Material and Energy valorisation of waste in a Circular Economy : Focus on Nutrient Recovery

COUNTRY REPORT SOUTH AFRICA – PART II

Prof Cristina Trois

SARCHI Chair in Waste and Climate Change

Task 36 IEA Bioenergy

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science & technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

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SARCHI Chair
WASTE AND CLIMATE CHANGE

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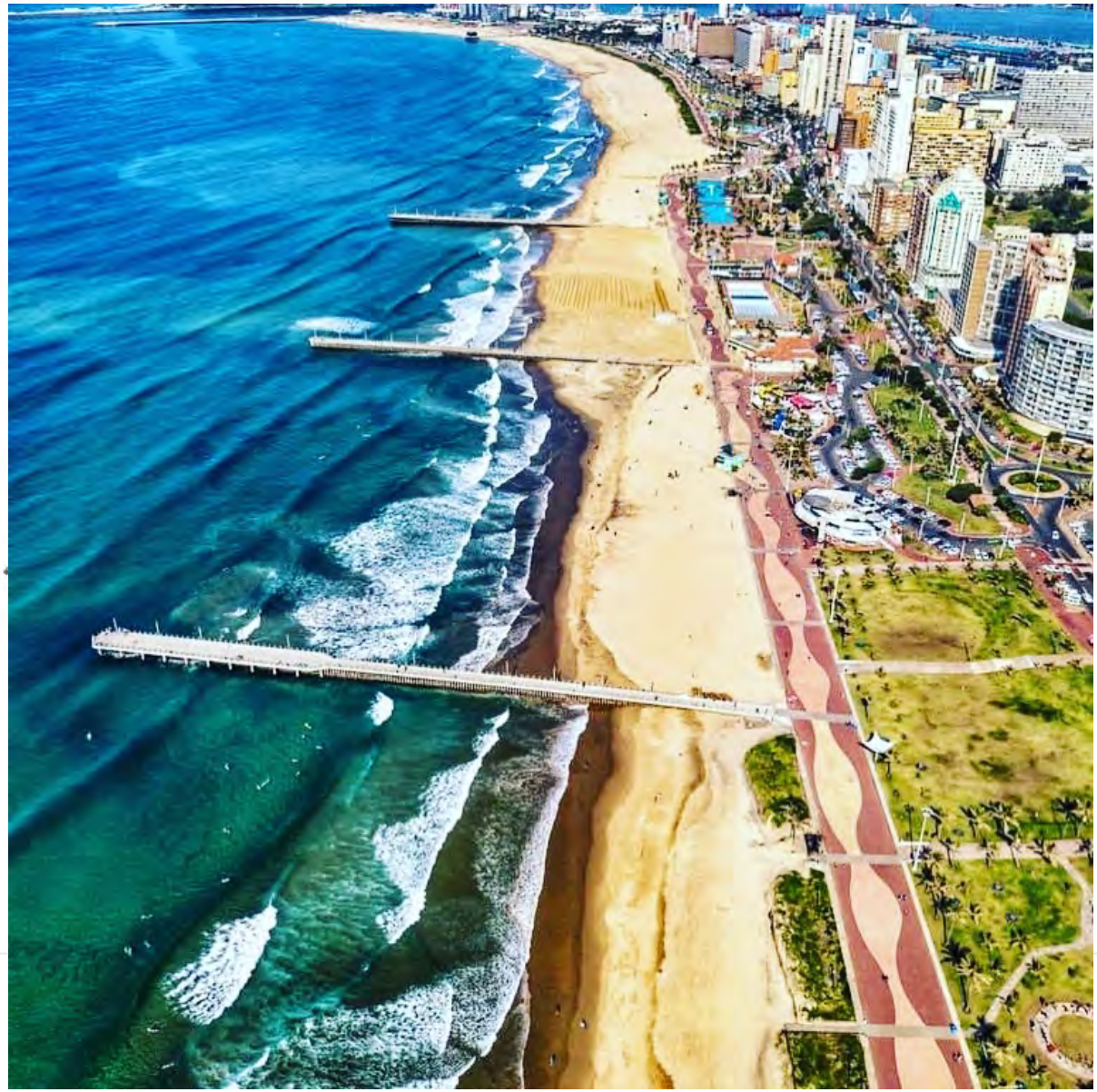
DAY 2 – OUTLINE

- Innovations in organic waste valorization in SA
- Priority Waste Streams of the Roadmap
- Research platforms for organic waste biorefinery/nutrient removal
- Need for nutrients recovery from waste in SA – case study in Durban
- Issues with nutrient recovery from digestate
- Present and future research under the SARCHI Chair – Organic Waste Management

Durban, South Africa



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Developing the waste sector through RDI

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NRF National Research Foundation | RISA Research and Innovation Support and Advancement

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sanedi
South African National Energy Development Institute

iwwg
international waste working group
SOUTHERN AFRICAN REGIONAL BRANCH

A WASTE RDI ROADMAP FOR SOUTH AFRICA

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

Prof Linda Godfrey
Project Manager: Waste Roadmap IU
CSIR Implementation Unit

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Innovation in organic waste valorization

- A new project on the valorisation of **saw dust** to obtain a variety of high-value marketable chemicals
- New value chains for high value products –
  - **Xylose** for conversion to **Xylitol** (artificial sweetener)
  - Pine oil
  - Nanocrystalline cellulose fibres

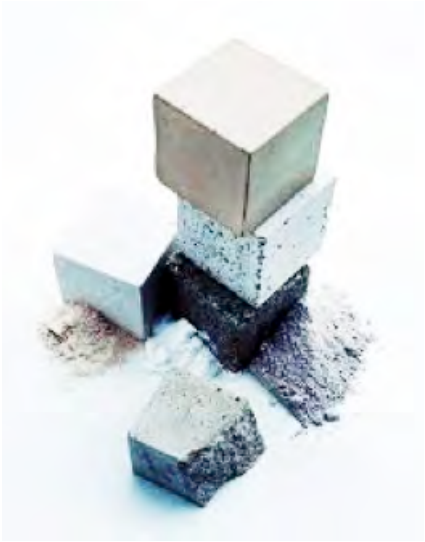
Innovation in organic waste valorization

- A new project on the valorisation of **chicken feather waste** to obtain a variety of high-value marketable products
- New value chains for high value products –
  - **Keratin** powder (protein) (tissue-engineering scaffolds, health care)
  - **Biocomposites**, textiles, electronics, cosmetics

Innovation in organic waste valorization

Traditional, low value

Innovative, high value



- A new project on the innovative use of **paper-mill sludge** and fibres from **waste tyres** as performance enhances of **green concrete**
- Paper sludge destined for incineration or landfill, used as a partial replacement of cement created '**tough concrete**'
  - Large increase in tensile strength **(+28%)**
  - Significant increase in flexural strength **(+11%)**
  - Insignificant change in compression strength **(+3%)**

Priority Waste Streams of Roadmap

- **Municipal Solid Waste**

  e.g. paper and packaging, C&D waste, OFMSW, residual waste

- **Electronic Waste (WEEE)**

  e.g. all fractions, metal, plastic, glass, etc.

- **Waste Plastic**

  e.g. pre- and post-consumer plastics (all)

- **Organic Waste**

  e.g. industrial biomass, OFMSW, food waste

- **Waste tyres**

Maximising the diversion of waste away from landfill **towards value-adding opportunities**, including **prevention** of waste and the optimised **extraction of value** from reuse, recycling and recovery, in order to create significant social, economic, and environmental **benefit** for South Africa.

Grant funded research projects

Beneficiation of **forestry biomass** waste streams
[Prof B Sithole, CSIR NRE, Durban]

Valorisation of **waste chicken feathers**
[Prof B Sithole, CSIR NRE, Durban]

Sustainable utilization and conversion of post-harvest **agricultural waste** residues into value added materials
[Dr M John, CSIR MSM, Port Elizabeth]

Value recovery from **solid confectionary waste**
[Prof S Harrison, UCT, Cape Town]

Grant funded research projects

Reactor design for industrial furfural production from sugar cane agricultural residues [Prof J Görgens, SUN, Stellenbosch]

Biogas and volatile fatty acids biorefinery by co-digestion of fruit juice wastes with lignocellulosic biomass [Prof J Görgens, SUN, Stellenbosch]

Production of novel cellulose nanocomposites from organic waste [Dr A Chimphango, SUN, Stellenbosch]

Constraints

- While considerable opportunity exists in value recovery from industrial biomass and organic waste, a number of constraints exist –
- Access to the material –
  - Municipalities are the gates keepers to the OFMSW
  - No incentive for industry to divert biomass from land
- Limited markets (at present)
  - Waste to bioenergy – feeding into the national grid
  - Waste to compost – seasonal, geographic
  - Waste to chemicals – emerging technologies

SA Biorefinery Research Platform

South African
Biorefinery
Research Platform

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Home | About | Research projects | Publications | Contact

The South African Biorefinery Research Platform is an initiative of the Department of Science and Technology (DST) aimed at consolidating research on the valorisation of biomass and biomass-waste being undertaken by South African Universities, Science Councils and public Research Institutions.

Find out more

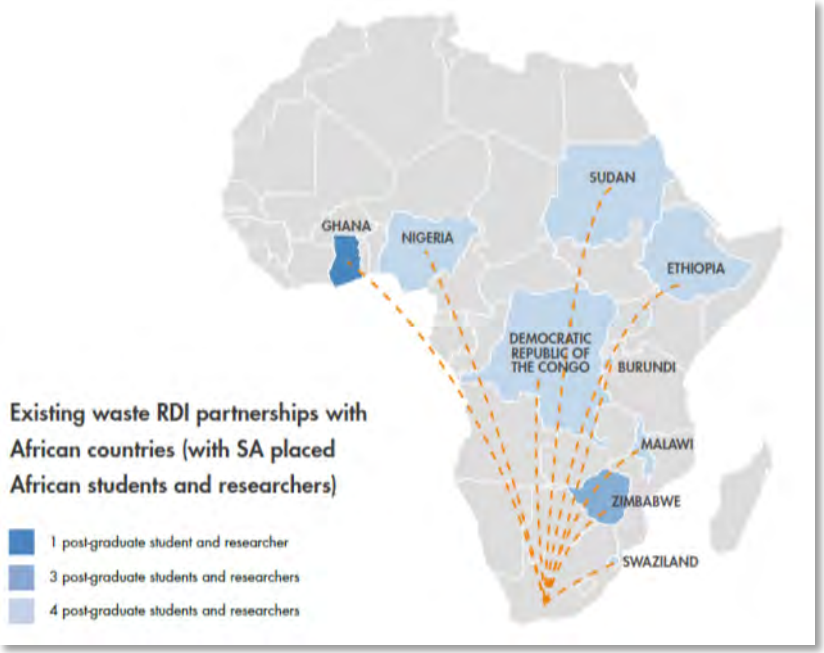
Key publications

Waste RDI Roadmap
PDF | 1.34 MB

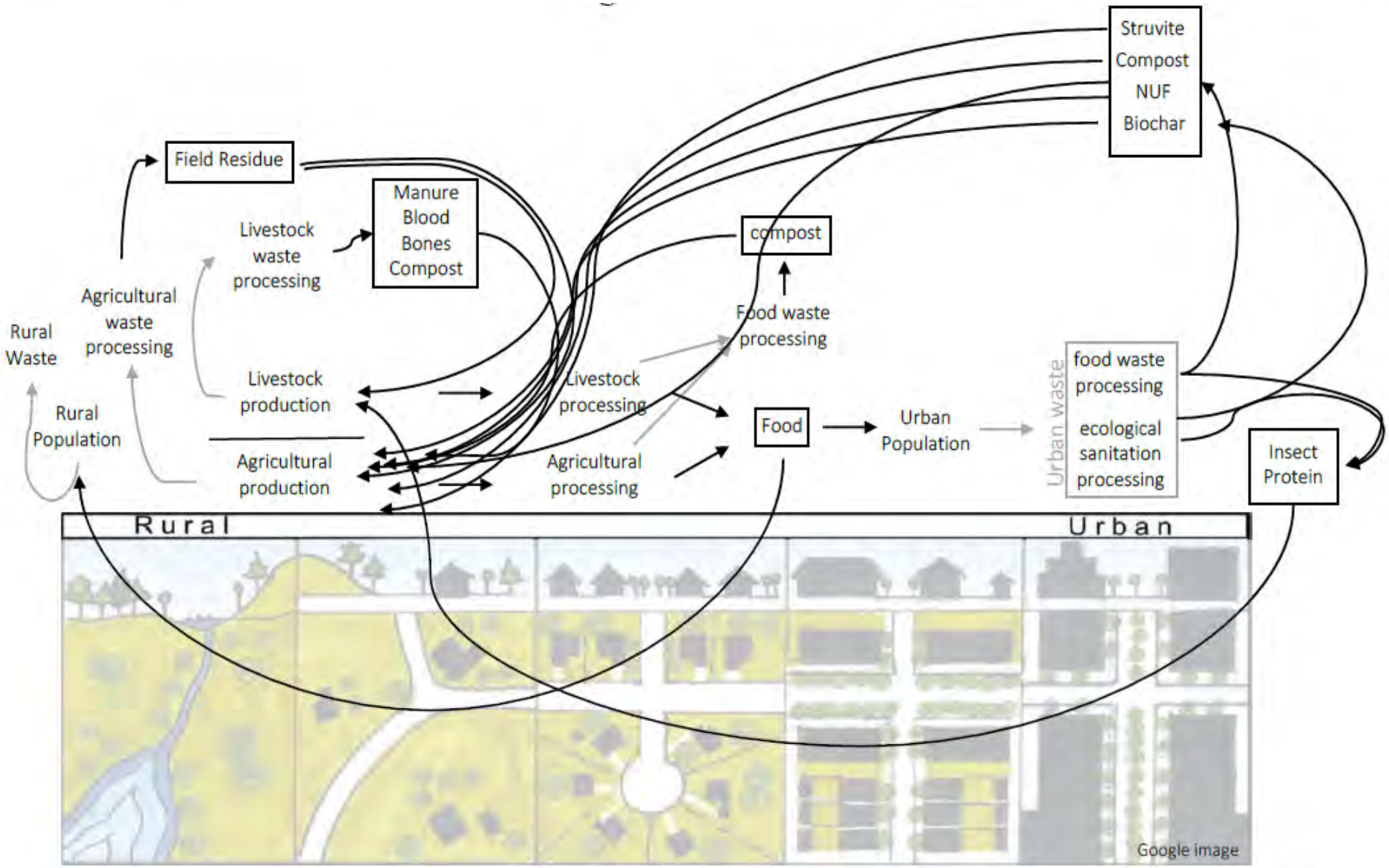
South Africa's Bio-Economy Strategy

Strategic Partnerships

- **Partnerships** are key to the implementation of the Roadmap
- Regional and international **research partnerships** remain limited (2017)
- An **opportunity** to establish and strengthen local, regional and international partnerships in solid waste R&D

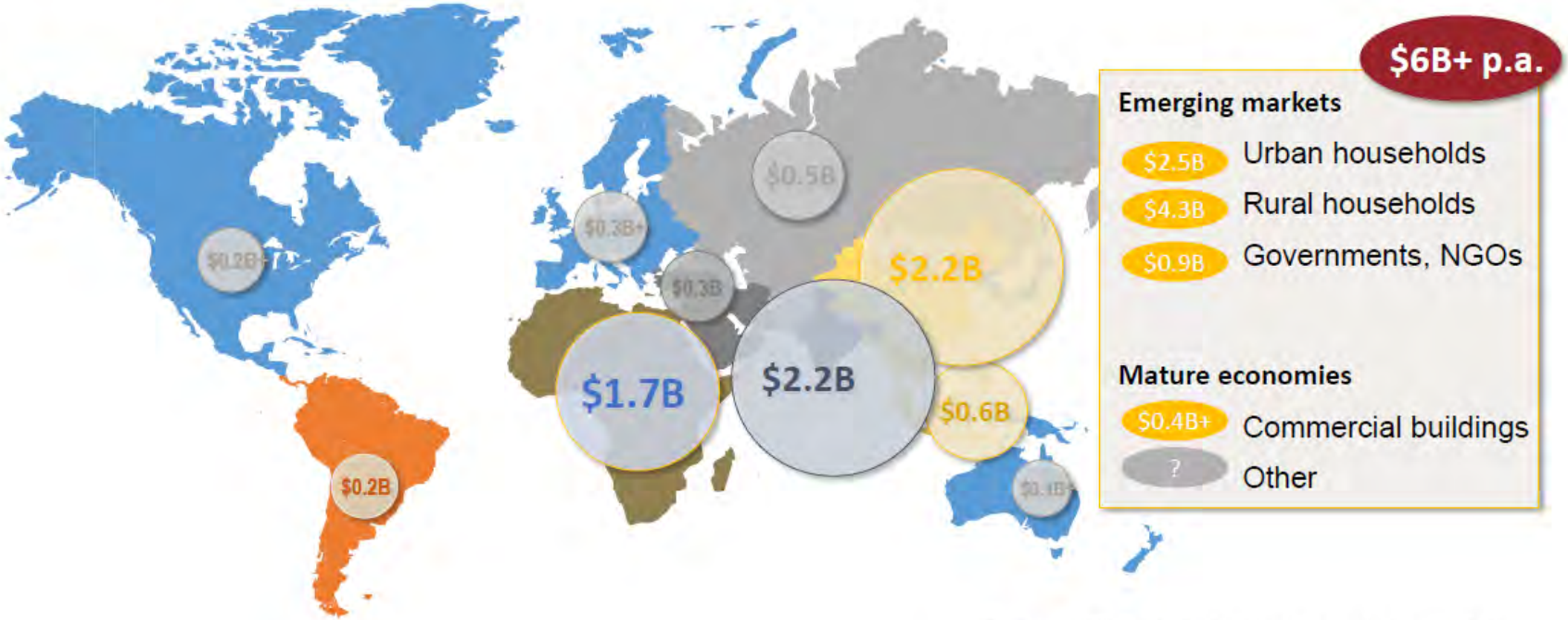


Urban- Rural Nutrient Cycle



Global Annual Market for Sanitation

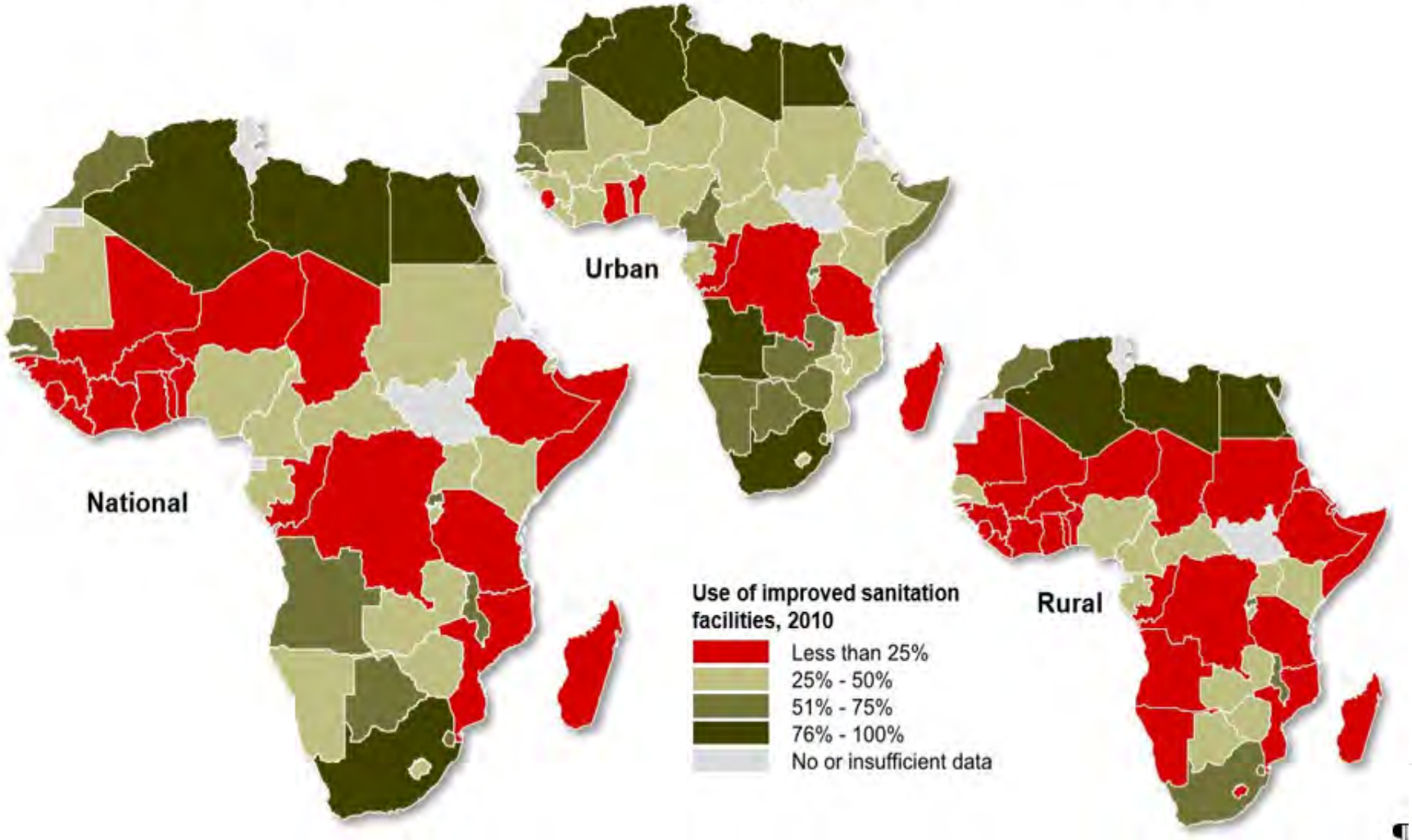
The RT represents a potential $6B+ global annual opportunity to help meet sanitation needs...



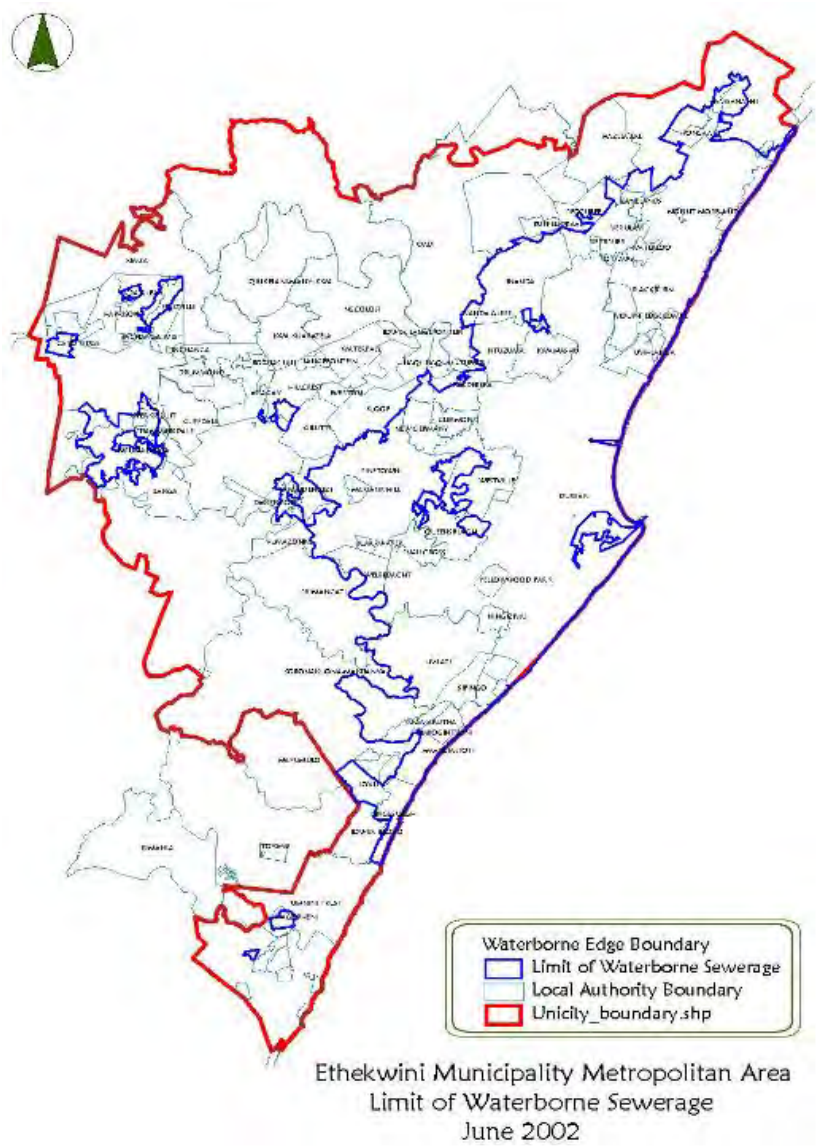
D. Kone, Bill & Melinda Gates Foundation (2014)

Sanitation in Africa

In 18 countries in sub-Saharan Africa a less than a quarter of the population uses an improved sanitation facility



Large Population on or Beyond the *Development Edge*



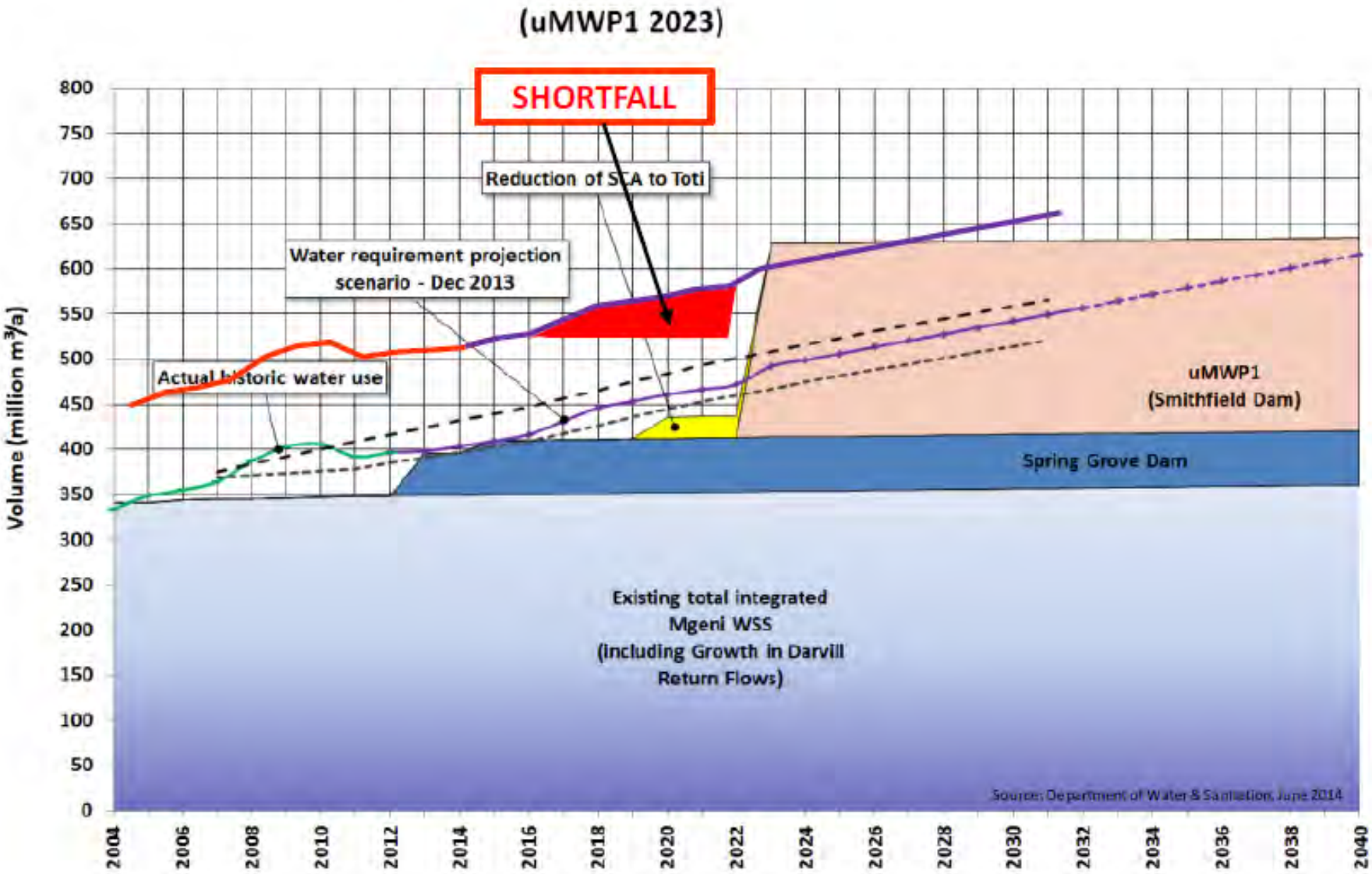
Approx. 4 mil people

1/3 sewered
1/3 on site
1/3 unserved

85 000 UD toilets

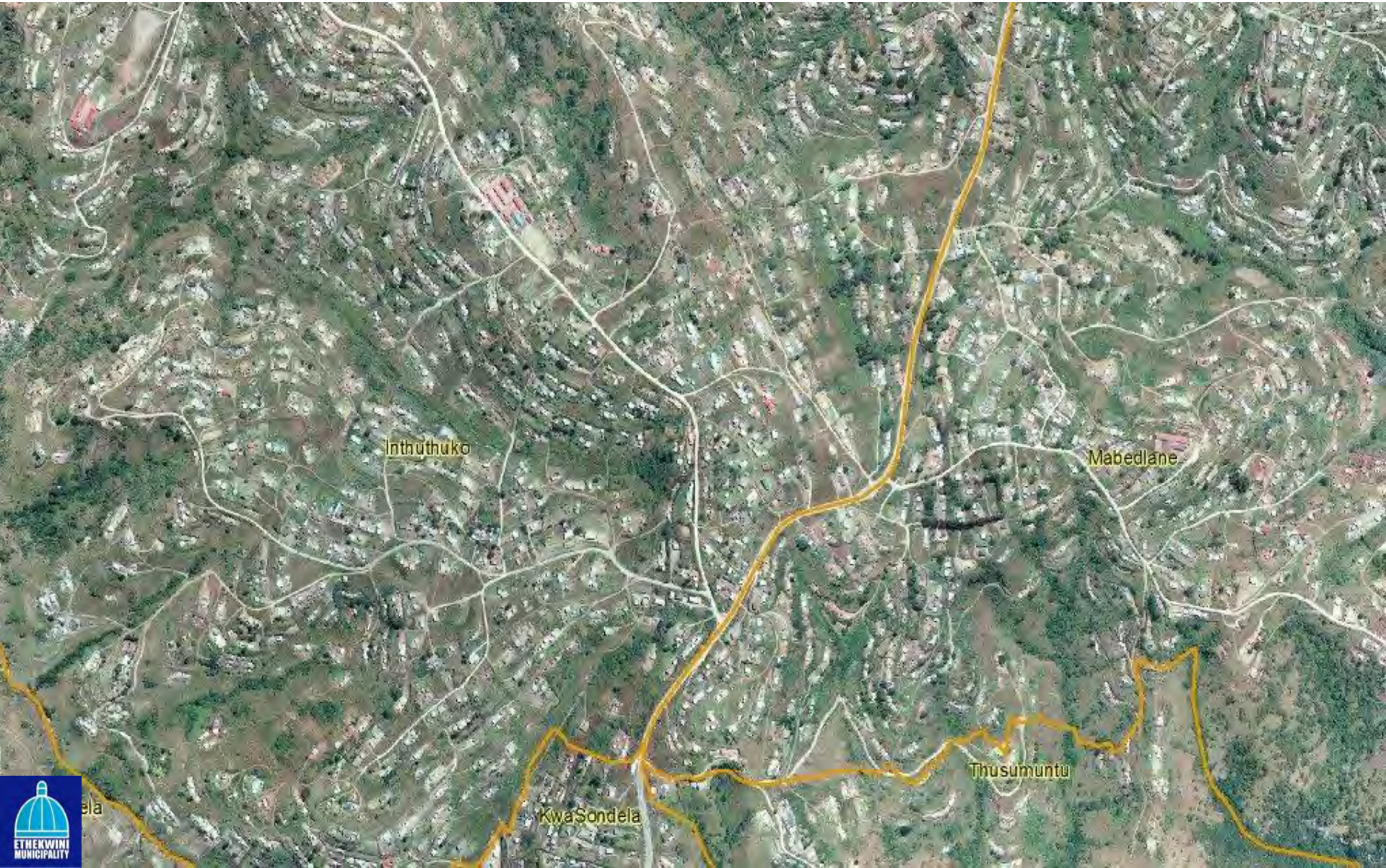
Large housing shortage

Water Resources - eThekwini

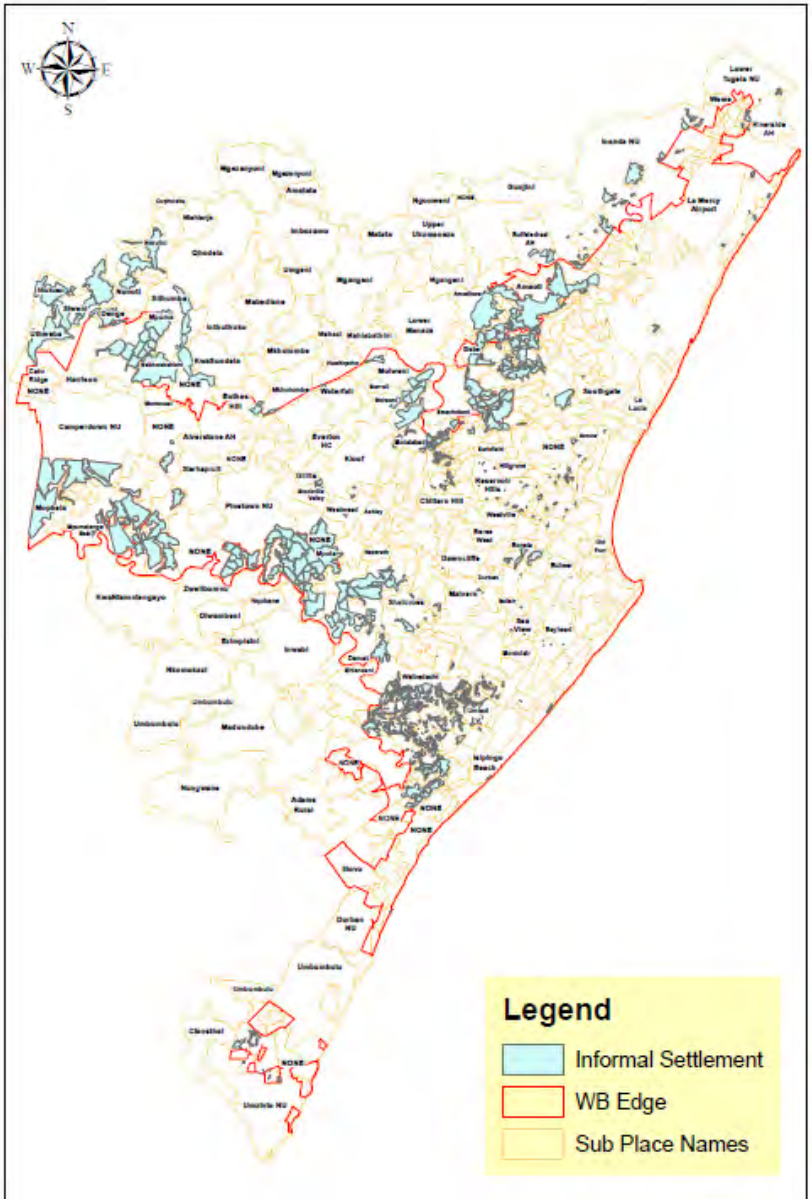


Rural area 2008

Rural area 2013

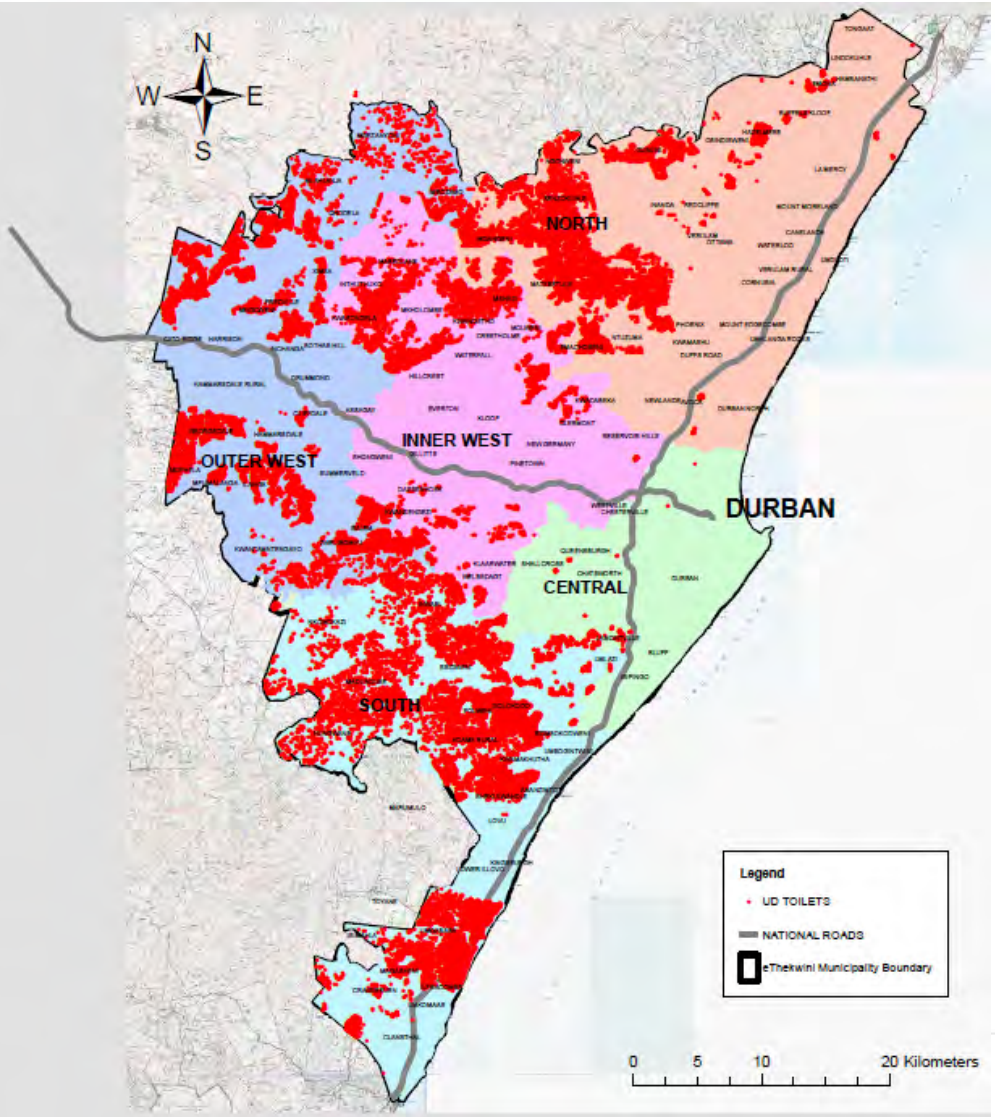


Informal Settlements



Approximately 1 mil people

Urine Diversion Toilets



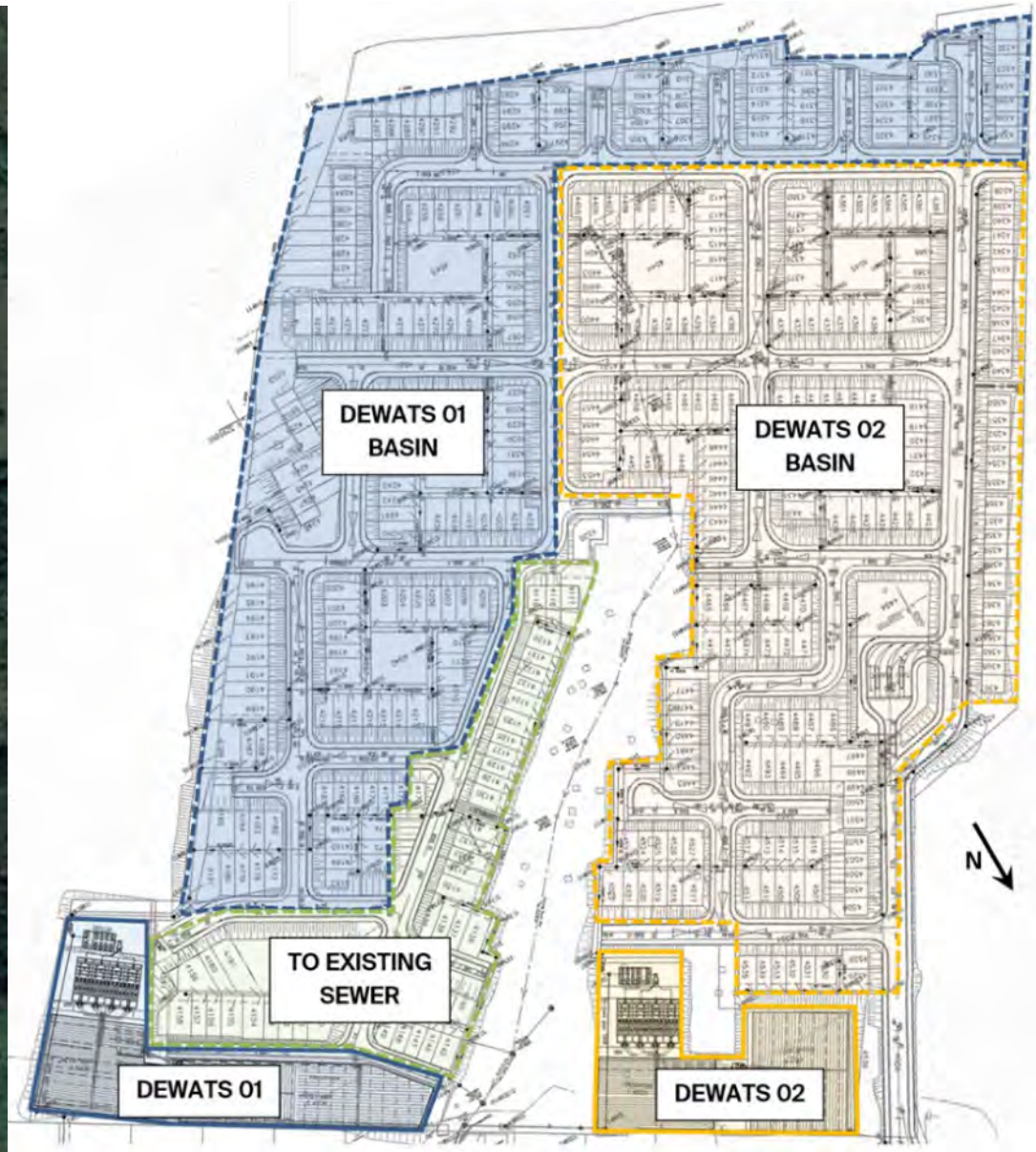
Approximately 80% use
30% satisfaction

Newlands Mashu Demonstration Site

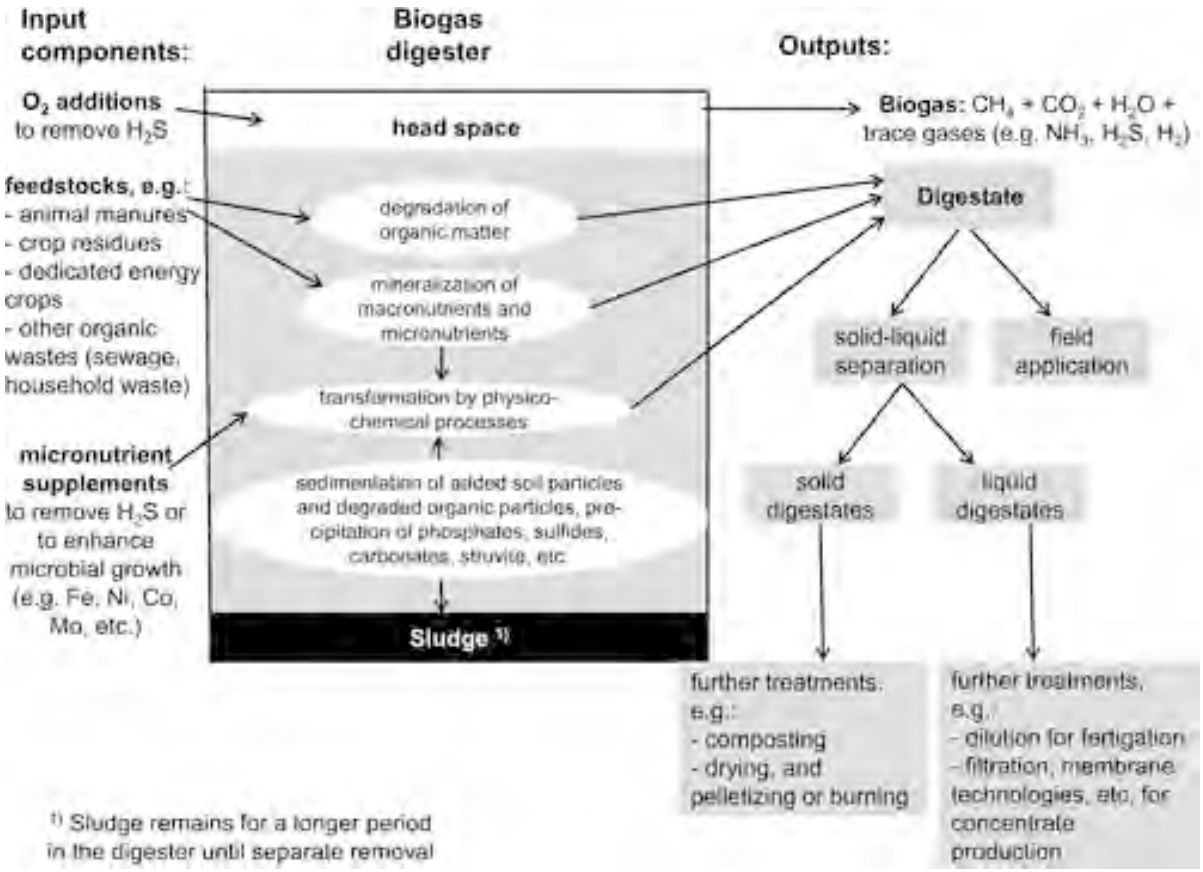
Banana City

	Banana City 1	Banana City 2	Combined
# houses	232	191	423
people served (8/hh)	1856	1528	3384
Design flow (m^3/d)	185.6	152.8	338.4
	Household loads (Henze,1997)		
N load (kg/d)	29.6	24.4	54
P Load (kg/d)	5.6	4.6	10.2
	ABR effluent (DEWATS design report)		
N load (kg/d)	14.8	12.2	27
P Load (kg/d)	2.2	1.8	4
	Wetlands effluent (Wetland design report)		
N load (kg/d)	6.5	4.3	11.8
P Load (kg/d)	2.2	1.8	4

Banana City


DEWATS 01
BASIN
DEWATS 02
BASIN
TO EXISTING
SEWER
DEWATS 01
DEWATS 02
N

Effects of anaerobic digestion on digestate nutrient availability and crop growth: A review



Complex organic N compounds are mineralized to NH_4^+-N in the digester. A part of the NH_4^+-N is used by the digester microorganism for growth

Engineering in Life Sciences, Volume: 12, Issue: 3, Pages: 242-257, First published: 11 May 2012, DOI: (10.1002/elsc.201100085)

Research Gaps On Nutrients Recovery From AD Plants

There are no systematic studies available on the influence of single feedstocks on nutrient contents and nutrient speciation in digestates, also including the C_{org} and organic N (N_{org}) components.

For a better understanding of the driving factors governing N turnover in the soil**, an accurate characterization of digestates' nutrient and OM composition, combined with experiments to assess the N-mineralization and N-immobilization processes after field spreading**, would be essential for a better characterization of the driving factors governing N turnover in the soil.

Research addressing the influence of the single feedstocks and the design of the fermentation process on composition of digestates is also needed. Furthermore, a better knowledge on the influence of single feedstocks on digestate composition is an important key for optimization of the feedstock management throughout the year, in order to obtain a higher share of the circulating N for spring amendments.

AD of crop residues and cover crops leads to an increase in the total amounts of mobile organic manures within the farming system, resulting in higher N use efficiency and an increased scope for target-oriented N application.

AD of dedicated energy crops often leads to an increase of the total amounts of organic fertilizers within the farming system, with all potential risks. AD of dairy manure does not affect short-term crop P availability under field conditions. **AD potentially increases plant S availability**, but simultaneously also the risk of S volatilization. However, **current knowledge about the S fertilizer value of digestates is very scarce**.

Engineering in Life Sciences, Volume: 12, Issue: 3, Pages: 242-257, First published: 11 May 2012, DOI: (10.1002/elsc.201100085)

Present and future research

STAGE 4
2013 – 2019
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-denitrifcation of landfill leachate in anoxic beds

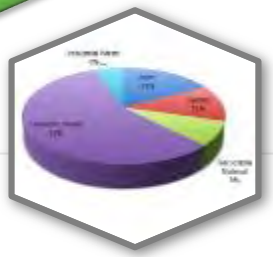
MINING WASTE AND BEREA RED SAND

- 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

ORGANIC WASTE MANAGEMENT

- Garden Waste, Agri-waste, Food waste, Energy crops for landfills, Bagasse from sugar cane

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, Integrated waste management systems for climate change stabilisation wedges

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)

Cranfield University

ETHEKWINI MUNICIPALITY DSW ☎ 031 311 8804

sanedi South African National Energy Development Institute

FA2: Design of appropriate and innovative treatment methods for leachate

Projects
Photocatalitic 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)

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

Projects
Quantification of GHG from waste and LCA

Students involved
Dr Elena Friedrich (Lecturer)

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)

Bioenergy production from AD of Cassava

Nathaniel Sawyerr (PhD)

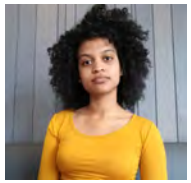
Fat and scum as biofuel

Surabhi Sivastrava (PhD)

BioEnergy in Rural areas
LOTTO funded Project

Dr Marc Kalina
Senior Researcher

FA4: African Cities of the Future – Green Concrete/Materials and Infrastructure

Projects	Students involved	
Alternative building materials	Frazer Smith (PhD)	
Sustainable smart mobility within the Aerotropolis	Prian 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)	

Collaborators / funders
Durban Solid Waste
USE-IT
Dr Moses Kiliswa (UKZN)
University of Trento (Italy)
University of Cagliari (Italy)
Prof. Mauro Coni (Cagliari)

Thank you!

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