



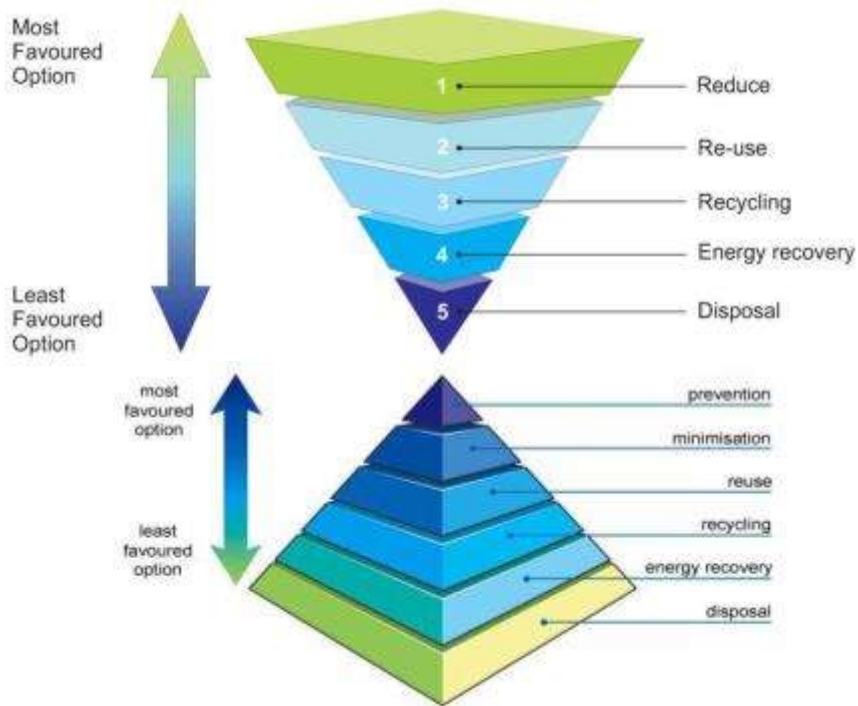
# Waste Management in South Africa



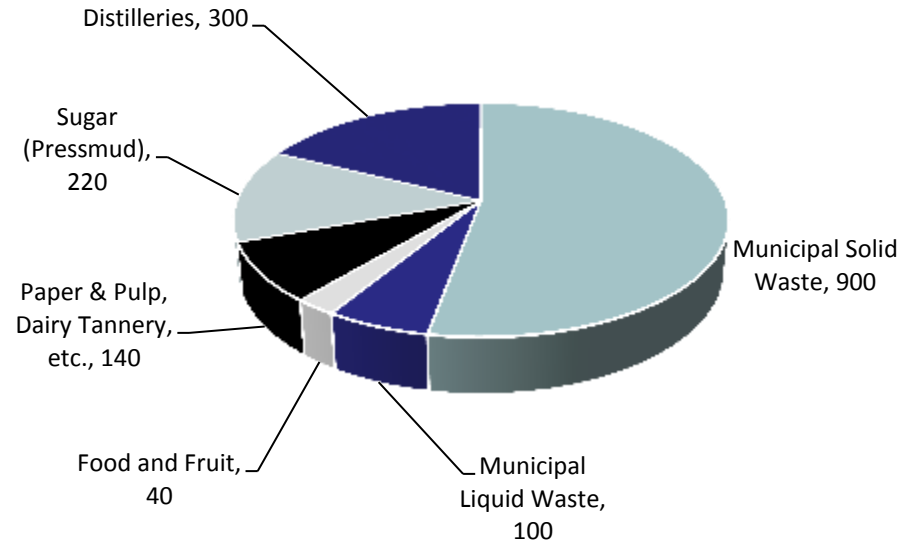
- **Challenge of meeting high standards in service delivery with limited resources**
- Lack of environmental control systems and appropriate legislation
- **Limited know-how,** indiscriminate dumping
- **Lack of reliable data on waste streams and GHG emissions indicators**
- Poor environmental and waste awareness of the general public



# Waste Hierarchy



(source: National Waste Management Strategy of South Africa (DEA))



Energy recovery potential (MWe) of different wastes from urban and industrial sectors

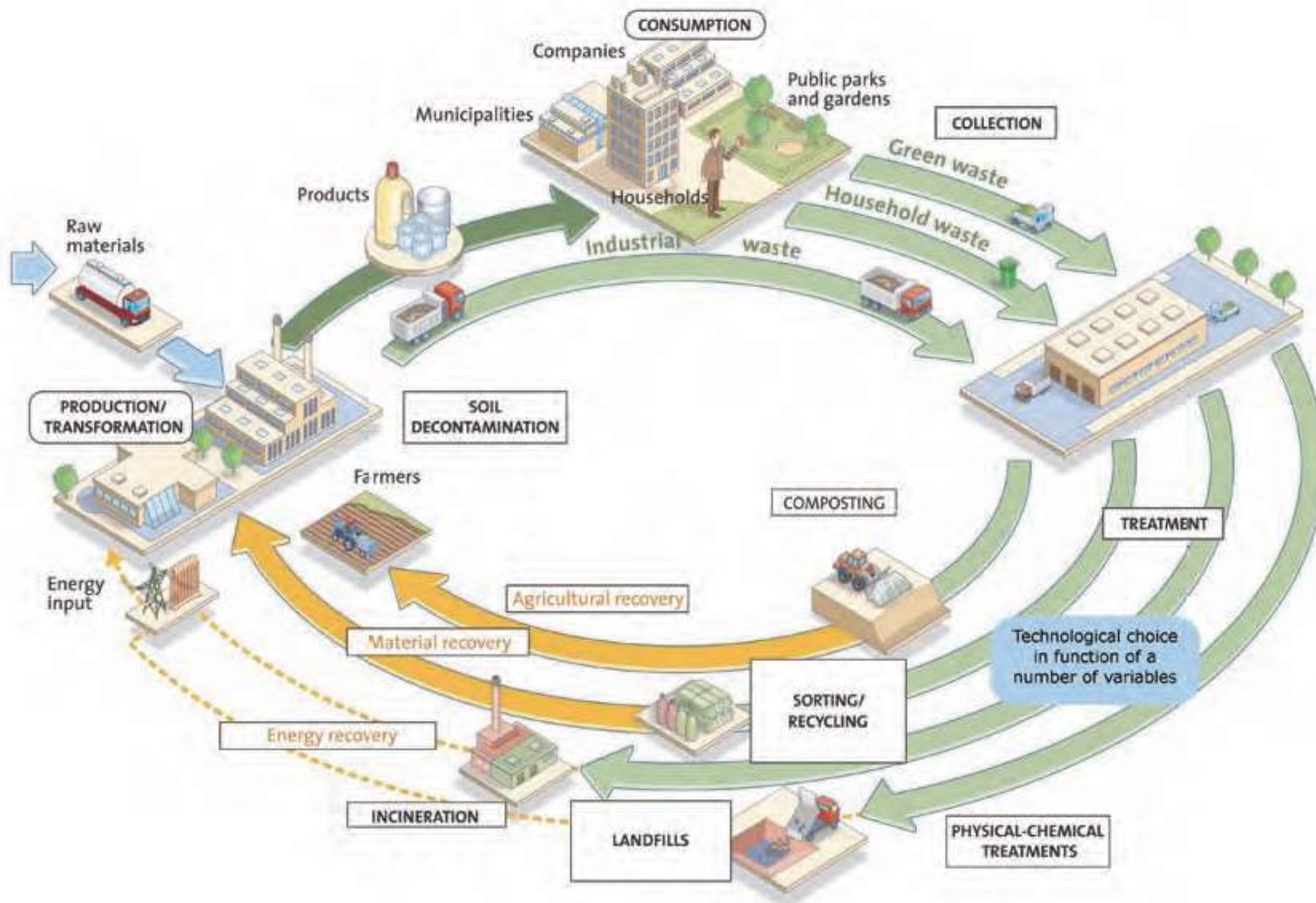
(source: R. Kothari et al., Renewable and Sustainable Energy Reviews 14 (2010) 3164-3170)

According to the Danish Energy Agency, **calorific value of waste is on average 10.5 MJ/kg.**

This means that **4 tons of waste** can substitute **1 ton of oil** or **1.6 tons of coal**. **1 ton of waste can produce 2 MWh for district heating and 0.67 MWh of electricity**



# Integrated Waste Management System



From ISWA White Paper – Waste and Climate Change, 2009

*Durban landfill, 1996*



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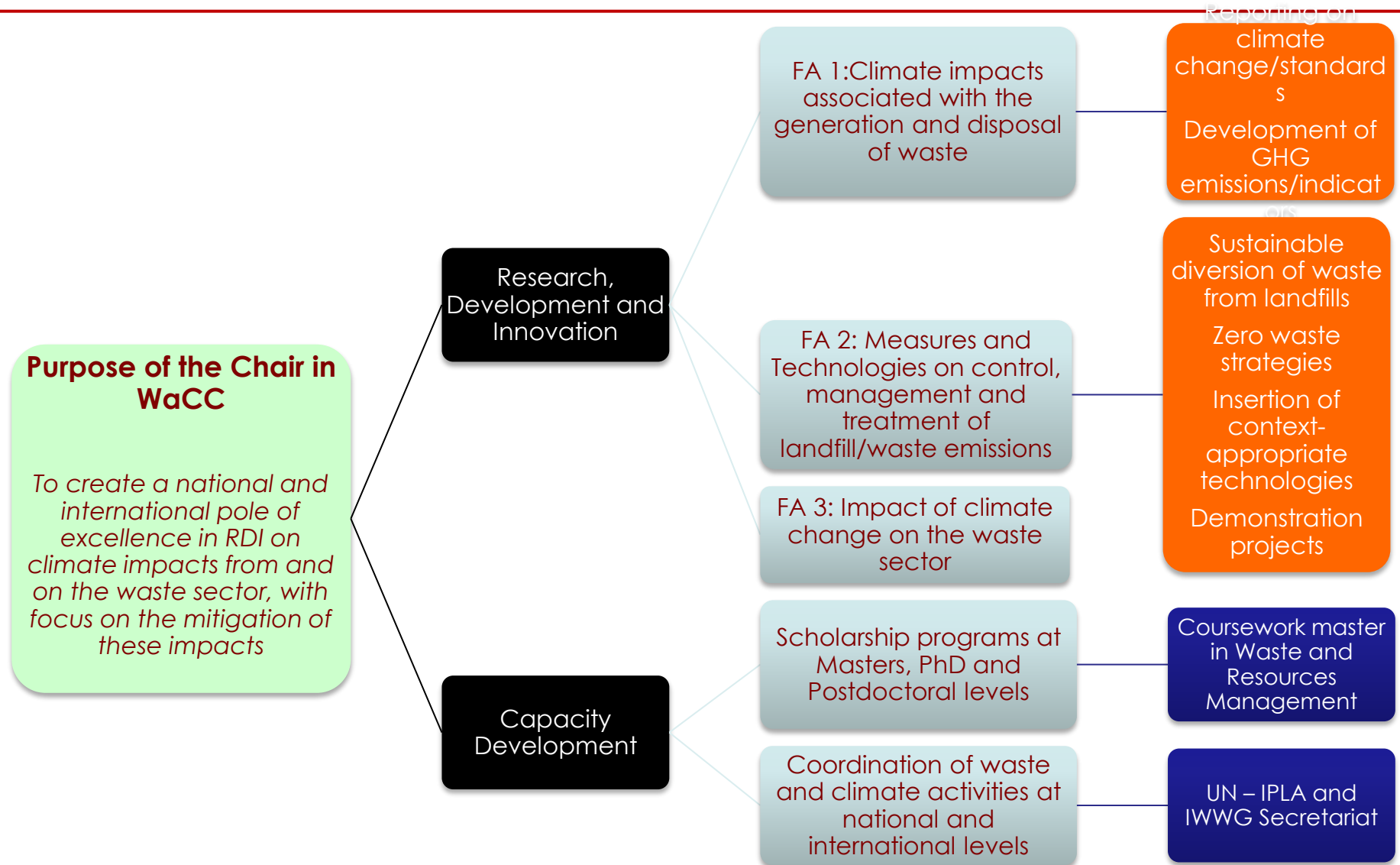


Durban landfill, 2006



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# Purpose, Focus and Objectives of the Chair





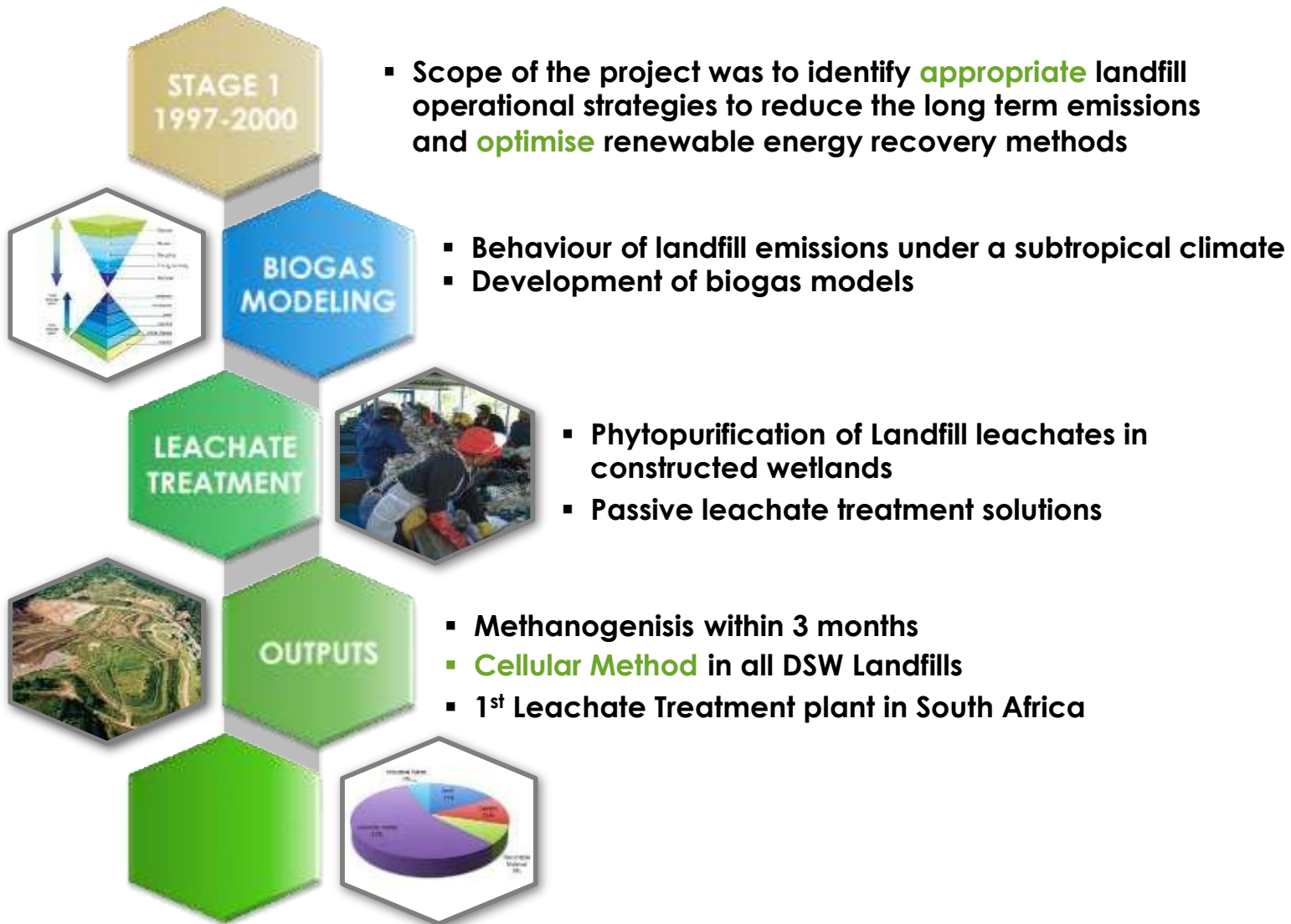
# A career in waste...not a wasted career



- Born in the beautiful island of Sardinia, Italy (too old to remember!!)
- Studies: MScEng (summa cum laude) + PhD in Environmental Engineering (Cagliari, Italy)
- Career: Full Professor and former Dean of Engineering at UKZN
- Over 20 years of experience in Environmental Sanitary Engineering and Waste Management
- **I lead a vibrant multi-disciplinary research group of some 20 postgrads and various researchers**
- We collaborate with top universities in the world and manage several multi-million projects funded by the eThekweni Municipality, THRIP, NRF and National LOTTERY.
- **Author of over 90 peer-reviewed publications, of which 45 in top ISI journals, 4 chapters in books and 45 peer-reviewed conference notes.**
- **C1 rated researcher with the National Research Foundation**, I am recognised as a national and international expert in waste and resources management and have made breakthrough research contribution to waste science, resource recovery and energy from waste in South Africa.
- In 2016, I was finalist and first runner up in the DST Distinguished Women in Science Awards.
- **I have successfully supervised and graduated over 50 postgraduate students.**
- I am a Professional Engineer with the Engineering Council of Italy since 1998, a fellow of the South African Academy of Engineers, of the Royal Society of South Africa and an active member of the Global Engineering Deans' Council, WISA, IWMSA (Institute of Waste Management Southern Africa), CIWM (Chartered Institute of Waste Managers (UK)) and of the Managing Board of the IWWG (International Waste Working Group).



# Control, Management and Treatment





# Output of Stage 1: 1<sup>st</sup> Leachate Treatment Plant in SA



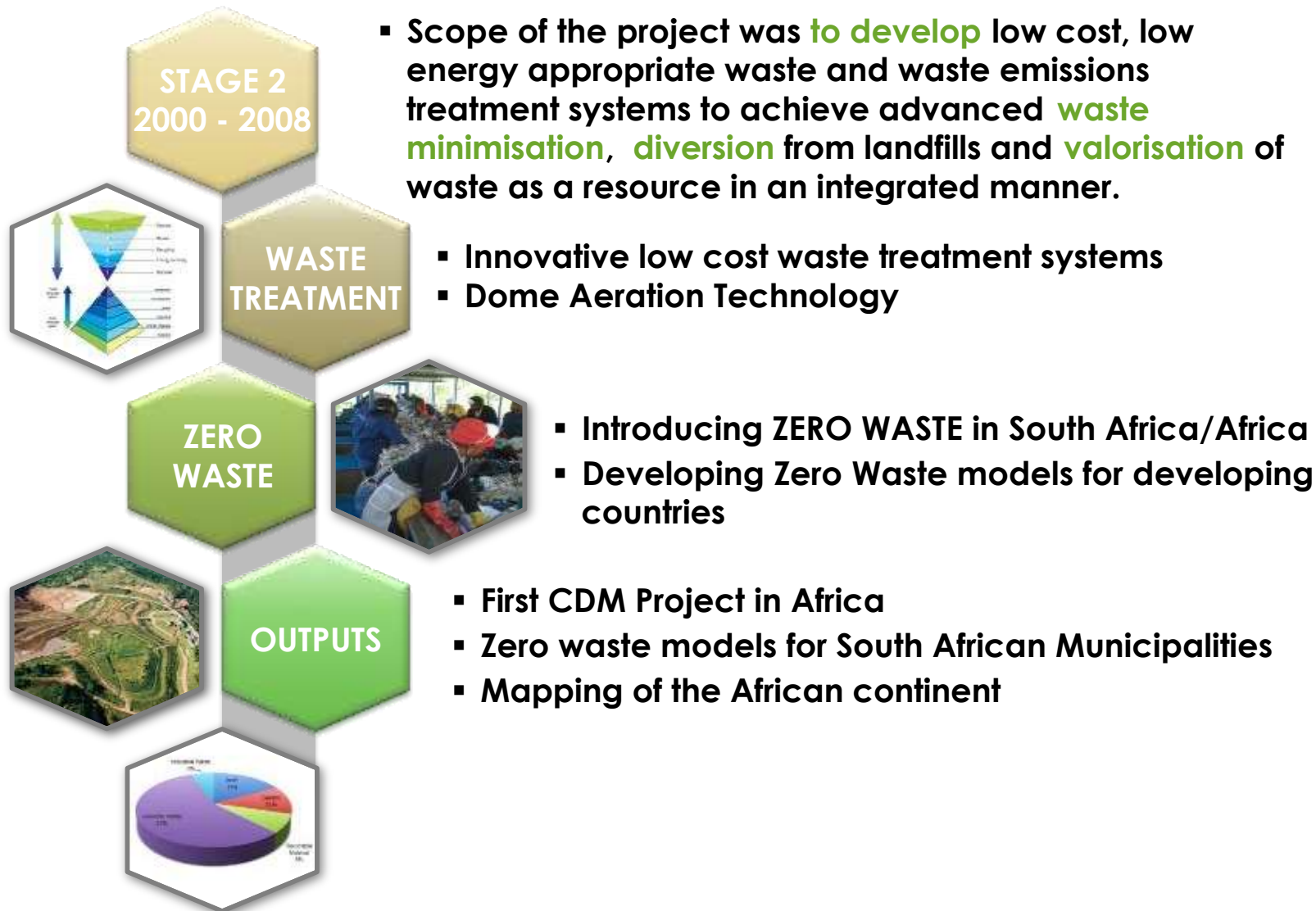


# Output of Stage 1: Cellular Method in ALL Landfills





# Integrated waste management – ZERO WASTE

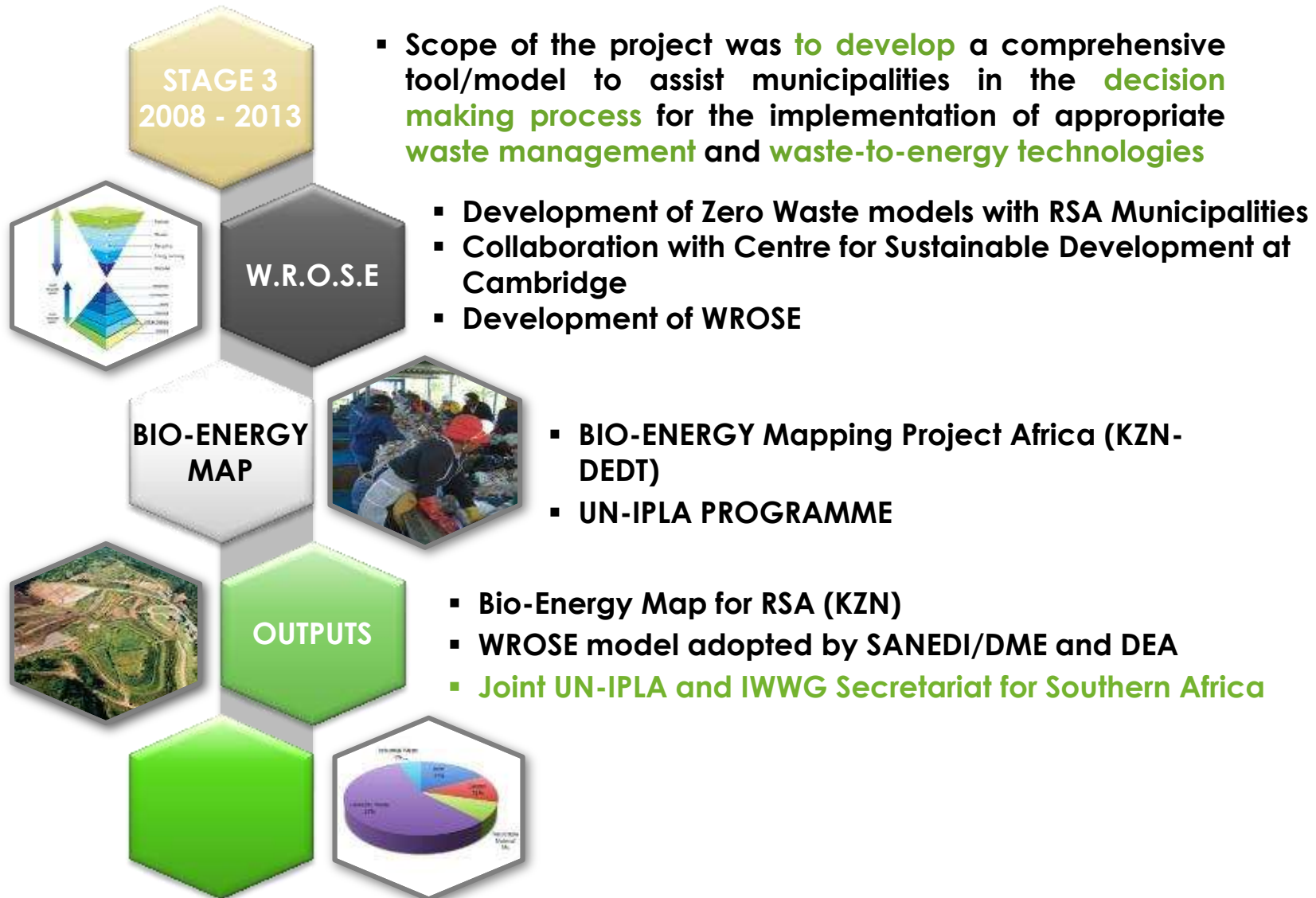


# Output of Stage 2-1<sup>st</sup> CDM Project in Africa

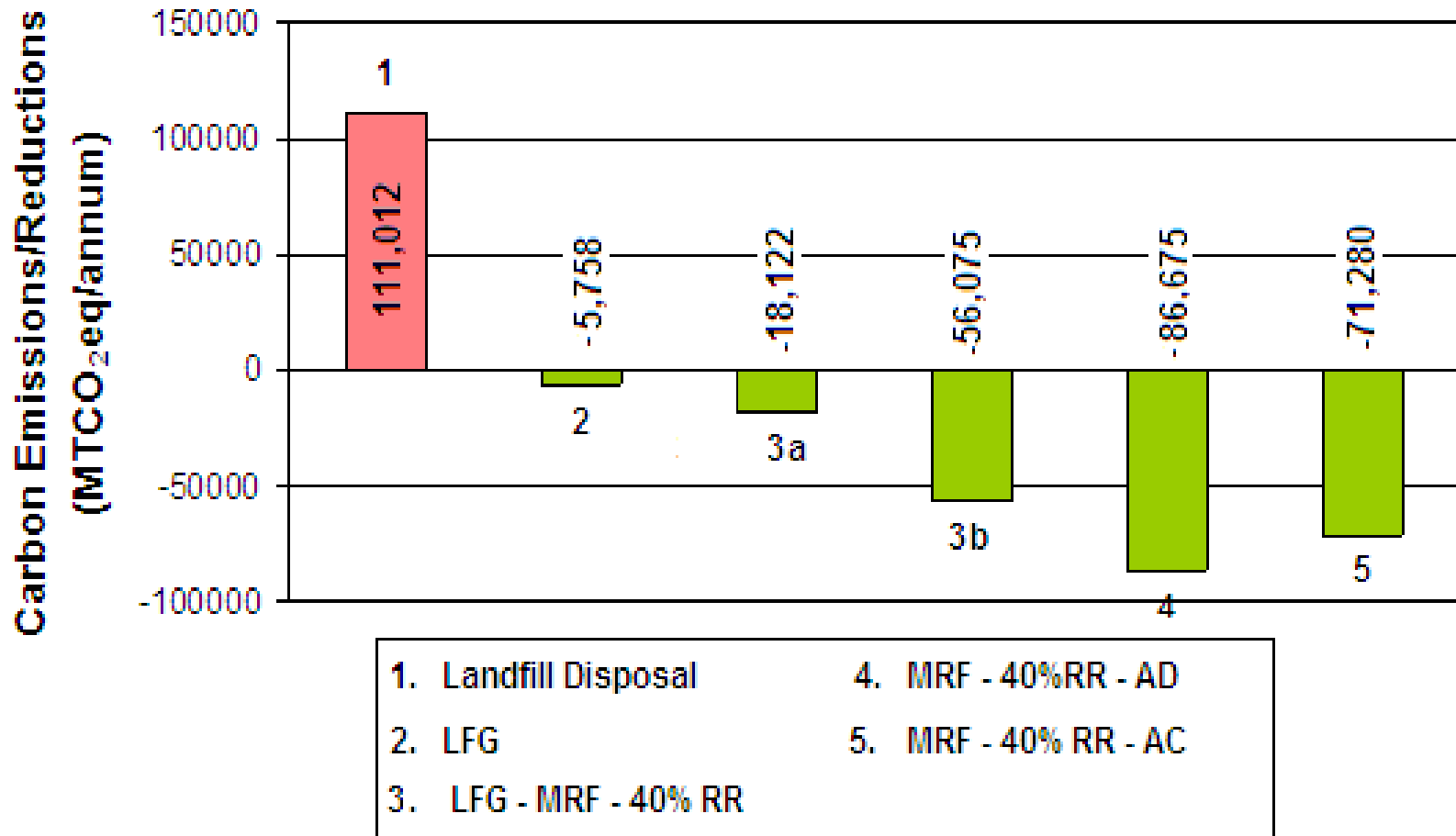


- ❑ 1<sup>st</sup> CDM Landfill Biogas-to-Energy Project in Africa
- ❑ Bisasar Rd landfill - extracts approximately 350 m<sup>3</sup>/hour, Component 1 produces approx. 9MWh
- ❑ Mariannahill landfill - 180 m<sup>3</sup>/hour is produced and an estimated 1775 m<sup>3</sup>/hour by 2024. Approximately 900 kWh of electricity is generated

# W.R.O.S.E – Waste Resource Optimisation and Scenario Evaluation Model



# Application of WROSE – GHG emissions





# Present and future research


STAGE 4  
2013 – 2017  
And beyond

- Scope of the project is to **develop** innovative ways for the **valorisation** of waste as a resource, beyond the conventional techniques of recycling, waste-to-energy, composting and anaerobic digestion



GARDEN REFUSE

- Innovative use of **garden refuse, pine bark and compost** as carbon source for the **bio-denitrification** of high strength leachates/effluents
- Innovative use of **biogenic waste/food waste** for the bio-denitrification of landfill leachate in anoxic beds



MINING WASTE AND BERA RED SAND

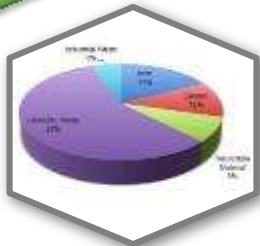
- Innovative use of **South African sands and Mining waste** for the treatment of ground water in **Permeable Reactive Barriers**
- **BIO-ROTOR** for metal extraction, nitrate, sulphate and phosphate removal using **Berea Red Sand and Red Mud**



CONSTRUCTION AND DEMOLITION WASTE

- Use of **Construction and Demolition waste** for roads construction
- Innovative use of waste fibers/pellets for construction of energy efficient buildings – **GREEN CONCRETE**

ENERGY CROPS ALGAE

- 
- Rehabilitation of landfills/capping using **energy crops**
  - Treatment of leachate using **algae/energy crops**
  - Experimenting with **algae/energy** for energy crops
  - **Hybrid reactors**

# FA1: WROSE, Zero Waste, Diversion of waste from Landfill, Resource recovery

## Projects

Advancement of the WROSE model with the inclusion of socio-economic and institutional indicators

Industrial Symbiosis and zero waste strategies

## Students involved

Sameera Kissoon  
(MScEng)

Kruschen Govender  
(Postdoc)



## Collaborators / funders

Durban Solid Waste  
SANEDI (RECORD)  
Durban Chemical Cluster  
USE-IT  
Warwick Junction Informal  
Markets (Durban)  
Prof. Rawatlal (UKZN)  
Dr Ntlibi Matete (UKZN)  
Cranfield University (UK)



# FA2: Design of appropriate and innovative treatment methods for leachate

## Projects

Photocatalytic leaching of metals from high strength leachates

Assessment of activated and non-activated natural iron-based sand for the treatment of nitrate from synthetic wastewater

Phytopurification of leachate in constructed wetlands

Energy crops for the biodenitrification of leachate

## Students involved

Dr Nore Mahdjoub  
(Senior Researcher)

Brett Reimers  
(MScEng)

Dr W. Woodenberg  
(Postdoc)



## Collaborators / funders

Durban Solid Waste  
Cranfield University (UK)  
Plant Pathology UNIT (UKZN)



# Plant Ecophysiology Research Group (UKZN)

## RESEARCH FOCI:

- Phyto-treatment of contaminated soil and water
  - Phyto-extraction of nutrients from waste

## PROJECTS RELATED TO:

- ❖ responses of plants to pollutants
- ❖ growth of bioenergy crops using waste water and sewage
  - ❖ use of plants for nutrient recovery from waste
  - ❖ microbe-based treatment of waste

## ← TRANSDISCIPLINARY APPROACH →

BIOCHEMISTRY

PHYSIOLOGY

MOLECULAR  
BIOLOGY

BIOPHYSICS

ECOLOGY



Group leader:  
Sershen

# FA3: Sustained carbon emissions reduction in Africa – Biogas modeling, GHG quantification, reporting

## Projects

Quantification of GHG from waste and LCA

Bioenergy production from AD of Cassava

Fat and scum as biofuel

BioEnergy in Rural areas  
LOTTO funded Project

## Students involved

Dr Elena Friedrich  
(Lecturer)

Nathaniel Sawyerr  
(PhD)

Surabhi Sivastrava  
(PhD)

Dr Marc Kalina  
Senior Researcher



## Collaborators / funders

Durban Solid Waste

SANEDI

National LOTTERY

Plant Pathology UNIT (UKZN)





Prof. Tilahun Sewoun (UKZN)

Dr Alaika Kassim (UKZN)

Phalane Lebotsa (UKZN)

PRG Prof. Buckley (UKZN)

# FA4: African Cities of the Future – Green Concrete

<b>Projects</b>	<b>Students involved</b>		<b>Collaborators / funders</b>
Alternative building materials	Frazer Smith (PhD)		Durban Solid Waste USE-IT Dr Moses Kiliswa (UKZN) University of Trento (Italy) University of Cagliari (Italy) Prof. Mauro Coni (Cagliari)
Sustainable smart mobility within the Aerotropolis	Priyan Reddy (MScEng)		
Investigation into the Feasibility of Using Paper-mill Sludge as a Partial Replacement for Cement	Sean Moodley (MScEng)		
Comparative Life Cycle Assessment (LCA) Applied to Asphalt Mixtures Containing Crumb Rubber Modified Bitumen Blends	Keyuran Govender (MScEng)		



# Come and have fun with us in Durbs!



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