A 10-Year Waste Research Development and Innovation Roadmap for South Africa
2015-2025

2018/19 Annual Progress Report

REFLECTING ON THE FOURTH YEAR OF IMPLEMENTATION

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

CSIR
our future through science

CONTENTS

The DST Team:

Dr Henry Roman
Director: Environmental Services and Technologies

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Ms Mannakazi Skoti
Intern: Environmental Services and Technologies

FOREWORD BY
THE DEPARTMENT OF SCIENCE AND TECHNOLOGY

The 2018/19 financial year was a momentous one for the Waste RDI Roadmap for a number of reasons. A highlight for the year was that 22 post-graduate students completed their studies in 2018. This is significant to the waste sector as the DST investment into human capital development (HCD) is bearing fruit and producing the much needed high-end skills for the sector to drive innovation.

THE GRADUATING COHORT is also contributing to the transformation of the sector in terms of demographic representation with the increase in black and female knowledge workers.

Another significant outcome was the launch of the first DST/NRF/CSIR SARChI Research Chairs in waste in South Africa. Following a rigorous review process undertaken by an NRF-convened panel, two very well recognised and respected NRF-rated researchers were appointed to the Chairs. Prof Catherina Schenck (UWC) and Prof Cristina Trois (UKZN) reflect the depth of waste expertise that is developing within South Africa's National System of Innovation (NSI), as well as the transformation that the sector in undergoing, with both Chairs having been awarded to women.

Another important development for the year was the Waste Roadmap Implementation Unit (WRIU) Manager being invited to serve on the Board of the International Environmental Technology Centre (IETC), a United Nations Environment Programme initiative based in Japan with a focus on waste management. The DST congratulates Prof Linda Godfrey on this achievement and for flying the South African flag in international forums, committees and Boards.

The funding for the implementation of the Roadmap is far from sufficient to fully realise the ambition of the programme. However, there has been a year-on-year increase in funding which bodes well for the continued implementation of the Roadmap. With the funding received to date, the WRIU has been innovative in its allocation to ensure maximum impact for South Africa. This included financial support for student development, with 36 post-graduate students supported across 20 grant projects during 2018/19. The investment in science and technology is necessary to encourage innovation within the waste sector, thereby also contributing to the outcomes of the Chemicals and Waste Phakisa signed-off by President Ramaphosa in March 2019.

The DST was also successful in its bid for EU-GBS funding that will be partially utilised to fund SMME development in the emerging Biorefinery sector, which serves to add value to what is currently perceived to be low-value organic waste. With organic waste and industrial biomass one of the largest general waste streams produced in South Africa, unlocking high-value beneficiation opportunities for this waste stream has the potential to create real social, economic and environmental benefits for the country. This is further highlighted in the academic book initiated by the DST, entitled *"Opportunities for biomass and organic waste valorization"* (Editors: Godfrey, Görgens and Roman and published by UNISA Press, 2018). The aim of these books is to bring South Africa's research into the public domain.

The DST funded research on the integration of informal waste pickers into the waste economy – the first social-science grant project awarded under the Roadmap in 2016 – has provided clear evidence on the role and value of the informal sector. The Department of Environmental Affairs (DEA) has partnered with the DST to produce evidence-based guidelines on informal sector integration that can be used by both local municipalities and the private sector. This is a concrete example of how targeted research grants can serve to provide evidence for policy-makers to draft more inclusive policies.

The DST remains committed to building a waste economy with its sister departments, the Department of Environmental Affairs and the Department of Trade and Industry, as part of realising the transition to a circular economy in South Africa.

Finally, the Department would like to acknowledge the private sector, and the role that business is playing in driving innovation in the South African waste economy.

Mr Imraan Patel
Deputy Director-General: Socio-Economic Partnerships

MESSAGE FROM
THE WRIU MANAGER, PROF LINDA GODFREY

The 2018/19 financial year has proven to be another busy year for the Waste Roadmap Implementation Unit (WRIU). While funding to the Roadmap remains considerably lower than required, we are seeing a continuing increase in R&D and innovation investment year-on-year.

THIS YEAR, we had a total investment of just over R7 million in Roadmap managed R&D grants to universities and science councils, with a total of 20 grant projects supported. This is in addition to research being funded by other entities of government and by business.

The Department of Science and Technology (DST), the National Research Foundation (NRF) and the CSIR launched the first two SARChI Research Chairs in solid waste management in South Africa in August 2018. The Chairs have already made excellent progress since then, mobilising funding support for 26 post-graduate students through direct and leveraged funding.

From left to right: Ms Mannakazi Skoti (DST), Prof Linda Godfrey (CSIR), Dr Henry Roman (DST)

The first Waste RDI Roadmap R&D grant projects were awarded in early 2016 and a number of these projects came to an end in March 2019. Since the start of the Roadmap implementation, a total of 12 grant projects have been completed, with a corresponding investment of R12.9 million. With the grant projects now maturing the number of students and project deliverables has increased significantly. A total of 25 post-graduate students, supported through the grant projects, have completed their studies to date. The grant projects have also produced 24 conference papers and presentations, 15 published journal papers, 4 technical reports and 3 technology packages.

As the Roadmap enters its fifth year of implementation, the trends in investment, students, researchers and outputs all continue to show positive growth. This is very encouraging as we believe it displays not only a clear recognition for the need for waste research, development and innovation in South Africa but more importantly, the relevance of the research being done.

A concerted effort has been made over the past year to engage with academics at the emerging universities to increase their participation in Roadmap activities. This included the first leg of a national Waste RDI Roadmap Roadshow to universities in Limpopo, Eastern Cape, Western Cape and KwaZulu-Natal.

The WRIU continues to play a strong science advocacy role, both locally and internationally. The intention being to showcase South Africa's waste RDI, build local and international capacity based on South African learning, and strengthen local and international partnerships. This includes working with post-graduate students to develop and frame their research projects based on relevant and topical issues.

With a new White Paper on Science and Technology for South Africa, and a clear recognition of the role of the Circular Economy in supporting development, we look forward to new opportunities in science, technology and innovation in the waste and secondary resources sectors.

We also look forward to the outcomes of the new targeted, Roadmap-funded, demonstration project on the use of waste plastic in road construction, mobilized by the DST and industry to support new end-use market development for waste plastics in South Africa. The project will be completed mid-2020.

The CSIR-DST Roadmap team said farewell to Ms Magamase Mange of the DST during 2018, as she moved on to new opportunities in the environmental sector. We would like to thank her for her invaluable contribution over the past five years in the development of the Roadmap and in its implementation, and we wish her all of the best.

The CSIR Team:

Mr Bongani Memela
Manager: Strategic Initiatives

Prof Linda Godfrey
Manager: Waste Roadmap Implementation Unit

Ms Marelize Ackerman
Financial Manager

Ms Lulu Makapela
Contract Manager

Mr Beeza Mtamzeli
Communications

> South Africa continues to strengthen its waste research, development and innovation profile in the local, regional and international waste community.

BACKGROUND AND OBJECTIVES

The Waste RDI Roadmap is an initiative of the Department of Science and Technology (DST) aimed at guiding South Africa's public and private sector investment in waste research, development and innovation (RDI) over the next 10 years (2015-2025).

Vision

Development and deployment of performance improvements in waste management has delivered a significant contribution to the strengthening of a sustainable regional secondary resources economy in South Africa.

Mission

This has been achieved by means of a National Waste RDI Programme that supports maximisation of diversion of waste 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 economic, social and environmental benefit.

Background

The DST recognised the role that RDI could play in achieving the objectives of the National Waste Management Strategy, in moving waste up the hierarchy away from landfilling, and in transforming the South African waste sector in a way that could provide environmental, social and economic benefit for the country.

In 2012, the DST, in partnership with the CSIR, embarked on a process to develop the Waste RDI Roadmap. This process, which was shaped by business, industry, government and academia, culminated in early 2015 with the publication of South Africa's first Waste RDI Roadmap.

The Waste RDI Roadmap is available to review online at **www.wasteroadmap.co.za.**

Objectives

With an investment ask of approximately R3.9 billion over 10 years, the successful implementation of the Roadmap is expected to assist government and industry to significantly increase the diversion of waste away from landfill towards value-adding alternatives, through more effective decision-making; faster insertion of context-appropriate technology; export of know-how and technology; and strengthened RDI capability and capacity.

The Roadmap, which is anchored in the mandate of the DST, is structured around three key pillars –

- human capital development (HCD)
- research and development (R&D)
- innovation (technological and social)

The Roadmap aims to address issues relating to five priority waste streams –

- municipal solid waste
- waste electrical and electronic equipment (WEEE)
- waste plastic
- organic waste
- waste tyres

Within six broad areas, or clusters, of activity –

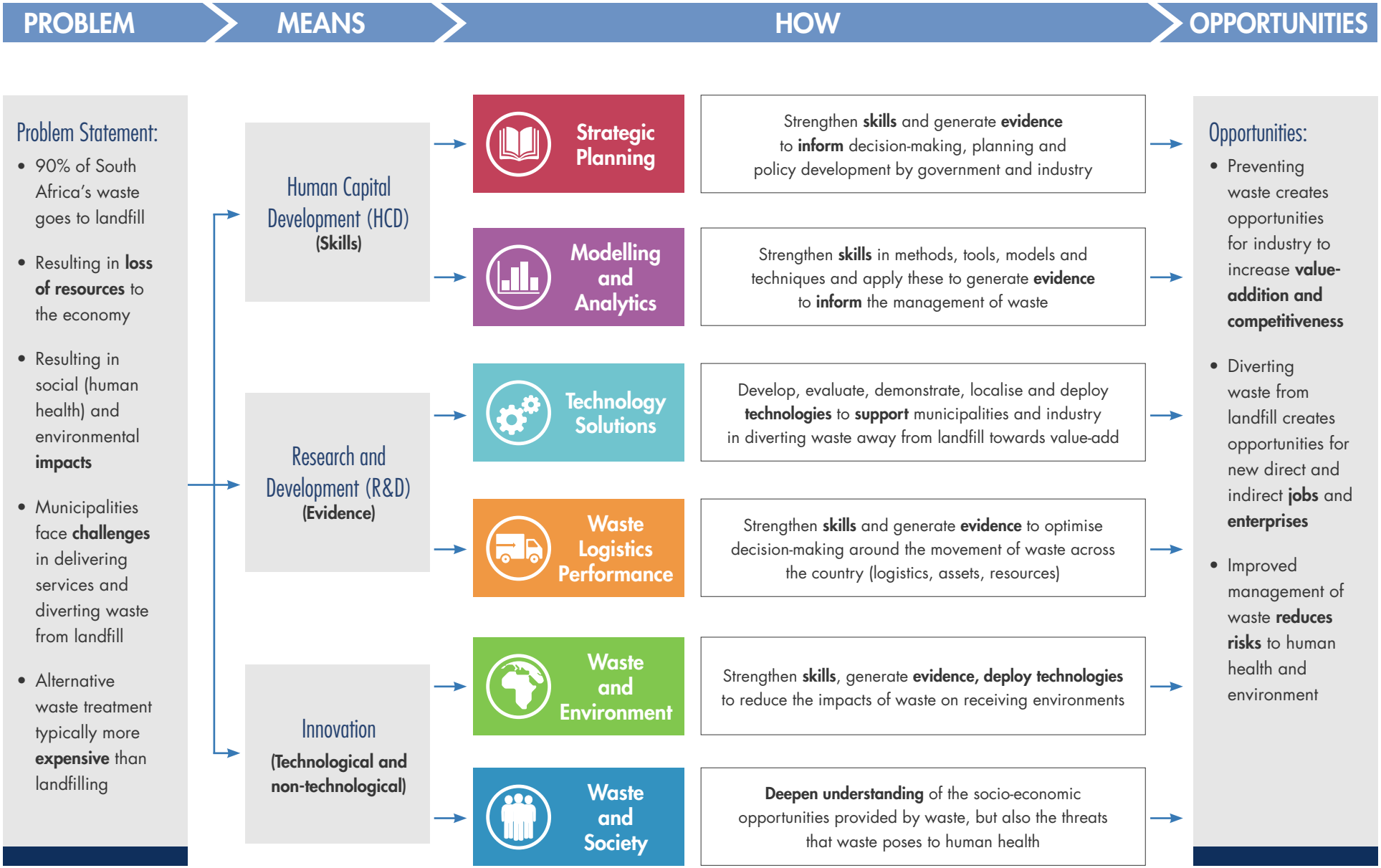
- strategic planning
- modelling and analytics
- technology solutions
- waste logistics performance
- waste and the environment
- waste and society

HUMAN CAPITAL DEVELOPMENT

RESEARCH & DEVELOPMENT

INNOVATION

PICTORIAL SUMMARY OF THE WASTE RDI ROADMAP



KEY FOCUS AREAS AND SERVICE OFFERINGS

Waste RDI Roadmap clusters and percentage of total investment per cluster expected (2015-2025)

Implementation

The CSIR was appointed by the DST to implement the Waste RDI Roadmap from 1 April 2015. The intention is for the CSIR, through the Waste RDI Roadmap Implementation Unit (WRIU), to drive human capital development (HCD), research and development (R&D) and innovation, in partnership with government, industry and academia; and to actively engage opportunities (local and international) for waste RDI collaboration and co-investment.

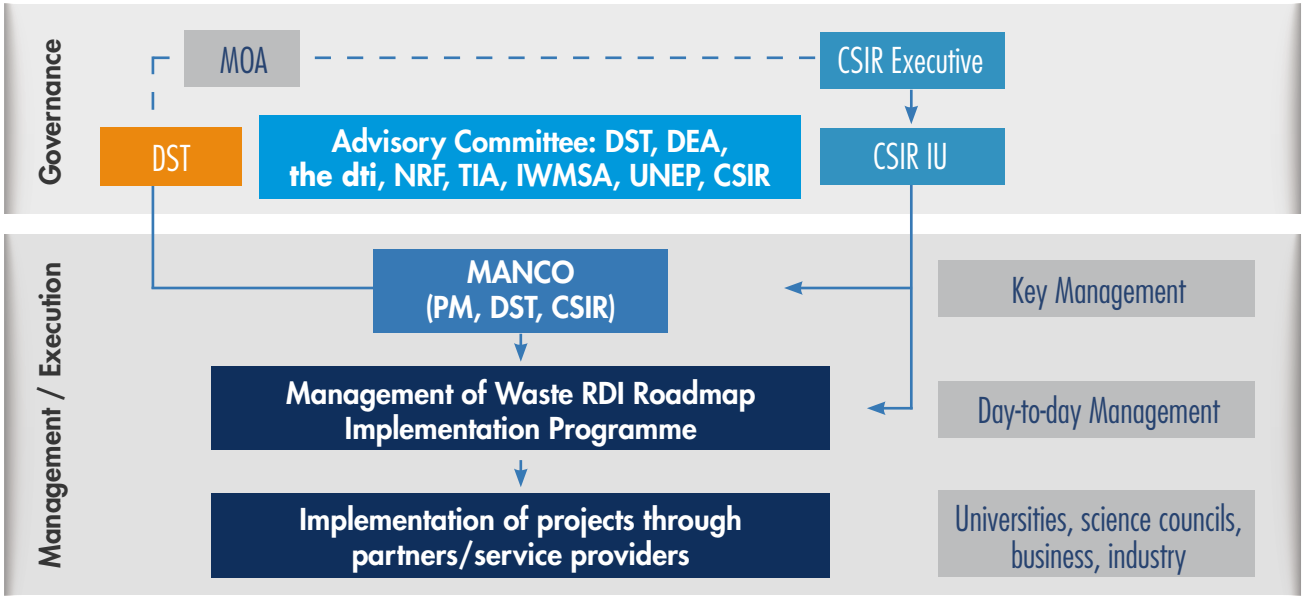
As shown here, the bulk of the Waste RDI Roadmap funding investment is planned for the "Technology Solutions" cluster, but with significant support to the other five clusters.

Human capital development, research and development and innovation continue to be funded in these key focus areas

GOVERNANCE

The Waste RDI Roadmap is implemented by the CSIR's Waste RDI Roadmap Implementation Unit (WRIU) in partnership with the DST, DST entities, other government departments, universities and science councils, business and industry. Effective governance and oversight of activities within the WRIU is fundamental to the Roadmap's implementation.

The Waste RDI Roadmap governance structure is as follows:



The DST would like to thank the members of the Steering Committee for their valuable guidance and input during 2018. The Steering Committee, convened for the period 2018-2020, includes representatives from:

Sector	Organisation
National Government	Department of Science and Technology, Department of Environmental Affairs, Department of Trade and Industry
R&D and Innovation Agencies	National Research Foundation (NRF), Technology Innovation Agency (TIA), Council for Scientific and Industrial Research (CSIR) (Host)
Waste Sector	Institute of Waste Management South Africa (IWMSA)
Multilateral non-governmental organisation	United Nations Environment Programme (UNEP)
Associations	South African Local Government Association (SALGA)

1 an **Operations Committee**, made up of the DST Director: Environmental Services and Technologies and the WRIU Manager, who meet monthly, or more frequently if required, to discuss operational matters

2 a **Management Committee** (MANCO), made up of senior representatives of the DST and CSIR Implementation Unit, who meet annually, or more frequently if required, to discuss management and oversight issues; and

3 an advisory **Steering Committee**, made up of representatives of government, government entities and the waste sector, who are tasked with reviewing the progress of the WRIU and giving input on the planned activities for the following year.

REFLECTING ON 2018/19

RESEARCH, DEVELOPMENT AND INNOVATION

60 final deliverables produced

81 researchers supported on Grant Projects

4 **new RDI grant projects awarded**

10 **successful recipient research institutions (new and existing)**

40.5 **MILLION RAND** invested in the national system of innovation

20 research grant projects funded (new and existing)

5.7 **MILLION RAND** allocated to new targeted R&D and demonstration projects

30.6 **MILLION RAND** **of committed funding for new and ongoing research projects**

19.2 **MILLION RAND** of new R&D proposals received

HUMAN CAPITAL DEVELOPMENT

36 post-graduate students supported through grant projects

22 post-graduate students directly supported through SARChI Chairs

5 post-graduate students supported through scholarships

17 students studying towards NWU higher degrees in waste management in 2018

4 Honours students enrolled for degree

13 Master's students enrolled for degree

3 interns supported through Grant Projects (workplace experience)

22 students successfully completed their degrees

11 Master's students supported through grant projects

1 PhD student supported through grant projects

2 Master's students supported through scholarships

1 PhD student supported through scholarships

4 Honours students completed their NWU waste management degrees

3 Masters students completed their NWU waste management degrees

COMMUNICATION IMPACT

POPULAR ARTICLES

30 print articles highlighting the Waste RDI Roadmap

25 presentations made

3 radio interviews

1 television interview

TOP DOWNLOADED PUBLICATIONS

- The economic benefits of moving up the waste management hierarchy
- Trends in waste management
- Waste sector survey
- WEEE technology landscape assessment
- Skills for an Innovative Waste Sector

WEBSITE

6 249	UNIQUE VISITORS
9 543	NUMBER OF VISITS
26 556	PAGES VISITED
2 221	DOCUMENTS DOWNLOADED

TOP 5 COUNTRIES ACCESSING THE WASTE RDI ROADMAP WEBSITE

HUMAN CAPITAL DEVELOPMENT (HCD)

Providing a pipeline of qualified post-graduate students into the waste and secondary resources sector with the skills to drive alternative waste treatment and to unlock opportunities

Increasing the supervisory capacity to mentor post-graduate students (honours, master's, doctoral) and post-doctoral researchers

STRENGTHENING SKILLS in waste management is a key priority of the Waste RDI Roadmap. A more capable public and private sector creates a strong foundation on which to transform the South African waste economy.

Building national capacity is achieved through a number of Roadmap instruments –

- Direct scholarships for post-graduate students
- Students supported partially or fully through Waste RDI grant projects
- Internships with organisations supported under the Waste RDI Roadmap
- SARChI Research Chairs

Post-graduate scholarships

Due to funding constraints in 2018/19, no new post-graduate scholarship call was issued under the Waste RDI Roadmap for the 2019 academic year.

Five (5) continuing post-graduate students were supported in 2018/19 through scholarships.

Internships

Three (3) interns were provided with workplace experience at South African science councils and universities in 2018/19. These interns were provided with opportunities to work with established researchers on Waste RDI Roadmap funded grant projects.

Grant funded post-graduate students

The 20 Waste RDI Roadmap grant projects funded in 2018/19 supported 36 Master's, PhD and Post-doc students (partially or fully). The grant projects are an important mechanism for building capacity aligned with the Waste RDI Roadmap, in South Africa.

While the Waste RDI Roadmap scholarship call is only open to South African citizens and South African permanent residents, the grant projects are able to fund any student studying at an accredited public South African Higher Education Institution. In this way, the Waste RDI Roadmap is able to support the strengthening of waste skills not only of South Africans, but of candidates from across Africa and beyond.

In addition to the 23 South African post-graduate students supported on research grant projects, an additional 13 students from across Africa were supported financially through the Waste RDI Roadmap. This is further discussed in the section on "Partnerships".

The majority of post-graduate students supported through Grants (47%) worked on organic waste and industrial biomass research projects, followed by municipal solid waste (28%).

Students at WasteCon 2018

Seven (7) post-graduate students, working on Roadmap funded grant projects, were given the opportunity to attend and present at the

Waste RDI Roadmap Grant students at WasteCon, Johannesburg, 2018

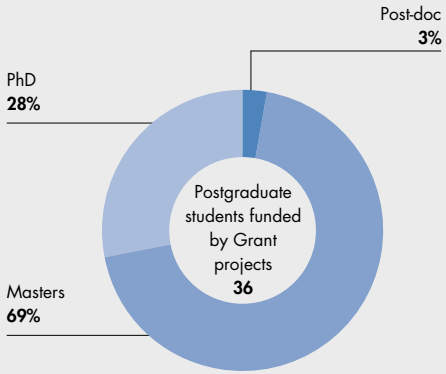
bi-annual WasteCon 2018 Conference held in Johannesburg. The students presented during a special scientific session of the conference.

The topics presented by the students included –

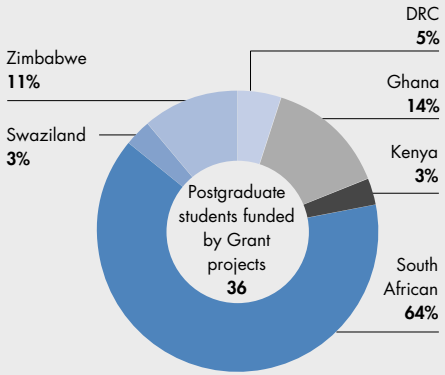
- Waste plastics pyrolysis for energy recovery (Salomie vd Westhuizen, Stellenbosch University)
- Recovery of rare earth elements from fluorescent lamp phosphor powders (Levie Bumhira, Stellenbosch University)
- Development of hemicellulose based products from agro-waste residues (Darrel Naidu, Nelson Mandela University)
- The policy and practice of reclaimer integration in the City of Johannesburg (Maite Sekhwela, University of Witwatersrand)
- Metal recovery subsequent to e-waste bioprocessing using biological matrices (Thabo Mabuka, University of Cape Town)
- Development of an environmentally friendly metal extraction process from Lithium-ion batteries (Bruce Musariri, Stellenbosch University)
- Printed circuit board leach residue as reductant in pyrometallurgical operations (Desmond Attah-Kyei, Stellenbosch University)

The WRIU would like to acknowledge the financial support provided by the Institute of Waste Management of Southern Africa (IWMSA) in covering the student's conference fees, and the Department of Science and Technology in covering the student's travel and subsistence costs.

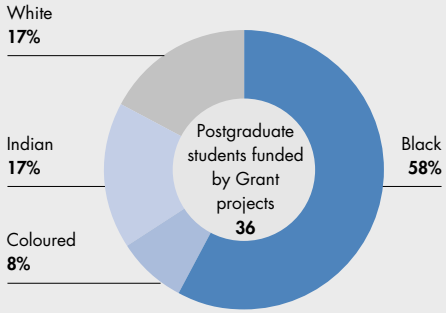
Grant funded students (by degree)



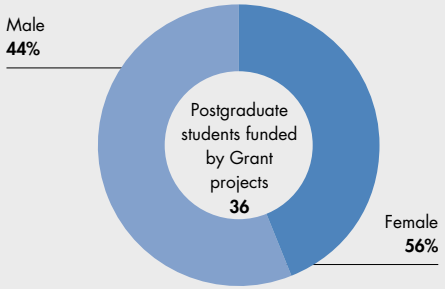
Grant funded students (by nationality)



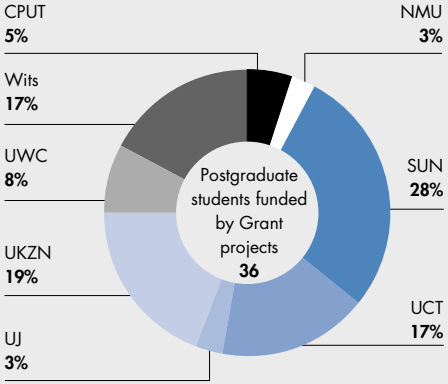
Grant funded students (by race)



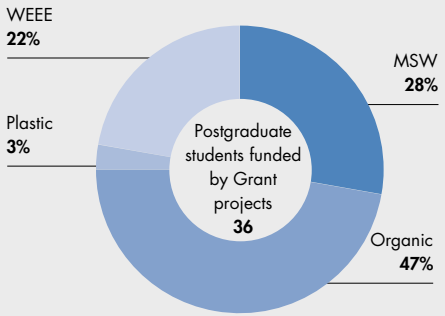
Grant funded students (by gender)



Grant funded students (by institution)



Grant funded students (by priority waste stream)



HUMAN CAPITAL DEVELOPMENT (CONTINUED)

Strengthening post-graduate qualifications

As at the start of the 2018 academic year, 17 students (4 Honours and 13 Master's) were undertaking post-graduate degrees in waste management at North-West University. NWU currently offers the Honours and Master's Degrees in Environmental Sciences with specialisation in Waste Management. Four (4) Honours and three (3) Master's students completed their degrees in waste management and graduated from North-West University at the end of 2018.

The South African Council on Higher Education (CHE) accredited the University of KwaZulu-Natal (UKZN) new Master's in Waste and Resources Management in early 2019. This is very exciting as it will contribute to unlocking new post-graduate opportunities for students in 2020. While waiting for the accreditation of the degree, UKZN offered some of the coursework material as part of an Extended Learning Summer School in *"Managing Waste as a Resource"*. The Summer School was run from the 26-30 November 2019 and included lecturers from Italy, Netherlands and South Africa.

Platforms for learning and knowledge exchange

South Africa has developed considerable expertise in waste and resource management in a developing country context, which is of growing interest to the local, regional and international waste community. The WRIU had the opportunity to share the South African perspective on waste management at a number of events in 2018/19. The rationale for participating in these events includes –

- Showcasing South Africa's waste R&D and Innovation locally and internationally
- Building local and international capacity based on South African learning
- Strengthening local and international partnerships

Creating and participating in platforms for knowledge exchange and learning, are important to achieving the goals of the Roadmap, in particular, strengthening human capital.

International Labour Organisation (ILO)

The DST and the CSIR once again partnered with the International Labour Organisation's training division (ILO-ITC) to present the international training programme *"Opportunities for green jobs in the waste sector"* in Turin, Italy, in November 2018.

The ILO-ITC training programme was attended by 19 participants from government, NGOs, business and universities based in Egypt, Ghana, Kenya, Korea, Nigeria, Philippines, Samoa, Serbia, South Africa, Switzerland, Zambia and Zimbabwe.

Partnership for action on Green Economy (PAGE)

The WRIU participated in the 3rd PAGE Ministerial Conference, held in Cape Town, South Africa from the 10-11 January 2019, entitled: *"Advancing Inclusive and Sustainable Economies"*. Prof Godfrey was invited to participate in two of the panel discussions on –

- Setting an overarching framework for policy reform
- Innovations and solutions for sustainable consumption and production – circular economy

United Nations Industrial Development Organisation

A South African delegation from the Department of Environmental Affairs (DEA), National Cleaner Production Centre (NCPC) and CSIR participated in the 5th Green Industry Conference for Sustainable Development, which took place in Bangkok, Thailand from the 3-5 October 2018. Prof Godfrey was invited to give the keynote address on *"The Circular Economy – What does it mean for development and green industries. A perspective from Africa"*. The full presentation is available on the Waste RDI Roadmap website.

International Solid Waste Association

The WRIU participated in the ISWA2018 Conference held in Kuala Lumpur, Malaysia from the 22-24 October 2018. Presentations were made on –

- *"Mapping the status of women in the global waste management sector"* as part of the ISWA Women of Waste (WOW) initiative
- *"Paper and packaging EPR in South Africa: Building on the informal sector"*, on behalf of PETCO, the material organisation responsible for PET EPR in South Africa

In addition, the WRIU participated in a post-ISWA2018 workshop on "Managing Landfills & Dumpsites in Developing Countries". The transition from dumpsites to engineered landfills is an important element of South Africa's transition

to increased reuse, recycling and recovery. It is important for developing countries to understand how to make this transition, given current legislative, financial and capacity constraints.

PEW/SYSTEMIQ

The WRIU was invited to participate as a member of the international expert technical panel for the *"Global Roadmap to Achieve Near Zero Ocean Plastic Leakage by 2040"*, convened by the Pew Charitable Trusts and SYSTEMIQ. The expert panel met three times during 2018/19 – July 2018 (London), November 2018 (Washington) and March 2019 (Hanoi). The intention of the project is to develop a model which will guide decision-makers in addressing the leakage of plastic waste to the environment, including the marine environment.

Participation in the expert panel provides opportunity to give input on waste (and in particular plastics) challenges facing Africa. It also ensures that the model to be developed as part of the project provides value to African countries on how to manage waste plastic in the future, e.g. evidence-based policy development.

Key resources on the UKZN Summer School, Durban, 2018

South African delegates from government, business and academia at the ISWA 2018 Conference, Kuala Lumpur

South African delegates at the 5th Green Industry Conference, Bangkok, Thailand, 2018

Participants of the DST-CSIR-ILO Green Jobs Training Programme, Turin, Italy, 2018

HUMAN CAPITAL DEVELOPMENT (CONTINUED)

Universities

The WRIU made a number of presentations to students and staff at South African universities in 2018/19. The intention was to share information on the Waste RDI Roadmap and on waste management challenges facing South Africa and Africa.

Post-graduate students

The WRIU has taken on a growing mentorship role to local and international post-graduate students in shaping their research projects. This includes identifying potential research topics of local, regional or international concern. During 2018/19, 14 Master's and PhD students engaged with the WRIU, seeking input and guidance on their research projects.

Circular Economy

The circular economy is finding more and more traction within the South African landscape, including the adoption of the concept within the new White Paper on Science and Technology for South Africa.

"The Circular Economy implies systemic change and a shift to a low- or zero-waste, resource-efficient society, and entails major changes to methods of production and consumption. Beyond the potential to save materials and leave a smaller footprint on the environment, a circular economy would create economic opportunities as new services and business models emerge, transforming the relationship between producer and consumer, and products and their users" [Draft White Paper, 2018]

Members of the Expert Technical Panel, London, July 2018

A number of presentations on the circular economy were made by the WRIU during 2018/19 –

- Godfrey, L. (2018). *Developing and achieving a successful circular econo*my in South Africa – A Strategic Overview. Mail & Guardian, Circular Economy: From Waste to Wealth, 26 June 2018, Johannesburg
- Godfrey, L. (2018). Fundamentals of a Circular Economy – Opportunities for South Africa. SAICA Circular Economy Forum, 14 August 2018, Johannesburg
- Godfrey, L. (2018). The Circular Economy – What does it mean for development and green industries: A perspective from Africa. 5th Green Industry Conference for Sustainable Development, 3 October 2018, Bangkok
- Godfrey, L. (2018). *Domesticating the circular economy to South Africa.* Dutch Ministry of Infrastructure and Water Management workshop, 17 October 2018, Johannesburg

Students and academic staff, at the University of Pretoria – Częstochowa University of Technology (Poland) workshop on "Environmental safety of biowaste in a circular economy", February 2019

In line with the national imperative of **equity** and **redress**, the Waste RDI Roadmap **scholarship programme** prioritised support for **appropriately qualified applicants** from designated groups viz. black and female, while ensuring that only applications that **meet the NRF merit review** and **selection criteria** are **supported**.

RESEARCH AND DEVELOPMENT

Supporting the generation of new scientific evidence, relevant to South Africa, that will inform policy, planning, decision-making

Supporting the development of new technology and of adapting technology to South African conditions through R&D

> The intention of the 2018/19 Grant Call on Municipal Solid Waste is to provide local and national government with useful and practical solutions to address the current waste management challenges experienced in municipalities in South Africa.

Research, Development and Innovation Grants

The Waste RDI Roadmap Implementation Unit partnered with the DEA, South African Local Government Association (SALGA) and the Waste Bureau in drafting the 2018/19 Open Grant Call on Municipal Solid Waste (MSW). The Call focussed on four areas of intervention –

- City cleanliness
- Diversion of organic and C&D waste
- Incentive models
- Phasing out uncontrolled dumpsites

The intention of the 2018/19 Grant Call was to provide government (local and national) with useful and practical solutions to address the current waste management challenges experienced in municipalities.

Applications received

A total of 14 applications were received under the 2018/19 Open Grant Call – a funding ask of R19.2m for R&D projects commencing in 2019. Applications were received from six (6) universities and science councils. There has been an increase in the number of applications received from emerging universities, which is encouraging to see. This may be the due to the particular nature of the call (MSW) or in response to the Waste RDI Roadmap Roadshow undertaken in 2018/19 to raise awareness regarding the Roadmap and the associated funding opportunities. All proposals, as required, were focussed on MSW.

Thematic spread of new R&D Grant applications and awards

The proposals received under the Open Call identified a number of academic and government partners. In addition to the six (6) applying institutions, another 10 South African academic partners and 10 local, metropolitan and district municipalities were included as project partners. This is very encouraging in ensuring relevance of the research and impact of the research findings.

The proposals were evaluated by an independent panel of experts from government and academia.

Awarded R&D grants

Of the 14 grant proposals received, only 2 projects were awarded to South African public research institutions, starting in 2019. The number was limited by the available funding, and not by the quality of proposals received. The overall success rate of eligible proposals received under the call was 14%. This is down from the 50% and 45% success rate in 2016/17 and 2015/16 respectively.

Monitoring of ongoing grant projects

The 20 Waste RDI grant projects (16 ongoing and 4 new) awarded to South African universities and science councils, were closely monitored over the financial year. This was done through quarterly reporting and annual steering committee meetings.

Inception meeting of the new grant project with Grant Holder Prof. C Schenck, University of the Western Cape

Steering Committee meeting with Grant Holder Dr M Samson, University of Witwatersrand – accompanied by post-graduate students

RESEARCH AND DEVELOPMENT (CONTINUED)

The profile of the 20 grant projects against the Waste RDI Roadmap clusters and priority waste streams are shown to the right.

Profile of research teams on projects

The 20 Waste RDI grant projects provided funding support to 81 researchers (non-unique) at 10 research institutions across South Africa in 2018/19. This is up from the 59 researchers supported in 2017/18.

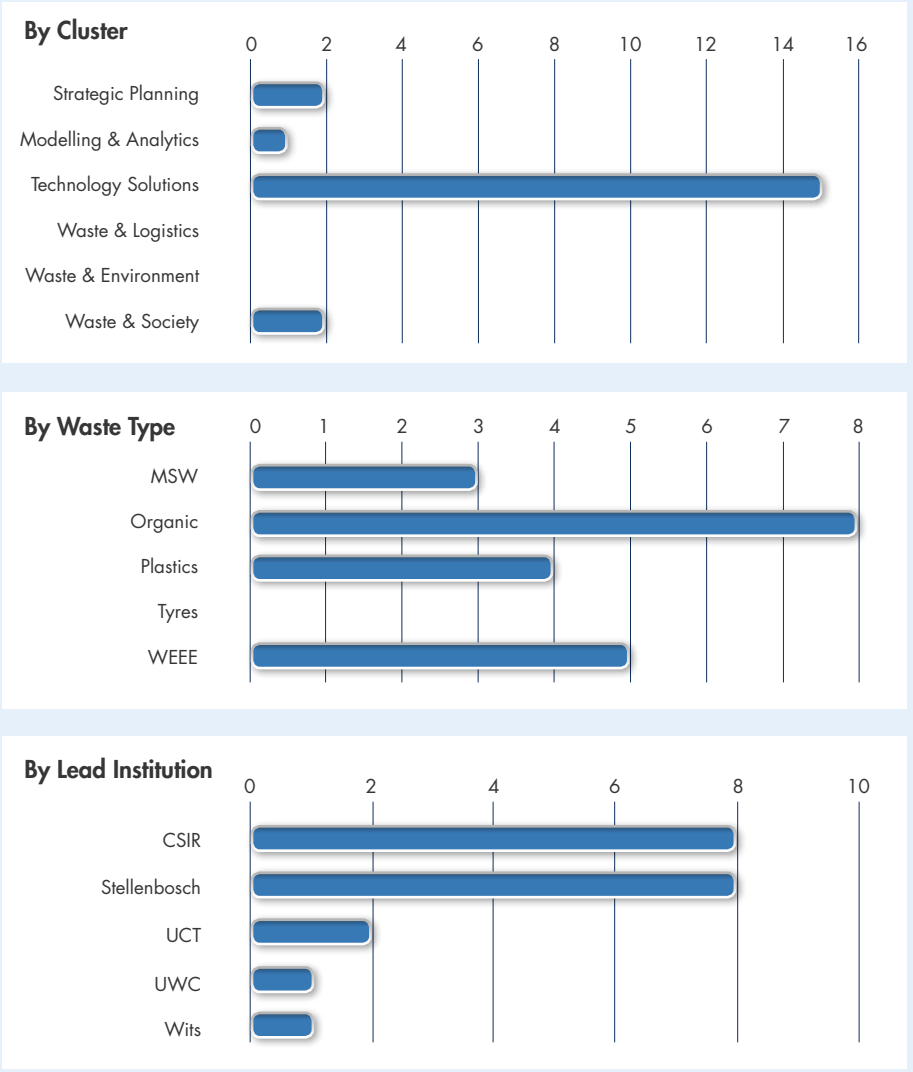
As with the post-graduate students, researchers supported on the grant projects stem predominantly from South Africa (77%), but also from other African countries, Europe, Asia and North America. This is another positive development for the South African waste sector. Not only is the Roadmap helping to build international capability and networks, but it is also ensuring that new ideas are introduced into the South African research community.

Targeted grant projects

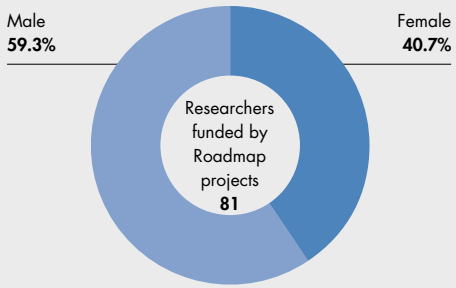
In addition to the Open Grant Call, the WRIU also sourced two (2) targeted projects during 2018/19. The total investment in new targeted projects was R5.7m for projects commencing in 2019. The targeted projects, which focus on waste plastic, include –

- Informing decisions on single-use plastic carrier bags in South Africa: Evidence from a Life Cycle Sustainability Assessment
- The use of plastic waste in road construction in South Africa (demonstration project)

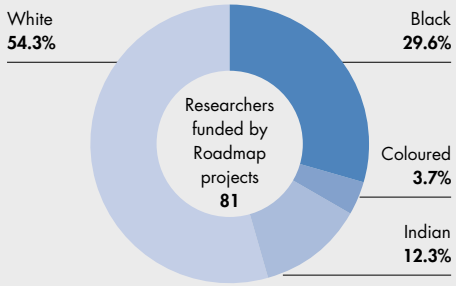
Thematic spread of R&D grant projects (New and Existing)



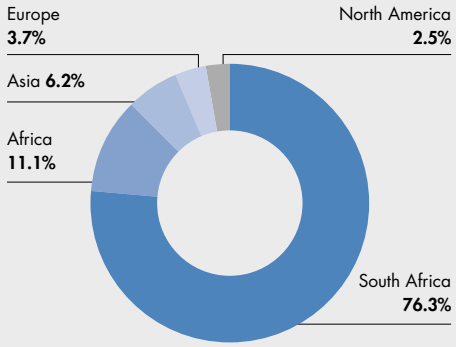
Grant funded researchers (by gender)



Grant funded researchers (by race)



Grant funded researchers (by nationality)



Informing decisions on single-use plastic carrier bags

The DEA has expressed its intentions to ban a number of single-use plastic items, including plastic carrier bags. This has been met with concern by the plastic industry, raising issues of economic impact and job losses in the plastic industry. This 13-month targeted research project is therefore aimed at determining the most appropriate carrier bag options for South Africa by considering not only the environmental, but also the social and economic impacts and benefits.

The use of plastic waste in road construction

A number of private companies have approached the research community in the past year to discuss the feasibility of using waste plastic in road construction. South Africa has strict standards with regards to the use of additives in bitumen, to ensure the performance of road pavements. As such, any new plastic materials or plastic-modified materials used in the local industry must be tested for compliance to the set criteria before they can be implemented in South Africa. This targeted 15-month demonstration project aims to determine the most appropriate plastic fractions (currently non-recyclable) and their performance with respect to local standards.

RESEARCH AND DEVELOPMENT (CONTINUED)

Completed grant projects

Ten (10) grant projects were completed during the 2018/19 financial year. A summary of the findings of these grant projects is provided in **Annexure 1**. The final deliverables have been made available on the Roadmap website.

Completed projects include –

- Beneficiation of forestry biomass waste streams (Prof B Sithole, CSIR)
- Valorisation of waste chicken feathers (Prof B Sithole, CSIR)
- Sustainable utilization of post-harvest waste (Dr M John, CSIR)
- Value recovery from solid confectionary waste (Prof S Harrison, UCT)
- Reactor design for industrial furfural production (Prof J Görgens, Stellenbosch)
- Extraction of value from solid waste by pyrolysis (Prof J Görgens, Stellenbosch)
- Recycling rare earth elements from fluorescent lamps (Prof C Dorfling, Stellenbosch)
- Lithium ion battery (LIB) recycling process (Dr G Akdogan, Stellenbosch)
- PCB leach residue as reductant (Dr G Akdogan, Stellenbosch)
- Techno-economic feasibility of PET waste to MOFs (Dr J Ren)

Grant project deliverables

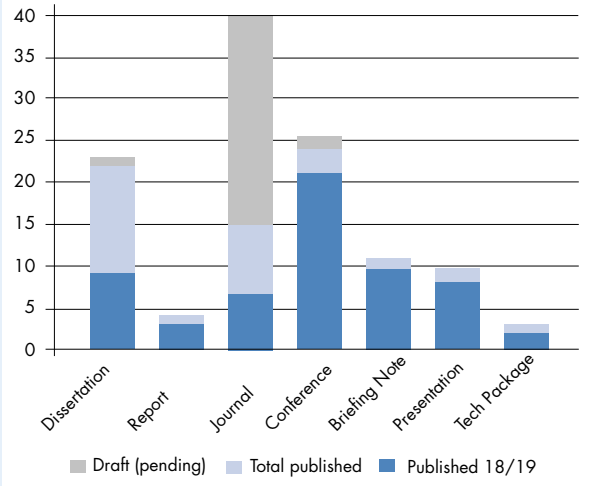
The portfolio of grant projects produced 60 final deliverables during 2018/19. This includes post-graduate dissertations, journal papers, technical reports, conference papers and presentations, and briefing notes.

- 21 Conference papers and presentations
- 10 Briefing notes
- 9 Dissertations
- 8 Summary presentations
- 7 Journal papers
- 3 Technical reports
- 2 Technology packages

A summary of the deliverables is provided in Annexure 2 and also referenced in the section "Waste RDI Outputs".

The current status of published RDI Roadmap grant project deliverables and draft deliverables is highlighted below.

Current status of published RDI Roadmap grant project deliverables and draft deliverables



Women-of-waste at the ISWA 2018 Conference in Kuala Lumpur, Malaysia

National Research Foundation

SARChI Research Chairs

The DST, NRF and CSIR jointly launched the first two SARChI Research Chairs in waste management in South Africa on the 14 August 2018. The launch, which was attended by more than 70 representatives of academia, business and government, provided an opportunity for Prof Schenck and Prof Trois to share their visions for the Research Chairs. The launch generated excellent media coverage, with more than 20 local and regional publications running with the story.

The SARChI Chairs will give effect to two of the Waste RDI Roadmap clusters – Waste & Environment (Climate) and Waste & Society. In this way, the Chairs will be instrumental in developing the portfolio of research and capability within these two Roadmap clusters. The SARChI Chairs also play an important role in leveraging new public and private sector research funding into the National System of Innovation.

Waste and Climate Change

Prof Trois, an NRF-rated researcher from the University of KwaZulu-Natal, has been appointed a Tier I Research Chair in Waste and Climate Change. The Research Chair will develop and implement a research programme that delivers evidence to support the improved understanding of the –

- Climate impacts associated with the generation and disposal of waste in South Africa;
- Measures (including technologies) to mitigate these impacts;
- The impact of climate change on the waste sector.

The Waste & Climate Change Chair has provided funding support for eight (8) post-graduate students in 2018/19.

Recent publications by the Chair include:

- Bwapwa, J.K., Anandraj, A. and Trois, C. (2018). Conceptual process design and simulation of microalgae oil conversion to aviation fuel biofuels. *Bioproducts and Biorefining*, 12 (6): 935-948. https://doi.org/10.1002/bbb.1878

Waste and Society

Prof Schenck, an NRF-rated researcher from the University of the Western Cape, has been appointed a Tier II Research Chair in Waste and Society. The Research Chair will develop and implement a research programme that delivers evidence to support the improved understanding of the –

- Opportunities to create jobs and improve livelihoods through the transition away from landfilling in South Africa;
- Business models to support a secondary resources economy, with a particular focus on SMMEs;
- Required behaviour change to drive the transition away from landfilling, including appropriate behaviour change interventions such as awareness and communication strategies for South Africa as a developing country.

The Waste & Society Chair has leveraged funding to support 18 post-graduate students in 2018/19. This includes 4 post-graduate students funded under the Waste RDI Roadmap Clean Cities grant project. The Chair has focussed their activities for 2018/19 on raising awareness on issues related to waste and society through network building, media engagement and presentations at workshops and conferences.

Recent publications by the Chair include:

- Schenck, C.J., Blaauw, P.F., Swart, E.C., Viljoen, J.M.M. and Mudavanhu, N. (2018). The management of South Africa's landfills and waste pickers on them: Impacting lives and livelihoods. *Development Southern Africa*, 36(1) https://doi.org/10.1080/0376835X.2018.1483822
- Viljoen, K., Blaauw, D. and Schenck, R. (2018). Sometimes you don't make enough to buy food: An analysis of South African street waste pickers' income. *Journal of Economic and Financial Sciences* ,11(1), a186. http://dx.doi.org/10.4102/jef.v11i1.186
- Schenck, C.J., Blaauw, P.F., Swart, E.C. and Viljoen, E.C. (2018). Social work and food security: Case study on the nutritional capabilities of the landfill waste pickers in South Africa. *International Social Work*, 61(4): 571–586. https://doi.org/10.1177/0020872817742703

Launch of the SARChI Research Chairs – Prof. C Trois (UKZN), Dr H Roman (DST) and Prof. C Schenck (UWC)

PARTNERSHIPS

"Waste research, development and innovation cannot, on its own, transform the waste sector. The Roadmap is one mechanism being implemented by government, through the Department of Science and Technology, to move waste away from landfilling. To ensure success, the Roadmap must be adopted as part of a suite of public and private sector responses aimed at addressing the challenges currently facing the waste sector"

"A partnership between government departments allows us to achieve the goals set out in national policy, while addressing issues of environmental protection, economic development, and technological and social innovation in a more holistic and integrated manner"

Government

National government departments are key to ensuring that Waste RDI Roadmap research outputs support decision-making, policy development and implementation. As line department responsible for waste, the DEA is an important partner in this regard. Collaboration with DEA during 2018/19 has included –

- Partnering on the University of the Witwatersrand grant project (Dr M Samson) on the "integration of the informal waste sector". In addition to co-funding the research, the DEA is supporting the extension of the research into a set of guidelines for practical integration of informal waste pickers in South Africa;
- Invitation to the WRIU to serve in a review/ advisory role on current national government waste projects;
- Partnering with DEA, SALGA and the Waste Bureau to identify municipal solid waste priorities which informed the Roadmap Grant Call for 2018/19.

The DEA and the Department of Trade and Industry (the dti), two key partner departments, both serve on the Roadmap Steering Committee.

Academia

Universities and science councils are at the heart of the Waste RDI Roadmap, undertaking much of the RDI necessary to successfully redirect waste away from landfill. The response of academia to the Waste RDI Roadmap Calls remains positive.

The WRIU currently has a network of approximately 120 researchers working in solid waste management and associated fields across South African public research institutions.

Waste RDI Roadmap Roadshow

During the March 2018 Steering Committee meeting, members raised concerns as to the weak participation of emerging universities in the Waste RDI Roadmap. It was noted that this may be the result of limited waste RDI capability within these universities as previously confirmed through the Waste RDI Roadmap Capability Mapping exercise, as well as a poor understanding of the opportunities provided by the Roadmap. The first leg of a national roadshow to universities was therefore conducted in 2018/19 to raise awareness about the activities of the Waste RDI Roadmap and the opportunities provided. Universities visited included –

- Cape Peninsula University of Technology
- Nelson Mandela University
- University of the Western Cape
- University of Limpopo
- University of KwaZulu-Natal

Additional universities will be visited during 2019/20.

African Reclaimers Organisation (ARO) members introduce themselves to the residents of Johannesburg, 2018

During 2018/19, staff from the WRIU have driven and participated in –

- Activities that have directly increased waste RDI collaboration with the private sector;
- Provided technical advisory support to government and industry;
- Collaborated in the international waste RDI arena,
  - in support of showcasing South Africa's waste RDI, and
  - in ensuring that intelligence is brought back in support of the Waste RDI Roadmap implementation.

This has included active engagement with, and specialist advisory support to –

South Africa –

- Department of Environmental Affairs
- Technology Innovation Agency (TIA)
- Plastics and packaging sector
- WEEE sector
- Organic waste sector
- Various provincial green economy, innovation and green skills forums

Regional –

- United Nations Environment Programme (UNEP)

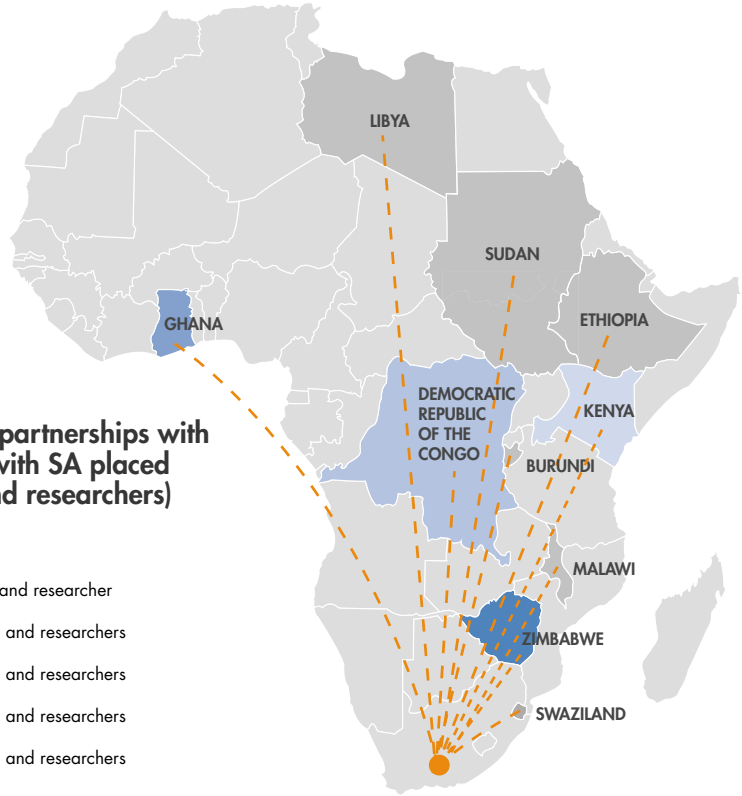
International –

- International Solid Waste Association (ISWA)
- United Nations International Labour Organization (ILO)
- United Nations Environment Programme (UNEP)
- United Nations Industrial Development Organisation (UNIDO)
- International Environmental Technology Centre (IETC)

Africa

As noted in the sections on grant-funded post-graduate students and grant-funded researchers, a number of students (13) and researchers (9) from other African countries are being provided with the opportunity to build their capacity through Waste RDI Roadmap research projects. These students and researchers, who are currently studying and working at South African universities and science councils, are financially supported through the South African Waste RDI Roadmap. They provide a network of potential research partnerships with their respective countries. However, it is important to ensure that regional and international funding support is available to nurture and grow these new African research partnerships going forward (e.g. African Union, SADC, NRF, etc.).

Existing waste RDI partnerships with African countries (with SA placed African students and researchers)



PARTNERSHIPS (CONTINUED)

South Africa-international waste RDI partnerships active in 2019/18

At least **11 research partnerships** in waste management, between South African research institutions and international organisations **were active in 2018/19**.

International

International research partnerships for 2018, as identified by the Waste RDI Roadmap network of academics, included South and North America, Africa, Europe and the UK. International funding to South African research institutions on waste-related research projects remains a small percentage of the current investment in waste RDI. Based on information provided by researchers (incomplete), around R1.6m (3.9%) of the R40.5m funding support for waste RDI in 2018/19, came from international funding sources (See Section on Investment). The exclusion of waste and secondary resources management as a priority research area in South African bilateral research programmes remains problematic to unlocking greater international research funding to the South African research community.

Current investment by the UK and European Governments in marine plastics research appears to be providing tangible opportunities for South Africa's research community, with a number of new marine-litter related projects identified for 2019.

In addition to direct research collaboration, the WRIU has also developed and strengthened international partnerships in 2018/19 in support of the Roadmap. These include –

South Africa – UK

The WRIU has worked closely with a number of UK-based organisations during 2018/19 on the topic of marine plastic pollution. The intention of the partnerships has been to understand how other countries are addressing this challenge through RDI, and to explore opportunities for greater research collaboration, including possible leveraged RDI funding.

South Africa – UN Environment

The WRIU has worked closely with UN Agencies during 2018/19 including the UN Environment (UNEP) and IETC on the finalisation and publication of the first Waste Management Outlook for Africa. The DST was a co-funder of the Outlook, which was launched in Pretoria, South Africa on World Environment Day, 5 June 2018.

The launch of the Outlook raised considerable media attention, profiling the challenges Africa faces with respect to waste management.

The WRIU also worked with UN Environment, as part of a team of international experts, on the Sixth Global Environment Outlook (GEO-6), which was launched at UNEA-4 in March 2019.

South Africa – IETC

Prof Godfrey, manager of the WRIU, has been invited to serve as a member of the International Advisory Board of the UN International Environmental Technology Centre (IETC). The Advisory Board was established to provide the Director of the IETC with policy and technical advice on the strategic direction and content of the programme of work of the Centre. The Board consists of international policy and technical experts covering major geographical regions.

South Africa – UNIDO

The WRIU partnered with the United Nations Industrial Development Organization (UNIDO) in 2018/19 to address the growing waste plastic problem in South Africa. A joint UNIDO/CSIR Concept Note has been submitted to the Government of Japan for consideration. The project, which is at early stages of design, aims to identify opportunities for material substitution for single-use plastic, including the assessment for local manufacturing.

Left: Dr Henry Roman (DST), Prof Linda Godfrey (CSIR), Cecilia Kinuthia-Njenga (UNEP) at the launch of the Africa Waste Management Outlook

South Africa – ISWA

The WRIU partnered with the International Solid Waste Association (ISWA) on an international research project aimed at mapping the role of women in the waste sector. This research was conducted as part of the Women-of-Waste (WOW) initiative. The results of the project were presented at the ISWA2018 Conference held in Kuala Lumpur, Malaysia in October 2018. The outcomes of the research project and the ISWA WOW session were published as –

- Godfrey, L., Jones, F., Nitzsche, G.M., Tsakona, M. and Garcés-Sánchez, G. (2018). Mapping the status of women in the global waste management sector. ISWA 2018 Conference, Kuala Lumpur, Malaysia, October 2018.
- Godfrey, L., Jamtsho, T., Khatoon, A., Linh, NTH., Nitzsche, G., Norovsambuu, A., Pradhan, M., Rucevska, I., Shekar, N., and Tsakona, M. (2018). Gender and Waste: Harsh Impacts – New Opportunities. Briefing Note, December 2018.

WASTE RDI OUTPUTS

THE IMPACT that the Waste RDI Roadmap aims to achieve is to support the improved management of waste and the increased diversion of waste away from landfill towards alternative waste treatment technologies, thereby maximising the potential environmental, social and economic benefits. In support of this goal, the Waste RDI Roadmap committed to the following research, development and innovation outputs over the next 10 years, if fully supported financially –

		Target	*Supported*[1]	*Completed*[2]
Human Capital Development	Post Docs	65	4	0
	PhDs	165	23	3
	Master's	245	36	17
Knowledge Generation	Registered patents	25	–	–
	Patent applications	70	–	–
	Publications	590	40	15
Technology Development	Products and services to market	4	–	–
	Technology packages	20	3	3
	Prototypes	60	–	–

[1] These students are at various stages of completion but have not graduated with their degrees
[2] Students who successfully completed their degrees may also be counted under "supported"

A total of 63 Honours, Masters, PhD and Post-doc students were supported in 2018/19 under the WRIU, 5 students through scholarships, 36 students through grant projects, and 22 students through SARChI Chairs (and associated funding, excluding the 4 grant funded students).

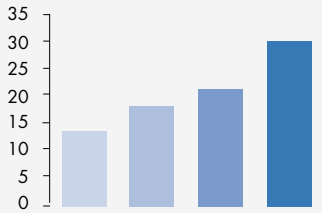
A total of 29 students have to date, successfully completed their degrees, four (4) through scholarships and 25 through grant projects. This includes 9 Honours, 17 Masters students and 3 PhD students, funded via Roadmap grants and scholarships.

These figures exclude students funded through other funding mechanisms, such as the NRF *(unavailable)* or industry *(unavailable)*.

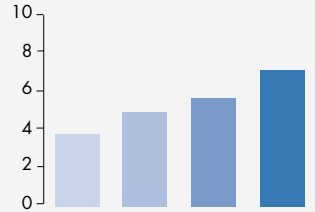
Other key indicators of impact include: increased investment in waste RDI *(See Section on Investment)*, and increased waste RDI collaboration between the South African research community and the private waste and secondary resources sector.

Trends

Committed funding (new and ongoing RDI grants) (Rm) (2015-2018)

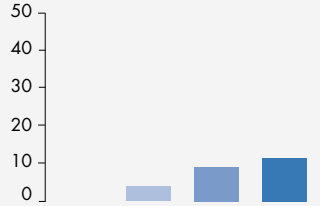


Annual investment in RDI grants (Rm) (2015-2018)

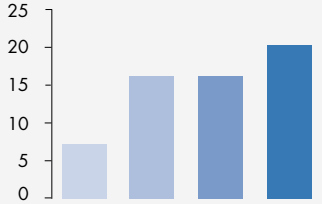


Grant-funded students supported (2015-2018)

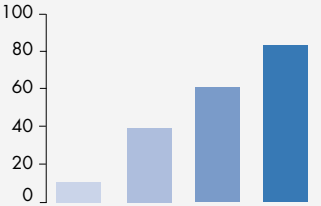
Grant-funded students completed (2015-2018)



Number of RDI grants funded (2015-2018)



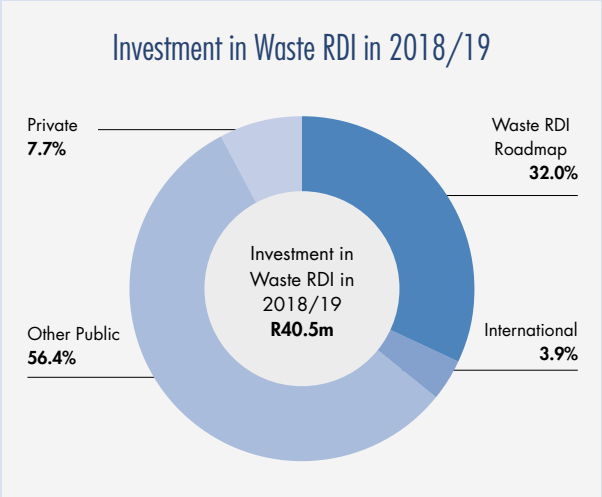
Grant-funded researchers supported (2015-2018)



INVESTMENT IN WASTE RDI IN SOUTH AFRICA

As reported in previous years, there remains no single mechanism (information system) to extract data on the investment being made in waste RDI in the South African national system of innovation (NSI). As such, the following information on Waste RDI Investment for 2018/19 was collected by means of a questionnaire sent to researchers working in public research institutions in South Africa. Therefore, the data reported here is susceptible to weaknesses in reporting by researchers. The financial figures presented here should be seen as a minimum spend, with a high degree of uncertainty.

It is estimated that at least R40.5 million was invested in Waste RDI in South Africa in 2018/19. This remains within the region of previous years and does not reflect any significant increase in public and private sector investment in waste research. As with previous years, other public sector funding remains the major source of investment in waste RDI (above 50%), followed by investment made directly through the Waste RDI Roadmap, which for 2018/19 was recorded at 32.0%. International funding and private sector funding remain below what is expected.



FINANCIAL STATEMENT

The 2018/19 financial investment in the Waste RDI Roadmap was significantly up from the 2017/18 investment, thanks to increased funding from the DST. However, the funding still remains significantly below that outlined in the Waste RDI Roadmap. This has a direct bearing on the extent and magnitude of activities of the Roadmap.

All financial figures are exclusive of VAT.

REVENUE	2018/19	2017/18
DST seed funding	26 027 048.30	15 002 178.47
Other revenue	395 000.00	80 000.00
Total Revenue	**26 422 048.30**	**15 082 178.47**
EXPENSES		
Communications	69 317.82	23 800.00
CSIR Project Management Unit	2 383 690.07	1 617 256.82
Non-recoverable innovation grants	0.00	0.00
Non-recoverable R&D grants	7 003 067.67	5 574 390.38
Targeted RDI projects	0.00	0.00
Post-graduate scholarships	34 731.32	0.00
SARChI Research Chairs	3 360 000.00	0.00
Traveling	108 241.42	92 322.39
Workshops and general running	0.00	0.00
Total Expenses	**12 959 048.30**	**7 307 769.59**
Income for continuing operations [1]	**13 463 000.00**	**7 774 408.88**
Net Income	**0.00**	**0.00**

Notes to financial statement:

(1) Income for continuing operations is committed funding for grant projects awarded in 2015-2018, for which disbursements will be made in the 2019/20 financial year.

THE OUTLOOK FOR 2019/20

A review of the activities of 2018/19 suggests increased interest and activity in waste research, development and innovation in South Africa. This may be due to increased policy/legislative activity as well as increased citizen and business concern regarding certain waste issues. Despite the reasons, this is encouraging for increased investment and impact from the South African research community.

The focus for the coming financial year, 2019/20 therefore remains firmly on –

- Closely monitoring currently funded post-graduate studies and research projects to ensure maximum impact through this first phase of investment.
- Increasing national activity in waste RDI through industry and government partnerships
- Ensuring that investments in waste RDI are strategic, and research outputs are relevant, thereby increasing impact and supporting uptake by local and regional partners
- Continuing science advocacy role in supporting capacity development, raised profile of South Africa's waste RDI, an increased RDI collaboration
- Strengthening the investment in local waste RDI through, among others, country-to-country bilateral agreements and industry partnerships
- Ongoing support for the two SARChI Research Chairs

In addition, the following new activities are planned –

- A new Open RDI Grant call to be launched mid-2019
- A science review of marine plastic pollution in South Africa
- A study on the feasibility of establishing a Waste Technology and Innovation Centre in South Africa

As the Waste RDI Roadmap enters its 5th year of implementation, our sights remain firmly on achieving the vision and mission of the 10-year Waste RDI Roadmap and the anticipated RDI outputs.

ANNEXURES

ANNEXURE 1: **SUMMARY OF COMPLETED WASTE RDI ROADMAP RESEARCH PROJECTS**

Beneficiation of forestry biomass waste streams

PROJECT INFORMATION
Waste Roadmap Instrument: Open Grant Call
Grant number: CSIR/IU/WRIU/2016/003
Lead Institution: CSIR
Project Leader: Prof B Sithole
Research budget: R2 870 434.00
Co-investment: CSIR Thematic Funding
Project timeframe: 1 April 2016 – 31 March 2019

The overarching aim of this research project was to beneficiate biomass processing waste streams or by-products of the forestry, timber, pulp and paper (FTPP) sector into high-value products. This would result in these waste products being diverted from landfills, thus resulting in both economic gains and minimised environmental footprint for the industry. Within this framework, the study aimed to investigate and modify existing technologies or develop new technologies to fractionate South African saw dust and sludge into its individual components such as lignin, cellulose, hemicellulose and extractives via chemical means. These chemical components can then be used as a valuable raw material resource for beneficiation into a range of biochemicals and biomaterials.

Through a literature survey and in-house review, the project team identified 129 pathways involving chemical, thermochemical, biological and mechanical processing from seven types of waste and residues from the FTPP industry – sawdust & offcuts, bark, leaves, sludge, black liquor, dregs and ash. The various processing pathways and associated technologies were assessed in terms of technology readiness level (TRL) and market potential.

Established commercial technologies have guaranteed performance and could be implemented with little technology risk. They are hampered by not being cost-competitive with alternatives currently on the market or having low user/consumer preference.

Valorisation of waste chicken feathers

PROJECT INFORMATION
Waste Roadmap Instrument: Open Grant Call
Grant number: CSIR/IU/WRIU/2016/004
Lead Institution: CSIR
Project Leader: Prof B Sithole
Research budget: R1 851 818.00
Co-investment: CSIR Thematic Funding
Project timeframe: 1 April 2016 – 31 March 2019

Several different approaches have been used for disposing of waste chicken feathers, including landfilling and incineration. An alternative to reduce these environmentally unfavourable disposal options is the utilization of feather constituents as animal feed. Traditional methods to degrade feathers for subsequent use as animal feed include alkali hydrolysis and cooking under steam pressure. These methods are problematic in that they not only destroy the amino acids (methionine, lysine and histidine) in the feathers but also consume large amounts of energy. A closer look at the structure and composition of feathers shows that the whole part of a chicken feather (quill and fibre) can be used as a source of a pure structural protein called keratin which can be exploited for conversion into a number of high-value bio products.

Biofilms were successfully produced from starch and keratin obtained from waste avocado seeds and waste chicken feathers respectively. These biofilms could be used: in the food packaging industry (as a cost-effective and environmental alternative source of raw material to the commonly used packaging materials; in wound dressings; in the fashion industry (as artificial lens and breast implants); in biomedical applications, e.g. artificial skin replacement; and in the pharmaceutical industry (as drug delivery and transdermal drug delivery systems). Non-existence of breakthrough keratin-based biomaterial in the clinical applications shows innovative opportunities for further investigation of keratin biomaterials, including chicken feather keratin-based biomaterials. Chicken feather fibres could be used to eliminate fluff pulp/SAPs (super absorbent paper) nonwoven sheets in the manufacture of disposable diapers to reduce environmental pollution.

All project deliverables are available for download from the Waste RDI Roadmap website: **http://wasteroadmap.co.za**

ANNEXURE 1: **SUMMARY OF COMPLETED WASTE RDI ROADMAP RESEARCH PROJECTS**

Sustainable utilization of post-harvest waste

PROJECT INFORMATION

Waste Roadmap Instrument: Open Grant Call
Grant number: CSIR/IU/WRIU/2016/005
Lead Institution: CSIR
Project Leader: Dr M John
Research budget: R1 391 679.00
Co-investment: CSIR Thematic Funding
Project timeframe: 1 April 2016 – 31 March 2019

The disposal of biomass waste in an economically and environmentally acceptable manner is a critical issue facing modern industries. This is mainly due to increased difficulties in locating disposal works and complying with even more stringent environmental quality requirements imposed by waste management and disposal legislations. The waste streams generated by the agricultural biomass processing sectors are composed of valuable materials that can potentially be utilised as a raw material feedstock to produce high-value products. The specific aim of this project is to develop value added materials from agricultural waste residues (maize stalks and sugarcane bagasse) that are abundantly available in South Africa. This is to replace petroleum based non-biodegradable materials that pose serious environmental problems due to landfill.

In this project, agricultural residues (maize stalks and sugarcane bagasse) were fractionated to obtain cellulose, lignin and hemicellulose fractions. Lignin and xylan fractions were extracted from corn stover residues and bagasse by the process of alkaline extraction. The extracted xylan and lignin fractions were subjected to compositional analysis and FTIR studies. The lignin and hemicellulose fractions were converted to biocomposite products.

Value recovery from solid confectionary waste

PROJECT INFORMATION

Waste Roadmap Instrument: Open Grant Call
Grant number: CSIR/IU/WRIU/2016/006
Lead Institution: University of Cape Town
Project Leader: Prof S Harrison
Research budget: R1 533 455.00
Co-investment: NRF
Project timeframe: 1 April 2016 – 31 March 2019

The aim of this research was to examine the confectionary industry and assess the scale of confectionary waste available in South Africa. Investigate the composition of the confectionary waste to that required for use in the bioprocess. Examine the potential of using the biorefinery concept to add value to confectionary waste by its bioconversion to a range of products. Finally, to undertake a techno-economic evaluation of the production of value added products from the waste sources, according to the proposed process flowsheets.

In the confectionery industry, three types of waste can be identified: sugar-based, chocolate-based and starch-based. South Africa produces over 300 000 tonnes per year of sugar-based confectionery which is estimated to result in nearly 30 000 tonnes of waste – and that is before counting chocolate- and starch-based waste.

The experimental studies demonstrated that all these products can be made from confectionery waste – a purple pigment, Polyhydroxyalkanoates (PHA), Poly-γ-glutamate (PGA), bioethanol and biogas. Each has been shown to work at proof of concept and requires optimisation of process performance. Early-stage techno-economic studies of the PHA and PGA processes show that these have economic potential.

All project deliverables are available for download from the Waste RDI Roadmap website: **http://wasteroadmap.co.za**

ANNEXURE 1: **SUMMARY OF COMPLETED WASTE RDI ROADMAP RESEARCH PROJECTS**

Reactor design for industrial furfural production

PROJECT INFORMATION

Waste Roadmap Instrument: Open Grant Call
Grant number: CSIR/IU/WRIU/2016/007
Lead Institution: Stellenbosch University
Project Leader: Prof J Görgens
Research budget: R533 531.00
Co-investment: –
Project timeframe: 1 April 2016 – 31 March 2019

The production of the platform chemical furfural from the pentose-content of lignocellulosic biomass (such as the pentose-rich agricultural wastes from the sugar cane industry) is a well-known renewable and thus sustainable alternative for the production of compounds otherwise derived from fossil-based resources. Furfural is a versatile platform chemical that is used e.g. as a pesticide, a fuel additive, the production of resins, among others. The targeted feedstock in this project will be agricultural residues from the sugar industry, which consists mainly of two streams of lignocellulosic wastes, i.e. the sugarcane harvest residues at the farmers and the bagasse at the sugar mill. The main aim of this research project was to optimise the reactor design for furfural production from polysaccharidic material (xylan or agricultural residues) at industrially relevant conditions (specifically substrate loading).

Kinetic study of xylan and xylose conversion to furfural was conducted and separate kinetic models were developed to interpret the experimental results. The kinetic study demonstrated that only temperature and acid concentration contribute to conversion processes significantly. The comparison of the kinetic behaviour of xylan and xylose to furfural resulted in fundamental knowledge, which can be useful for the industry dealing with furfural production. Furthermore, furfural degradation was investigated in the absence of sugar (xylose) to generate an industrially relevant understanding of the contribution of resinification and fragmentation to furfural degradation. Degradation reactions result in Humin formation which can be combusted to produce 1.3% of the energy required for steam generation in the furfural production process.

Extraction of value from solid waste by pyrolysis

PROJECT INFORMATION

Waste Roadmap Instrument: Open Grant Call
Grant number: CSIR/IU/WRIU/2016/011
Lead Institution: Stellenbosch University
Project Leader: Prof J Görgens
Research budget: R1 865 442.00
Co-investment: Mpact, PlasticsSA, PAMSA, THRIP
Project timeframe: 1 April 2016 – 31 March 2019

Several pyrolysis studies conducted at laboratory scale, for valourisation of various types of wastes, have resulted in promising outcomes. The goal of this project was to confirm the potential of pyrolysis at pilot scale and optimise the conversion of industrial processes.

The conversion of Polypropylene (PP) into liquid fuels under atmospheric and vacuum conditions were both promising. Nonetheless, vacuum pyrolysis showed greater potential in the conversion of energy stored in waste PP into liquid fuels. Also, it was inferred that condensable products recovered under vacuum conditions contained fewer aromatic compounds (with more paraffinic compounds) because of their prevalent diesel composition. This means these products possess better combustion characteristics than corresponding products obtained under atmospheric conditions, which were mostly dominated by aromatics (due to their dominant gasoline composition). Condensable products recovered under atmospheric and vacuum conditions will therefore be much suited for applications in gasoline (petrol) and diesel engines respectively, although further treatments such as distillation to obtain pure products will be required. The experimental results with PP were also compared to similar results obtained with polystyrene and multilayer plastic wastes. An economic assessment was done to determine the minimum fuel selling price (MFSP) of the oil obtained from these 3 different waste plastics.

All project deliverables are available for download from the Waste RDI Roadmap website: **http://wasteroadmap.co.za**

ANNEXURE 1: **SUMMARY OF COMPLETED WASTE RDI ROADMAP RESEARCH PROJECTS**

Recycling rare earth elements from fluorescent lamps

PROJECT INFORMATION
Waste Roadmap Instrument: Open Grant Call
Grant number: CSIR/IU/WRIU/2016/012
Lead Institution: Stellenbosch University
Project Leader: Prof C Dorfling
Research budget: R416 918.00
Co-investment: –
Project timeframe: 30 January 2017 – 31 March 2019

The aim of this research project was to investigate the recovery of rare earth elements (REEs) from phosphor powder recovered from end-of-life fluorescent lamps using a hydrometallurgical process route. A multiple leaching stage approach was tested for metal dissolution, where after solvent extraction tests were performed for metal recovery from the pregnant leach solutions. The proposed process yields Y_2O_3 and mixed rare earth oxide (Y_2O_3, Eu_2O_3, Tb_2O_3, CeO_2) product streams at an overall REE recovery exceeding 90%.

REEs are strategically important resources given their widespread use in manufacturing of high technology equipment and consumer goods. Recovery of REEs from secondary resources will play an integral part in the REEs market. Manufacturers of fluorescent lamps consume a large portion of the world's Europium (Eu), Terbium (Tb) and Yttrium (Y) production; recycling of these lamps is important to maintain economic balance, and creates the opportunity for local production of REEs and its associated products. South African lamp recyclers focus on dismantling and physical separation of the different components, but very limited processing capacity exists for complete value recovery from the phosphor powders. This project identified technologies / processes potentially suitable for metal recovery from fluorescent lamp phosphors, and experimentally evaluated the performance of the respective unit operations in an integrated manner; a conceptual flow sheet yielding various rare earth oxide product streams at an overall recovery exceeding 90% was proposed.

Lithium ion battery (LIB) recycling process

PROJECT INFORMATION
Waste Roadmap Instrument: Open Grant Call
Grant number: CSIR/IU/WRIU/2017/014
Lead Institution: Stellenbosch University
Project Leader: Dr G Akdogan
Research budget: R404 497.00
Co-investment: –
Project timeframe: 30 January 2017 – 31 March 2019

In general, spent lithium ion batteries (LIBs) are discarded as domestic waste. In landfills, heavy metals from the LIBs have the potential to leach slowly into soil, groundwater or surface water.

The main aim of this research project was to evaluate the technical feasibility of using organic acids as lixiviants for Co, Li and Ni recovery from end-of-life lithium-ion batteries (LIBs) and to recover the metals from the resulting pregnant leach solution (PLS). Batch leaching tests to investigate the effects of H_2O_2 addition, temperature and acid concentration on metal dissolution were performed using citric acid and DL-malic acid.

Leaching results suggest that organic acids can possibly substitute inorganic acids as environmentally friendly lixiviants. Following leaching solvent extraction and precipitation tests were performed for metal recovery from the pregnant leach solutions. The proposed process involves Mn and Al extraction from PLS using D2EHPA, followed by phosphate precipitation at 50°C targeting Co and Ni and subsequent phosphate precipitation at 80°C for Li recovery. The process yields three products: a 93% pure Mn product, a Co-Ni product with 42 wt. % Co and 57 wt. % Ni and a Li product with 89 wt. % Li. The results highlighted key fundamental and technical aspects of the Li-Co-Ni-Mn recovery process that require further investigation especially in challenging recovery-cost paradigm with solvent extraction and precipitation processes.

All project deliverables are available for download from the Waste RDI Roadmap website: **http://wasteroadmap.co.za**

ANNEXURE 1: **SUMMARY OF COMPLETED WASTE RDI ROADMAP RESEARCH PROJECTS**

PCB leach residue as reductant

PROJECT INFORMATION

Waste Roadmap Instrument: Open Grant Call
Grant number: CSIR/IU/WRIU/2017/016
Lead Institution: Stellenbosch University
Project Leader: Dr G Akdogan
Research budget: R446 727.00
Co-investment: –
Project timeframe: 30 January 2017 – 31 March 2019

Electrical and electronic equipment (EEE) manufacturing is one of the fastest growing global sectors. The proliferation of technology and remarkable market growth of EEE has shortened the lifespan resulting in the increase of e-waste. Electronic waste without the intent of reuse reached 49.8 million tonnes in 2018, with an annual growth rate of four to five percent. As a result of the high content of heavy metals and toxic flame retardants, disposal of electronic waste via landfilling is deleterious to the environment.

This project aimed to determine the technical feasibility of using the non-metallic fraction of printed circuit board (PCB) residue recovered after leaching of valuable metals as a supplementary reducing agent in ferrous and ferroalloy industries and quantify the potential advantages and disadvantages associated with its potential use in smelting operations. Thermodynamic simulations of chromite smelting and solid state pre-reduction of hematite revealed that PCB can be used partially to replace conventional reducing agents. From chromite smelting simulations, there was a decrease in the energy required for reduction as the weight percent of the PCB in the blend increased. In light of overall results, the optimum mass percent of PCB in the blend appeared to be around 20% with an energy savings of 200 kWh/t of ore. Furthermore, solid state pre-reduction tests with hematite showed that blends of PCB-carbon acted as better reductant than pure carbon due to the presence of hydrocarbons in the PCB.

Techno-economic feasibility of PET waste to MOFs

PROJECT INFORMATION

Waste Roadmap Instrument: Open Grant Call
Grant number: CSIR/IU/WRIU/2018/018
Lead Institution: CSIR
Project Leader: Dr J Ren
Research budget: R531 000.00
Co-investment: CSIR Thematic Funding
Project timeframe: 1 May 2018 – 31 March 2019

Polyethylene terephthalate (PET), as a dominant plastic packaging material, has impacted our lives since the 1960s with the global consumption reaching over 24 million tons per year. The disposal of waste PET has led to serious environmental problems.

This research project focused on the recovery of new, high-value products from coloured PET bottles and food trays, as they have been identified as a problematic fraction from the current waste PET recycling industry in South Africa. A process model was developed to cover the mass balance, which considered material flows, chemical build-up and energy requirements. The process would produce saleable metal-organic framework (MOF) products for the South African market. The analysis of economic appraisal and commercial viability showed that investing in MOFs will generate roughly a 5% Internal Rate of Return (IRR) on a production capacity of 10kg daily.

Given the fact that these results are positive at a small-scale, it is recommended that this investment should proceed. The environmental and opportunity cost that is avoided has not been considered in the financial analysis. This can further strengthen the revenue side of this production. While a return of 5% is not the most attractive, the PET waste that would be redirected to this production contributes to the South African waste management strategy and climate change objectives. In addition, since the South African government bond of 10 years yields a return of 8.52% return, this initiative is competitive with a 5% IRR.

All project deliverables are available for download from the Waste RDI Roadmap website: **http://wasteroadmap.co.za**

ANNEXURE 2: **SELECTED WASTE RDI ROADMAP DELIVERABLES PUBLISHED IN 2018/19**

Grant /001: M Samson (Wits)

Pholoto, L. (2018). *Theorizing the relations between space and waste: Residents' insights on recycling practices and waste pickers in Vaalpark, Sasolburg*. Masters dissertation. Johannesburg: University of Witwatersrand.

Dladla, N. (2018). *The Construct of State Practices: Excavating municipal relationships with waste pickers, the case of the City of Johannesburg*. Masters dissertation. Johannesburg: University of Witwatersrand.

Guya, M.J (2019). *Local state practices of informal waste picker integration: The case of Metsimaholo Local Municipality, Sasolburg*. Masters dissertation. Johannesburg: University of Witwatersrand.

Grant /003: B Sithole (CSIR)

Gibril, M.E., Lekha, P., Andrew, J., Sithole, B., Tesfaye, R. and Ramjugernath, D. (2018). Beneficiation of pulp and paper mill sludge: production and characterisation of functionalised crystalline nanocellulose. *Clean Technologies and Environmental Policy*, 20:1835-1845. doi.org/10.1007/s10098-018-1578-3

Gibril, M., Lekha, P., Andrew, J. and Sithole, B (2018). *Preparation of transparent nanocomposites using cellulose nanocrystals derived from dissolving wood pulp and mill sludge*. 3rd International Conference on Composites, Biocomposites and Nanocomposites (ICCBN), 7-9 November 2018, Port Elizabeth, South Africa.

Sithole, B. and Lekha, P. (2018). *Production of biogas from mill sludge using anaerobic digestion*. Royal Society-SIN workshop, 1-3 March 2018, Nairobi Kenya.

Stafford, W., De Lange, W., Nahman, A., Chunilall, V., Lekha, P., Andrew, J., Johakimu, J., Tesfay, T., Sithole, B. and Trotter, D. (2019). *Opportunities for new Biorefinery products from Forestry, Timber, Pulp & Paper wastes: An assessment of technology readiness and market potential*. CSIR Technical Report CSIR/NRE/GES/IR/2018/0091/A.

Grant /004: B Sithole (CSIR)

Tesfaye, T., Sithole, B., Ramjugernath, D. and Ndlela, L. (2018). Optimisation of surfactant decontamination and pre-treatment of waste chicken feathers by using response surface methodology. *Waste Management*, 72: 371-388. doi.org/10.1016/j.wasman.2017.11.013

Tesfaye, T., Sithole, B., Ramjugernath, D. Mokhothu, T. (2018). Valorisation of chicken feathers: Characterisation of thermal, mechanical and electrical properties. *Sustainable Chemistry and Pharmacy*, 9: 27-34

Tesfaye, T., Sithole, B. and Ramjugernath, D. (2018). Preparation, characterization and application of keratin based green biofilms from waste chicken feathers. *Int J Chem Sci.*, 16(3): 281-295. doi.org/10.21767/0972-768X.1000281

Tesfaye, T., Sithole, B. and Ramjugernath, D. (2018). Valorisation of Waste Chicken Feathers: Green Oil Sorbent. *Int J Chem Sci.*, 16(3): 282-294. doi.org/10.21767/0972-768X.1000282

Khumalo, M., Tesfaye, T., Sithole, B. and Ramjugernath, D. (2018). Possible Beneficiation of Waste Chicken Feathers Via Conversion into Biomedical Applications. *Int J Chem Sci.*, 17(1): 298-317. doi.org/ 10.21767/0972-768X.1000298

Tesfaye, T., Chunilall, V., Sithole, B. and Ramjugernath, D. (2019). Identification of Waste Chicken Feathers Degradation Products using Pyrolysis Gas Chromatography/Mass Spectrometry. *Int J Chem Sci*,17(1): 304-314. doi.org/10.21767/0972-768X.1000304

Kakonke, M. (2019). *Valorization of chicken feathers: Production of superabsorbant fabrics via nonwoven technology*. Masters dissertation. Durban: University of KwaZulu-Natal.

Kakonke, G. (2018). *A review of production and properties of nonwoven superabsorbent core fabrics used in disposable diapers and feminine hygiene products*. 3rd International Conference on Composites, Biocomposites and Nanocomposites (ICCBN), 7-9 November 2018, Port Elizabeth, South Africa.

Khumalo, M. (2018). *Possible beneficiation of waste chicken feathers via conversion into biomedical applications*. 3rd International Conference on Composites, Biocomposites and Nanocomposites (ICCBN), 7-9 November 2018, Port Elizabeth, South Africa.

Fagbemi, O., Tesfaye, T., Sithole, B. and Ramjugernath, D. (2018). *Valorisation of waste chicken feathers: Utilisation as a binder in the forest products industry*. 3rd International Conference on Composites, Biocomposites and Nanocomposites (ICCBN), 7-9 November 2018, Port Elizabeth, South Africa.

Grant /005: M John (CSIR)

John, M., Mtibe, A. and Naidu, D. (2018). *Sustainable materials and technologies from biomass resources*. 3rd International Conference on Composites, Biocomposites and Nanocomposites (ICCBN), 7-9 November 2018, Port Elizabeth, South Africa.

Naidu, D. (2018). *Films for food packaging based on xylan from agricultural waste residues*. 3rd International Conference on Composites, Biocomposites and Nanocomposites (ICCBN), 7-9 November 2018, Port Elizabeth, South Africa.

Grant /007: J Görgens (SUN)

Lamptey, I. (2019). *Comparative kinetic analysis of furfural production from xylan and xylose*. Masters dissertation. Stellenbosch: University of Stellenbosch.

Grant /011: J Görgens (SUN)

Parku, G. (2019). *Pyrolysis of waste polypropylene plastics for energy recovery: Investigation of operating parameters and process development at pilot scale*. Masters dissertation. Stellenbosch: University of Stellenbosch.

ANNEXURE 2: **SELECTED WASTE RDI ROADMAP DELIVERABLES PUBLISHED IN 2018/19**

Grant /012: C Dorfling (SUN)

Bumhira, L. (2019). *Recovery of rare earth elements from fluorescent lamp phosphors*. Masters dissertation. Stellenbosch: University of Stellenbosch.

Bumhira, L., Dorfling, C. and Akdogan, G. (2018). *Leaching rare earth elements from phosphors recovered from end-of-life fluorescent lamps*. Hi-Tech Metals '18 Conference, 22-23 November 2018, Cape Town, South Africa.

Grant /013: S Harrison (UCT)

Edward, C.J., Pather, T., Govender, R., Ngoma, E., Govender-Opitz, E., Kotsiopoulos, A. and Harrison, S. (2018). *Determination of ferrous oxidation kinetics in the presence of metals associated with printed circuit boards to determine the potential for bioleaching of e-waste*. Biohydrometallurgy '18 Conference, 12-13 June 2018, Windhoek, Namibia.

Mabuka, T. (2018). *Metal recovery subsequent to e-waste bioprocessing using biological matrices*. 24th WasteCon Conference, 15-19 October 2018, Johannesburg, South Africa.

Grant /014: G Akdogan (SUN)

Musariri, B. (2019). Development of an environmentally friendly lithium-ion battery recycling process. Masters dissertation. Stellenbosch: University of Stellenbosch.

Musariri, B., Akdogan, G. and Dorfling, C. (2018) *Evaluating organic acids as alternative leaching reagents for metal recovery from lithium ion batteries*. Hi-Tech Metals '18 Conference, 22-23 November 2018, Cape Town, South Africa.

Musariri, B. (2018). *Development of an environmentally friendly metal extraction process from lithium-ion batteries*. 24th WasteCon Conference, 15-19 October 2018, Johannesburg, South Africa.

Grant /016: G Akdogan (SUN)

Attah-Kyei, D. (2019). *Investigating the use of printed circuit board leach residue as reductant in pyrometallurgical operations*. Masters dissertation. Stellenbosch: University of Stellenbosch.

Attah-Kyei, D. (2018). *Printed circuit board leach residue as a reductant for pyrometallurgical operation*. 24th WasteCon Conference, 15-19 October 2018, Johannesburg, South Africa.

Grant /018: J Ren (SUN)

Ren, J., Musyoka, N., Dyosiba, X., and Semelane, S. (2019). *Techno-economic feasibility assessment on the viability of using waste PET (trays and coloured bottles) to produce metal-organic framework (MOFs)*. CSIR Report. Pretoria: CSIR.

ANNEXURE 3: **WASTE RDI ROADMAP SCHOLARSHIPS (ONGOING AND COMPLETED)**

No	Applicant	Title	Aligned with priority waste	Aligned with cluster	University	Supervisor	Funding instrument	Year awarded
1	**Mr JP du Toit**	Hydrogen bioproduction from waste glycerol by Rhodopseudomonas palustris immobilized in a transparent PVA cryogel	Organic waste	Technology solutions	SUN	Dr R Pott	Upgraded from Masters to PhD	2016-2017
6	**Ms S Candiotes**	Gauteng households' definition of food waste as well as their attribution of blame along the South Africa food chain	Organic waste	Waste & Society	UP	Dr N Marx-Pienaar	Master's scholarship	2017-2018
7	**Mr A Gada**	Development of eco-compatible bio-composites from recycled post-consumer plastic and agricultural biomass	Organic waste	Technology solutions	NMMU	Dr S Muniyasamy	Master's scholarship	2017-2018
8	**Mr D Maluleke**	Bioleaching as a unit operation for the recovery of copper and other metal of value from WEEE	WEEE	Technology solutions	UCT	Prof S Harrison	Doctoral scholarship	2017-2018
9	**Mr S Matebese**	Assessing the integration of sustainable waste management principles in dealing with illegal dumping in informal settlements	Municipal waste	Waste & Society	CPUT	V Zungu	Master's scholarship	2017-2018
1	**Mr R Nchabereng**	The recovery of gold from waste mobile phones printed circuit boards (PCBs) using thiosulphate leaching and copper cementation process	WEEE	Technology solutions	CPUT	Mr M Aziz	Master's scholarship	Graduated
2	**Ms M Nider-Heitmann**	Techno-economic analysis and comparison of biorefinery scenarios for the production of succinic acid, itaconic acid and polyhydroxyalkanoates from sugarcane waste	Organic waste	Modelling and analytics	SUN	Prof J Görgens	PhD scholarship	Graduated
3	**Mr G Potgieter**	Base metal recovery from glycine leach solutions using Ion exchange and solvent extraction	WEEE	Technology solutions	SUN	Dr C Dorfling	Master's scholarship	Graduated
4	**Mr S Thakur**	NGOs and household solid waste management: Assessing the project sustainability of solid waste management practices in Peri-urban areas	Municipal waste	Strategic planning	UKZN	Dr M Hansen and Dr A Nel	Master's scholarship	Graduated

ANNEXURE 4: **WASTE RDI ROADMAP GRANT PROJECTS (ONGOING AND COMPLETED)**

No	Applicant	Title	Aligned with priority waste	Aligned with cluster	Principal Investigator	Funding instrument	Funding term
2016_1	**University of the Witwatersrand**	Lessons from waste picker integration initiatives – Development of evidence based guidelines to integrate waste pickers into South African Municipal Waste Management Systems	MSW	Waste & Society	Dr M Samson	Non-recoverable open R&D grant	4/2016 - 9/2019
2017_8	**Stellenbosch University**	Biogas and volatile fatty acids biorefinery by co-digestion of fruit juice industry solid and liquid wastes with lignocellulosic biomass	Organic	Technology solutions	Prof J Görgens	Non-recoverable open R&D grant	4/2016 - 6/2018
2016_9	**Stellenbosch University**	Organic waste: a bioresource for production of novel cellulose nanocomposites	Organic	Technology solutions	Dr A Chimphango	Non-recoverable open R&D grant	4/2016 - 3/2020
2017_13	**University of Cape Town**	Integrated process flowsheet for the sequential extraction and recovery of valuable metals from WEEE	WEEE	Technology solutions	Prof S Harrison	Non-recoverable open R&D grant	1/2017 - 3/2020
2017_15	**Stellenbosch University**	Thermal treatment of printed circuit board waste and its effect on downstream metal recovery processes	WEEE	Technology solutions	Prof C Dorfling	Non-recoverable open R&D grant	1/2017 - 3/2020
2018_17	**CSIR**	Increasing reliable, scientific data and information of food losses and waste in South Africa	Organic	Strategic Planning	Dr S Oelofse	Non-recoverable targeted grant	4/2018 - 3/2021
2018_19	**UWC**	Understanding societal behaviour in order to reduce and divert waste going to landfills	MSW	Waste & Society	Prof C Schenck	Non-recoverable open R&D grant	1/2019 - 12/2021
2018_20	**CSIR**	Incentives for municipalities to divert waste from landfill in South Africa	MSW	Strategic Planning	Mr A Nahman	Non-recoverable open R&D grant	1/2019 - 3/2021
2018_21	**CSIR**	The use of plastic waste in road construction in South Africa	Plastic	Technology solutions	Mr G Mturi	Non-recoverable targeted grant	3/2019 - 5/2020
2018_22	**CSIR**	Informing decisions on single-use plastic carrier bags in South Africa: Evidence from a life cycle sustainability assessment	Plastic	Modelling & Analytics	Mr A Nahman	Non-recoverable targeted grant	3/2019 - 3/2020

ANNEXURE 4: **COMPLETED GRANT PROJECTS**

No	Applicant	Title	Aligned with priority waste	Aligned with cluster	Principal Investigator	Funding instrument	Funding term
2016_2	**CSIR (NRE)**	A Decision Support Tool for Implementing Municipal Waste Separation at Source: Incorporating Socio-economic and Environmental Impacts	MSW	Modelling & Analytics	Mr A Nahman	Non-recoverable open R&D grant	4/2016 - 3/2018
2016_3	**CSIR (NRE)**	Beneficiation of forestry biomass waste streams	Organic	Technology solutions	Dr B Sithole	Non-recoverable open R&D grant	4/2016 - 3/2019
2016_4	**CSIR (NRE)**	Valorisation of chicken feathers	Organic	Technology solutions	Dr B Sithole	Non-recoverable open R&D grant	4/2016 - 3/2019
2016_5	**CSIR (MSM)**	Sustainable utilization and conversion of post-harvest agricultural waste residues into value added materials	Organic	Technology solutions	Dr M John	Non-recoverable open R&D grant	4/2016 - 3/2019
2016_6	**University of Cape Town**	Value recovery from solid confectionary waste	Organic	Technology solutions	Prof S Harrison	Non-recoverable open R&D grant	4/2016 - 3/2019
2016_7	**Stellenbosch University**	Reactor design for industrial furfural production from sugar cane agricultural residues	Organic	Technology solutions	Prof J Görgens	Non-recoverable open R&D grant	4/2016 - 3/2018
2016_10	**Stellenbosch University**	Amino acid leaching of metals from printed circuit board waste	WEEE	Technology solutions	Prof C Dorfling	Non-recoverable open R&D grant	4/2016 - 3/2018
2016_11	**Stellenbosch University**	Extraction of value from solid waste by pyrolysis conversion: Pilot scale optimisation	Plastics	Technology solutions	Prof J Görgens	Non-recoverable open innovation grant	4/2016 - 3/2018
2017_12	**Stellenbosch University**	Recycling rare earth elements from fluorescent lamps	WEEE	Technology solutions	Prof C Dorfling	Non-recoverable open R&D grant	1/2017 - 3/2019
2017_14	**Stellenbosch University**	Environmentally friendly lithium ion battery (LIB) recycling process	WEEE	Technology solutions	Dr G Akdogan	Non-recoverable open R&D grant	1/2017 - 3/2019
2017_16	**Stellenbosch University**	Use of PCB leach residue as reductant in pyrometallurgical operations	WEEE	Technology solutions	Dr G Akdogan	Non-recoverable open R&D grant	1/2017 - 3/2019
2018_18	**CSIR**	Techno-economic feasibility assessment on the viability of using waste PET to produce MOFs	Plastic	Technology solutions	Dr J Ren	Non-recoverable targeted grant	5/2018 - 3/2019

July 2019

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