Waste RDI Roadmap: Human Capital Development Track and Trace Study

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EXECUTIVE SUMMARY

South Africa's waste management challenges intersect with the country's broader socioeconomic issues of inequality, poverty, and unemployment, creating an opportunity to develop strategic skills initiatives for the waste sector. To address critical skills shortages in this sector, the Council for Scientific and Industrial Research (CSIR), with support from the Department of Science and Innovation (DSI), implemented the Waste RDI Roadmap Human Capital Development (HCD) Programme. Through funding postgraduate education and internships, this programme aims to enhance the sector's capacity to promote environmental sustainability while contributing to employment creation and economic growth. This evaluation report presents findings from a tracer study assessing the program's effectiveness and impact.

Conceptual Framework Underpinning the Study

The study employed the school-to-work transitions (STWTs) framework (Nilson, 2019) to understand how graduates move from education into employment. This framework acknowledges that modern career paths are rarely linear and are shaped by multiple interacting factors, namely:

- *Individual characteristics* (e.g., academic ability, gender, race/ethnicity and family background) significantly influence post-qualification outcomes in South Africa's divided education system.
- *Institutional factors* encompass the role of educational institutions and their relative standing and acknowledge that graduates from different institutions face varying employment prospects due to historical inequalities and employer perceptions.
- *Labour market context* considering broader economic conditions, sector-specific dynamics, and active labour market policies.

These dimensions are significant in South Africa, where high unemployment and historical inequalities persist. The framework recognises that successful transitions often require multiple support mechanisms, especially in a developing economy.

This conceptual framework informed the study's mixed-methods approach, guiding the examination of individual transition experiences and structural factors affecting employment outcomes. It provided a lens for understanding how personal characteristics, institutional factors, and labour market conditions interact to shape beneficiaries' career trajectories in the Waste Sector.

Sample Characteristics

The research described in this study was a tracer study that targeted 206 beneficiaries of the Waste RDI Roadmap HCD programme between the reference period of 2015 and 2023. Contact details for 144 beneficiaries were sourced from the provided student database, inputs made by grant holders (higher education institutions), and social media searches.

The study achieved a 56% response rate, with 80 beneficiaries participating from a potential pool of 144 contactable beneficiaries. The sample comprised predominantly female respondents (59%), with participants averaging 32 years of age. South African citizens constituted 81% of respondents, and 13% were nationals from other African countries. The racial composition reflected 64% Black African, 14% White and Indian/Asian, and 9% Coloured participants, with 3% reporting disabilities.

The study found that half of the respondents came from households which reported monthly household earnings exceeding R20,501, which by South African standards, placing them within the middle to upper-middle income brackets. Importantly 14% of the HCD graduates came from

households in the lower income quintiles earning under R9,500 monthly—representing progress in expanding access to potential graduates from households in the lower income quintiles—this modest percentage underscoring persistent barriers.

Geographically, respondents were concentrated in the country's economic hubs, with significant representation from Gauteng, Western Cape, and KwaZulu-Natal. A notable 10% of graduates (n=7) left South Africa post-qualification. Of these graduates, four were from the African continent and most likely returned to their home country or elsewhere on the continent effectively contributing to waste sector capacity building on the continent.

Three graduates took up further studies and employment opportunities in developed economies, representing a relatively modest level of international professional mobility rather than a concerning skills exodus.

Academically, most beneficiaries (62%) were funded for Master's degrees, followed by Doctoral studies (16%) and Honours degrees (11%), with the University of KwaZulu-Natal emerging as the primary host institution (21%). Most received full (39%) or partial (24%) scholarship support, primarily learning about the programme through academic networks and supervisors.

This profile suggests the programme successfully attracted a diverse cohort of postgraduate students while highlighting opportunities to strengthen recruitment across demographic groups and institutions.

Labour Market Outcomes

The study's findings indicate complex employment transition patterns among programme beneficiaries. Of those who completed their qualifications:

- 60% secured full-time employment, demonstrating the programme's success in developing employable skills;
- A further 14% of graduates chose to pursue further full-time studies, indicating the programme's role in building advanced research capacity.

The above reflects that three of every four graduates (74%) secured either full-time employment or were pursuing further studies both of which are key objectives of the Waste Sector HCD Programme.

- The labour market transition patterns after completion of their qualification reveal that 10% of graduates entered part-time employment;
- Approximately one in three graduates (31%) were retained in the waste sector, making sector retention a significant challenge, This disparity between general employability and Waste Sector-specific employment outcomes points to structural challenges in sector absorption and career pathway development;
- 3% pursued self-employment opportunities exclusively in non-waste sectors. The absence of self-employment within the waste sector suggests potential barriers to entrepreneurship.
- Unemployment among graduates stands at 14%, with pronounced gender disparities. Female graduates face particular challenges, experiencing longer job search periods and higher unemployment rates (21%) than their male counterparts (3%). This gender gap extends to full-time employment, where 70% of male graduates secured positions compared to 53% of females.

The study identified several key barriers to Waste Sector employment, including limited practical waste sector experience, sector gatekeeping, particularly in research, lack of graduate awareness of

opportunities for employment in the Waste Sector and inadequate industry exposure during training. Programme withdrawals, while limited, were primarily attributed to inadequate supervision support, financial constraints, and misalignment between programme duration and completion requirements, particularly for doctoral studies.

Employer assessments highlighted graduates' strong technical capabilities and adaptability, provided excellent role models for other colleagues and more importantly enhanced the performance of the institution. An employer credited the graduate for their company's performance having improved illustrated by the quote below:

> *"Since [the beneficiary] has been here, we have been doing so much better with passing all of our audits, not like before when we had challenges with that."*

Several employers emphasised the need for interns to have enhanced practical experience. The study revealed critical challenges in tracking beneficiary outcomes, pointing to necessary improvements in information management systems, particularly given the programme's transfer to DSI management in 2024.

Assessment of HCD Programme Impact and Value

The Waste RDI Roadmap HCD Programme has demonstrated significant success in developing high-level research and professional capabilities within South Africa's waste sector, while also contributing to regional capacity building. The programme successfully supported 206 beneficiaries between 2015-2023, with strong representation at master's (62%) and doctoral (16%) levels. Key achievements include:

- Development of specialised technical expertise, with 70% of employers rating graduates' knowledge as "very relevant" to sector needs
- Strong academic outcomes, with 71% of beneficiaries rating training and mentorship as "excellent"
- Contribution to transformation goals through majority black African participation (64%) and strong female representation (59%)
- Regional capacity building through supporting students from other African countries (13%)
- Successful employment outcomes with 73% of graduates securing employment or pursuing further studies

However, opportunities exist to enhance programme effectiveness through:

- Strengthening industry integration and practical training components
- Improving programme visibility beyond academic networks
- Addressing gender disparities in employment outcomes
- Enhancing beneficiary tracking and information management systems

Recommendations

These findings suggest the need for strategic interventions across several dimensions: strengthening industry integration through structured partnerships, addressing gender-specific barriers to employment, enhancing practical training components, and improving beneficiary tracking systems.

The evaluation recommends a comprehensive approach to programme enhancement, focusing on both academic excellence and practical skill development while ensuring better alignment between graduate capabilities and sector needs.

The evaluation identified the following critical areas requiring strategic intervention:

1. Strengthen HCD programmes monitoring and evaluation infrastructure through enhanced information management systems and improved tracking of programme beneficiaries. This could be achieved through the use of grant conditions including supporting grant holders to maintain databases and contact with alumni.
2. Enhancing industry exposure and engagements to the HCD programme through funding requirements and allocations without overstepping the programme's role.
3. Improve sector integration by expanding practical training opportunities and aligning curricula with industry needs. This could be achieved through financial support for graduate conference attendance and industry co-supervision which may provide practical exposure within an academic framework
4. Make available targeted funding streams to address representation gaps. It can do so by promoting special calls to direct research towards priority areas as identified jointly by higher education institutions and industry.
5. Strengthen networking between past and current programme beneficiaries which will leverage existing investments. It could also provide support for mentorship and professional development within an academic context.
6. Promote equitable outcomes through the funding structure by addressing access barriers through financial support mechanisms. For example, this could include assigning quotas for the enrolment of beneficiaries from lower household quintiles.
7. Enhance programme visibility through strategic outreach and awareness interventions and stronger industry partnerships

These recommendations stay within the program's core mandate of graduate funding while using that leverage point to achieve broader objectives. Would you like me to elaborate on any of these areas or suggest additional funding-specific mechanisms?

Policy Implications

The findings call for policy interventions across three interconnected domains:

1. Skills Development: Mandate industry-integrated postgraduate training, including practical components and structured mentorship
2. Employment Transitions: Establish clear professional pathways with particular attention to gender equity and sector retention
3. Waste Sector Development: Create formal mechanisms for academic-industry coordination and address structural barriers to sector entry, leveraging the funding instruments to facilitate this.

Concluding Remarks

The report concludes that the Waste RDI Roadmap HCD Programme is critical in developing specialised human capital for a skilled workforce in the South African Waste Sector, particularly as the country addresses environmental sustainability challenges and transitions toward a circular economy. By addressing the identified challenges and implementing the recommended improvements, the programme can enhance its effectiveness, support environmental sustainability, and reduce unemployment in South Africa.

The programme's transition to DSI management in 2024 presents a timely opportunity to implement the above recommendations. Success requires sustained commitment from all stakeholders – government, academic institutions, and industry partners – to create more effective pathways for

graduates into the waste sector while addressing identified structural challenges. These improvements will position the programme to better serve South Africa's Waste Sector development needs and support the country's transition to a circular economy.

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ACRONYMS AND ABBREVIATIONS

Acronyms / Abbreviations	Description
CSIR	Council for Scientific and Industrial Research
DSI	Department of Science and Innovation
ESSP	Environmental Sector Skills Plan
FoGD	Focus Group Discussion
HCD	Human Capital Development
HSRC	Human Sciences Research Council
HSRM	Hydrogen Society Roadmap for South Africa
IWMSA	Institute of Waste Management of Southern Africa
LFPR	Labour Force Participation Rate
NDP	National Development Plan
NQF	National Qualification Framework
NSI	National System of Innovation
POPIA	Protection of Personal Information Act
RDI	Research, Development, and Innovation
REC	Research Ethics Committee
SAIIA	South Africa Institute of International Affairs
SARChI	South African Research Chairs Initiative
STI	Strategic Investment in Science, Technology and Innovation
STWTs	School-to-Work Transitions
STEM	Science, Technology, Engineering and Mathematics
ToC	Theory of Change
ToR	Terms of Reference
TVET	Technical and Vocational Education and Training
UIF	Unemployment Insurance Fund
WEEE	Waste Electrical and Electronic Equipment
WRIU	Waste RDI Roadmap Implementation Unit

1 Introduction

1.1 Background to Study

The Human Sciences Research Council (HSRC) was appointed by the Department of Science and Innovation (DSI) through the Waste Research, Development and Innovation (RDI) Roadmap to implement a tracer impact evaluation study of the Waste RDI Roadmap Human Capital Development (HCD) Programme. This initiative, hosted by the Council for Scientific and Industrial Research (CSIR), represents a strategic investment in South Africa's waste management capabilities.

The Waste RDI Roadmap represents a comprehensive intervention designed to transform South Africa's waste management landscape by providing strategic direction for research investments, accelerating technological adoption, and building robust innovation capacity. A fundamental component of this initiative is its focus on human capital development, recognising the critical role of specialised skills in facilitating the country's transition toward circular economy principles and sustainable waste management practices.

Despite significant investments in postgraduate education within the waste sector, preliminary evidence suggests several structural challenges: limited sector absorption of graduates, inadequate knowledge transfer mechanisms, and insufficient opportunities for experiential learning under seasoned industry professionals. These challenges necessitate a systematic evaluation of the programme's outcomes and impact.

Employing a mixed-methods approach incorporating beneficiary surveys, employer feedback, and focused beneficiary discussions, this study aimed to generate evidence-based insights to optimise the alignment between human capital development initiatives and sector requirements. This comprehensive evaluation approach aims to provide strategic direction for the future implementation of the Waste RDI Roadmap, ensuring that investments in human capital development yield meaningful outcomes for both individual beneficiaries and the sector as a whole.

1.2 Structure of this Report

Section 2 of the report provides a brief contextual background, which explores the socio-economic challenges in South Africa, particularly with regard to unemployment, inequality, and the potential for the Waste Sector to contribute to job creation and sustainability. The conceptual framework in *Section 3* discusses the theoretical underpinnings related to school-to-work transitions (STWTs), highlighting factors that influence graduates' ability to enter the labour market successfully. *Section 4* provides an overview of the methodology, including the research design, data collection methods, study population, ethical considerations and study limitations, offering transparency on how the study was conducted. This is followed by a profile of the respondents in *Section 5,* providing demographic and socio-economic information of the participants. *Section 6* follows with the labour market outcomes of beneficiaries, which analyses beneficiaries' employment status, sector-specific employment, and the challenges they face in securing jobs. Insights are further drawn from focus groups and interviews, capturing beneficiaries' experiences and challenges of participation in the HCD programme in *Section 7,* followed by *e*mployers' assessment of the graduates in *Section 8.* A summary of the findings and limitations of the study are covered in *Section 9,* while actionable steps are recommended to enhance the programme's effectiveness in *Section 10*.

2 Study in Context

South Africa faces a waste management crisis. According to the most recent State of Waste Report (Department of Environmental Affairs, 2018), approximately 90% of all waste is still directed to landfills, despite the waste hierarchy being embedded in national waste policy. Furthermore, significant amounts of waste are being illegally dumped due to declining waste collection levels. With only 20% of all waste being recycled, this represents a significant loss of economic resources and poses escalating environmental risks.

This environmental challenge intersects with South Africa's severe socio-economic crisis, marked by the world's highest unemployment rate. The impact of this unemployment rate is particularly severe among youth (64% for ages 15-24) and women (47% economically inactive) (Stats SA, 2024). Despite higher education traditionally serving as an employment buffer, graduate unemployment has been rising since 2010, with women facing disproportionate barriers to economic participation.

The Waste Sector presents a strategic opportunity to address both environmental sustainability and unemployment. However, the sector's growth is constrained by critical skills shortages. The Waste RDI Roadmap provides an opportunity to support sector job creation through three key interventions: *human capital development, research advancement, and innovation promotion*. By aligning higher education programmes with waste economy needs and fostering collaboration between educational institutions, government, and industry, the framework supports the transformation of the waste sector into a significant contributor to economic development while addressing environmental challenges. This integrated approach positions the waste sector as a catalyst for sustainable development, offering solutions to both environmental degradation and unemployment while creating pathways for skilled graduates to contribute to South Africa's circular economy transition.

2.1 The Waste RDI Roadmap

The Waste RDI Roadmap is an initiative of the DSI, hosted by the CSIR, that guides investment in waste research, development, and innovation over the 2015-2025 period. With an investment of R125m over the period 2015-2024 (3.2% of the original Roadmap ask of R3.89 billion), successful implementation of the Waste RDI Roadmap is expected to assist government and industry in enhancing the diversion of waste away from landfills, increased inclusion of technology in waste management and the adaptation of existing technology as well as promoting innovations, both technical and social, into the waste management sector. Of the three core pillars of the Waste RDI Roadmap, namely *Human Capital Development* (HCD), *Research and Development* (R&D), and *Innovation*, the current report is concerned with HCD.

2.2 The Waste RDI Roadmap HCD Programme

The Waste RDI Roadmap HCD Programme, housed within the CSIR, aims to support the development of a proficient public and private sector capable of transforming the South African Waste Sector. It does so through two primary mechanisms:

- Postgraduate degrees offering specialisation in solid waste management;
- Development of a pipeline of skilled and qualified postgraduate students into the Waste Sector.

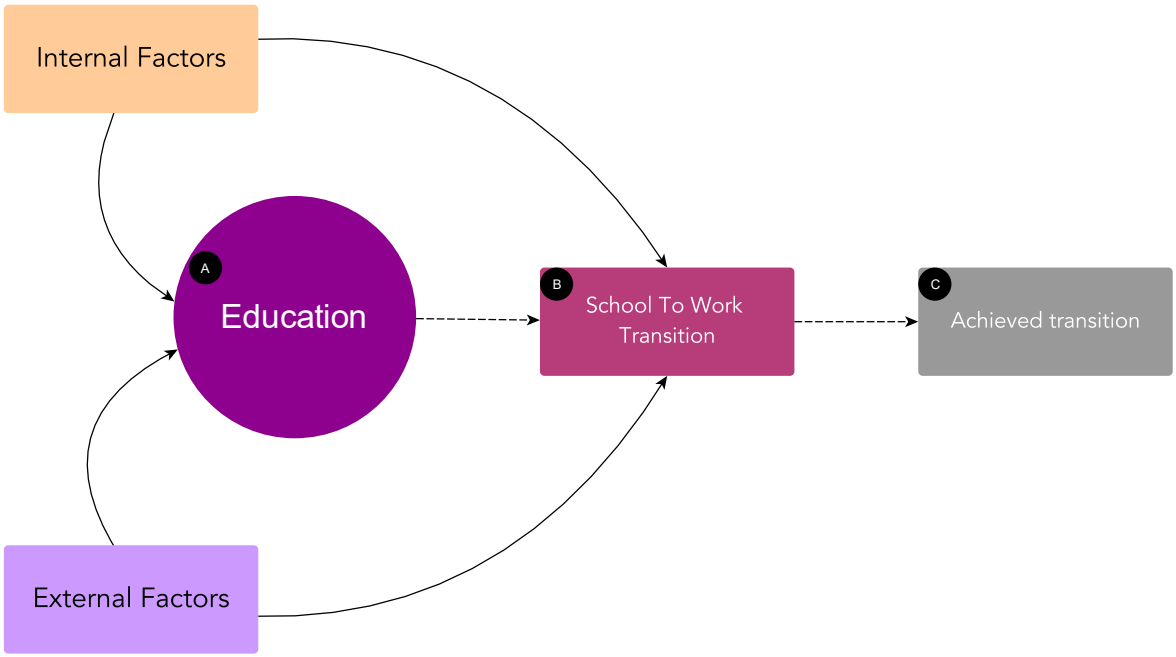
The Waste RDI Roadmap HCD Programme has several funding instruments to build human capacity, namely, direct scholarships for postgraduate students, partial or full funding under Waste RDI Roadmap grant projects, partial or full funding under SARChI Chairs, and internships.

3 Conceptual Framework

This study aimed to explore the outcomes of the Waste RDI Roadmap HCD Programme beneficiaries after completing their qualifications, focusing on their employment status and contributions to institutions and the waste sector. Additionally, it assessed the programme's effectiveness, efficiency, and sustainability in meeting its objectives.

The study draws on the conceptual framework for understanding school-to-work transitions (STWTs), which highlights factors influencing the smoothness or challenges of these transitions. Evidence suggests that STWT pathways are increasingly non-linear, protracted, and uncertain. Figure 1 below illustrates the three stages of transition and the internal and external factors interacting with the educational system to influence STWT outcomes (Nilsson, 2019). This framework is particularly relevant for bridging the knowledge gap on STWT in developing countries.

Figure 1: Conceptual framework of the school-to-work transitions process



Source: Nilsson, 2019, p. 748

The internal and external factors can be grouped into three categories: individual characteristics, institutional factors, and labour market context.

Individual Characteristics

Factors such as academic ability, gender, race/ethnicity, and family background significantly influence post-school transitions in South Africa (Bhorat et al., 2017; Case & Ashwin, 2018).

Key considerations include:

- South Africa's divided education system produces unequal outcomes, with white and affluent youth achieving better results (Fleisch, 2008; Reddy et al., 2019).
- Socioeconomic status strongly predicts educational attainment, with poorer learners less likely to reach matric or university (Moses et al., 2017).

- Gender patterns reveal that while girls outperform boys academically, they face poorer labour market outcomes, often mediated by race (Bhorat et al., 2017; Broekhuizen & Spaull, 2017).
- Black learners in South Africa exhibit higher post-school enrolment despite facing labour market discrimination (Bradley & Taylor, 2002).

Institutional Factors

The type of school or university attended significantly impacts outcomes in South Africa's unequal education system. University graduates enjoy better prospects than TVET college graduates, often perceived as less competitive (Ismail & Mujuru, 2020; Lehohla, 2017). Even among universities, graduates from historically white institutions fare better due to employer bias and greater access to social capital (Rogan & Reynolds, 2016; Walker & Fongwa, 2017). These disparities reflect the broader segregation within South Africa's schooling and post-school systems.

Macroeconomic Conditions and Labour Market Context

Macroeconomic conditions and labour market policies heavily influence job availability for school leavers. In low-income countries like South Africa, slow economic growth and expanding labour forces limit decent job opportunities, particularly for first-time entrants (Khan, 2020). Across Africa, labour markets are shifting towards vulnerable service sector jobs, exacerbating challenges for youth employment (Ryan, 1999). Active labour market policies, such as training, hiring incentives, and public works programmes, aim to address these challenges. While vocational and technical training has shown some positive impacts, results remain mixed, with multi-pronged approaches proving most effective (Crépon & van den Berg, 2016; Nilsson, 2019b). Employers also play a critical role in facilitating transitions through workplace training, mentoring, and skills development investments (Smith & Comyn, 2004).

Active Labour Market Policies

Globally, active labour market policies promote economic growth and employment access, often targeting youth through training, hiring incentives, job matching, enterprise promotion, and public works programmes (Crépon & van den Berg, 2016). Training programmes vary in skills taught, delivery, duration, and investment, with evidence showing some positive long-term impacts, though results remain mixed (Crépon & van den Berg, 2016; Nilsson, 2019b). For example, business skills training supports enterprise creation, while public employment programmes often struggle with inefficiencies. Reviews indicate that vocational and technical training for youth in developing countries improves employment and income, while programmes transferring cash or assets may have more sustained impacts (Nilsson, 2019b). Combined approaches are generally more effective for facilitating STWTs than standalone efforts. Other influential factors include geographic and economic cycles, language, and disability (Bradley & Nguyen, 2004; Hannan et al., 1996). Employers also play a critical role through workplace training, mentoring, skills development investments, and partnerships with educational institutions (Smith & Comyn, 2004). Overall, multi-pronged active labour market policies are most effective in addressing the complexities of the employment landscape.

In summary, STWT outcomes are shaped by a complex interplay of individual, institutional, and labour market factors, with multi-faceted interventions offering the most promise for improving transitions in developing contexts like South Africa.

4 Methodology

4.1 Study Background and Objectives

The specific objectives of the study were to:

- Gather data about the **effectiveness and impacts of the Waste RDI Roadmap HCD programme**, direct or indirect and intended or unintended.
- Provide the Waste RDI Roadmap Implementation Unit with **information regarding the activities, outcomes, and employment of HCD programme beneficiaries** who completed their qualification or internship.
- Determine **the nature of employment of beneficiaries who secured employment** post-completion of their qualification or internship.
- Determine **the extent to which HCD programme beneficiaries were retained** in the Waste Sector
- Pilot a survey of the **beneficiaries' employers' perceptions of the value** of the HCD programme.
- Generate evidence of **key achievements and challenges** to inform the decision-making process by the Waste RDI Roadmap management and accounting authority on programme delivery mechanisms and how these can be improved in the future to ensure sustainability.

4.2 Research Design

The research design is a tracer study where the chosen methodology comprised a mixed methods approach including:

- A desktop review of published and grey literature and available documentation relevant to the study;
- Survey with beneficiaries of the Waste RDI Roadmap HCD Programme;
- Focus groups with beneficiaries of the Waste RDI Roadmap HCD Programme; and
- An employer survey.

Beneficiaries were identified from the Waste RDI Roadmap student database, with the reference period being 2015 to 2023. The tracer study sought to investigate beneficiary trajectories, particularly in the labour market, after graduation from university. In particular, the study was concerned with whether beneficiaries who were traced had found employment within the Waste Sector and at what level.

4.3 Tracer Studies

Tracer studies serve as a vital instrument for evaluating program effectiveness by following participant journeys over time. Through systematic tracking of outcomes, these studies provide critical insights into the long-term impact of initiatives on both individual success and broader societal development while highlighting areas needing improvement in educational curricula and training programmes (Senekal & Munro, 2019).

The value of tracer studies also lies in their comprehensive approach to understanding multiple dimensions of participant outcomes. They examine crucial transitions from education to employment, track career progression, and assess how learned competencies are applied in the workplace. This approach enables educational institutions to align their offerings with job market demands and adapt teaching methodologies accordingly (Schomburg, 2016). Furthermore, these studies provide essential

data on labour market trends and skill requirements, informing policy decisions and program development (BOTA, 2010).

The methodology explores the complex relationship between education and employment by examining how graduates apply their academic knowledge and skills. Beyond educational factors, these studies consider broader influences such as demographic characteristics, prior work experience, and labour market conditions, providing a holistic understanding of employment outcomes.

However, researchers must navigate several significant challenges. These include ensuring representative sampling, maintaining contact with participants, addressing low response rates, and managing the limitations of self-reported data (Yalley, 2022). Success requires robust methodological approaches and careful consideration of these limitations when interpreting results. Despite these challenges, tracer studies remain fundamental to understanding program effectiveness and guiding evidence-based improvements in educational and training initiatives (Senekal & Munro, 2019).

4.4 Study Population and Sampling

4.4.1 Constructing the Beneficiary Study Population

The Waste RDI Roadmap beneficiary database informed the basis for the population construction, with the reference period being 2015 to 2023. All beneficiaries were initially targeted to attain contact details and thereafter excluded based on predetermined criteria:

- Recipient of scholarships/bursaries funded indirectly by the CSIR via the HEIs;
- Either completion of the qualification or dropout from the programme before completion;

The study population included beneficiaries who exited the programme prior to completing their qualification, with the aim of understanding the factors that might have contributed to their exit. The database had 187 beneficiaries who had received support, following the removal of 11 duplicates and two deceased beneficiaries.

The study faced challenges accessing beneficiary contact details, as the database only included names, study information, Higher Education Institution details, enrolment data, and grant holder information. To address this and comply with the POPIA Act, grant holders were engaged to disseminate invitations to beneficiaries and the HSRC leveraged social media platforms (Twitter, LinkedIn, and Facebook) to trace beneficiaries and retrieve contact details. Through this approach, an additional 19 beneficiaries (excluding one duplicate) who had been recipients of study support were included in the database. The total study population thus increased to 206 beneficiaries.

Inclusion and Exclusion Criteria

In addition to beneficiaries who completed their studies, beneficiaries who exited the programme before completing their qualification were included in the study. Their inclusion was informed by the need to understand the factors that might have contributed to their exit.

Beneficiaries were excluded based on predetermined criteria of having received HCD funding during the reference period 2015 to 2023 and who were currently still enrolled for their studies.

Realised Study Population

Of the 206 beneficiaries:

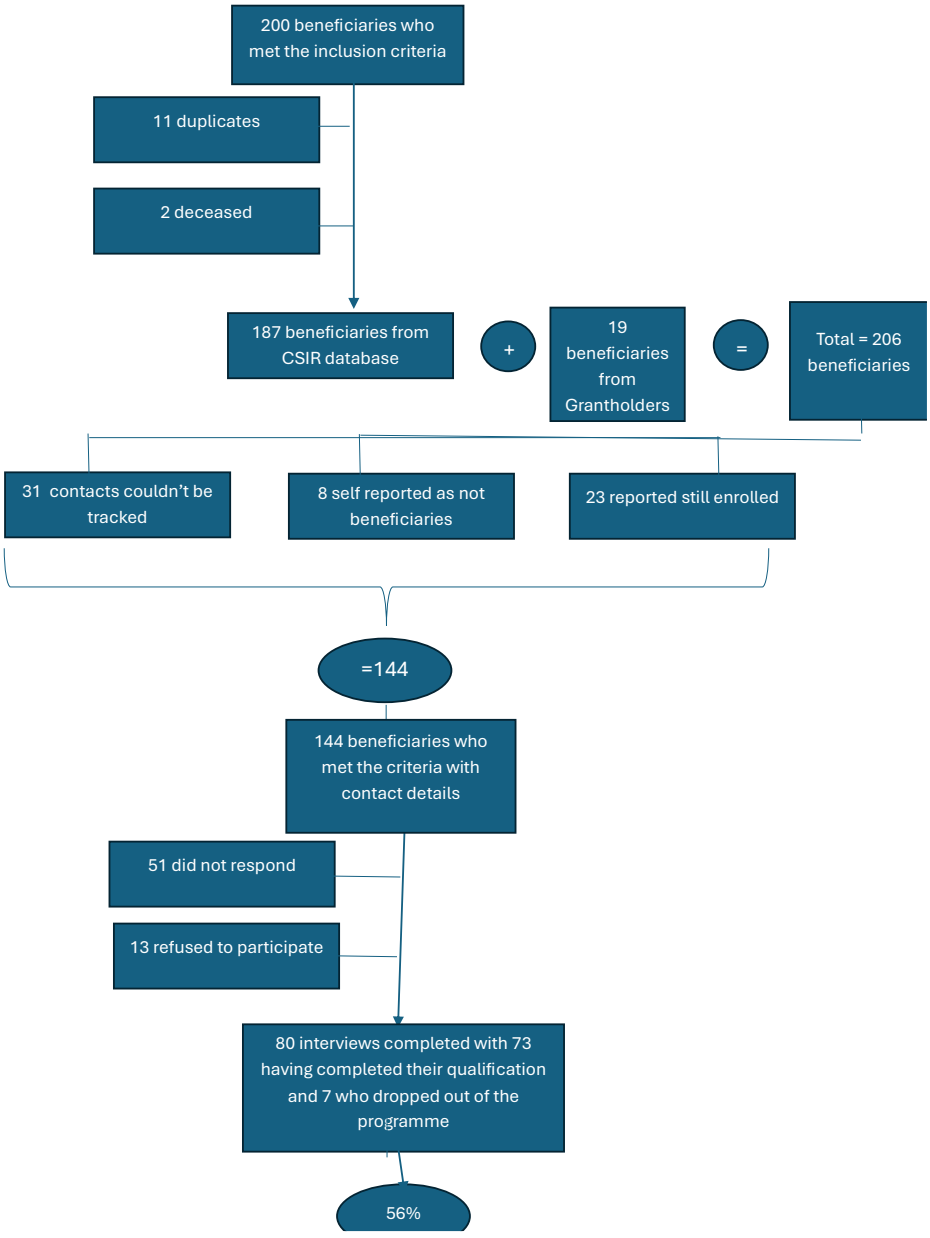
- Beneficiary contact details could not be found (n = 31);

- Targeted respondents reported not being beneficiaries (n = 8). This may likely have arisen from some beneficiaries not being aware of the support emanating from the HCD.
- Respondents reported that they were still enrolled (n = 23). This was despite clarifying if their enrolment was for a new qualification or the original one, as reported in the HCD database.

Therefore, the study population was reduced to 144 beneficiaries. Of these beneficiaries, 51 did not respond, 13 refused to participate, and 80 interviews were completed. Thus, the beneficiary survey response rate was 56%.

Of the 80 beneficiaries who participated in the interviews, 73 reported completing their qualification, and seven had dropped out of the programme.

Figure 2: Study population and sampling



Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

4.4.2 Focus Group Discussions

To generate qualitative information, four focus groups (FGs) were conducted with different groups of beneficiaries, namely those:

- Employed in the Waste Sector;
- Employed in a non-Waste Sector,
- Unemployed or studying further,
- Who had withdrawn from the survey

4.4.3 Employer Interviews

Beneficiaries were requested to provide contact details for their employers. The study reached out and secured interviews with five employers.

4.5 Data Collection

The *beneficiary survey* was conducted telephonically, and the information was captured online via the Redcap research data collection platform. The protocol for engaging with respective respondents involved attempting to reach the beneficiary up to three times on separate dates and times, after which they would be deemed non-responsive. The interview duration ranged from 30 to 45 minutes.

Focus group discussions with beneficiaries were conducted online via MS Teams. Each group consisted of no more than 6-8 respondents, and the discussion was captured via the interview recordings.

The *employer interviews* were also conducted telephonically, and the information was captured via the interview recordings.

4.6 Ethics Approval

The project was undertaken in line with the principles of ethical research involving human subjects. These principles included special attention to communicating the aims of the study and the rights of people participating in the research, with written informed consent and confidentiality in place. The study proposal key informant interview schedules, and consent forms were submitted as part of the Ethics Approval application to the HSRC Research Ethics Committee (REC). The study received full ethical clearance (REC 4/23/11/22).

4.7 Research Instruments

Three data collection instruments were developed namely, a beneficiary survey instrument, a beneficiary focus group interview schedule, and an employer survey instrument. These can be requested.

4.7.1 Beneficiary Survey Instrument

The primary objective of the survey was to understand the beneficiaries' post-qualification trajectories, beneficiary perceptions of the nature of the Waste RDI Roadmap HCD programme support they received, educational outcomes attributable to this support, and their professional development within the Waste Sector. The survey dimensions included:

- Beneficiary socio-demographic details.
- Nature of the Waste RDI Roadmap HCD Programme funding support received.
- Assessment of qualifications received, or internship/PhD placement participated in.

- Employment status before undertaking the waste-related qualification.
- Labour market status after completion of the qualification.
- Perceptions of their experience with the Waste RDI Roadmap HCD Programme.
- Recommendations for enhancing the labour market outcomes of Waste RDI Roadmap HCD Programme beneficiaries.

4.7.2 Beneficiary Focus Group Interview Schedule

The focus group schedule aimed to deepen our understanding and insights into the beneficiary's exposure to the HCD programme and their labour market transitions. The core dimensions of the beneficiary focus group instrument were:

- Nature of support received.
- Degree to which program expectations were met.
- Employment or study history post-graduation.
- Barriers or challenges encountered in finding employment after graduation.
- Current utilization of skills acquired during studies.
- Perceived benefits of the CSIR bursary program in preparing for the labour market.
- Beneficiary recommendations based on their experiences.

4.7.3 Employer Survey Instrument

The key objective of the interview with employers was to explore the level of awareness of employers in the waste sector about the Waste RDI Roadmap initiative and particularly the HCD programme. Additionally, it sought to deepen our understanding of the factors influencing the recruitment of beneficiaries by companies (within or outside of the Waste Sector) as well as to better understand the added value for the companies of employing the HCD beneficiaries as well as to ascertain recommendations on how the HCD programme's effectiveness could be enhanced further. Core focus areas for the employer survey were:

- Institution background.
- Company/organisation and Waste RDI Roadmap HCD Programme beneficiary.
- Challenges with respect to companies' skills acquisition.
- Waste sector and company skills needs.
- Matching of skills with company needs.
- Nature of mentor support provided.
- Nature of the impact of the Waste RDI Roadmap HCD Programme on the company.
- Recommendations to enhance the program.

4.8 Data Capturing, Analysis and Coding

The beneficiary survey data was captured in real time during telephonic interviews using the Redcap platform. Redcap ensured structured data entry, minimising errors through pre-defined fields and validation rules. Audio recordings from MS Teams of the focus group discussions and employer interviews were transcribed verbatim. All captured data were securely stored, ensuring compliance with POPIA. Access was restricted to authorised research team members only. The survey data from Redcap was exported to STATA for quantitative analysis while qualitative data was thematically coded within MS Excel by the research team.

4.9 Study Challenges and Limitations

Several limitations were encountered during the study that may have influenced the findings and should be considered when interpreting the results. One major limitation was selection bias due to incomplete or inaccurate contact details for beneficiaries. Despite efforts to source contact information through grant holders and social media outreach, contact details could not be obtained for 31 beneficiaries. As a result, the study was limited to those who could be successfully contacted, potentially excluding individuals with different experiences or outcomes.

The study achieved a 56% response rate among those with valid contact details. While this response rate is reasonable, non-respondents' perspectives may differ from those who participated. Additionally, some beneficiaries declined to participate or were unavailable despite multiple attempts to reach them, which may have led to the underrepresentation of certain viewpoints.

The study relied on self-reported data collected through surveys and focus groups, which may be subject to recall or social desirability bias. Beneficiaries might have misremembered details or provided answers they thought were expected. Furthermore, employer participation was limited as many participants did not wish to provide employer details.

Online connectivity issues during focus groups and interviews also presented challenges. These technical difficulties occasionally hindered participation and led to incomplete data collection.

More specific challenges included:

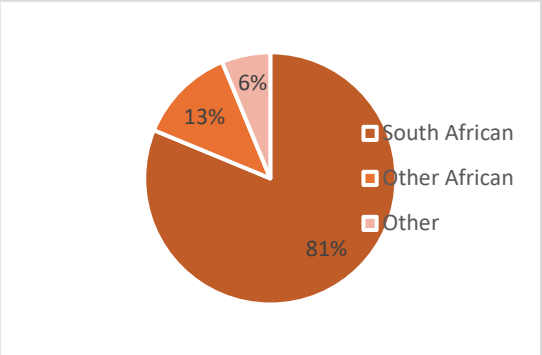
- **Lack of beneficiary contact details:** The lack of beneficiary contact details substantially delayed the fieldwork component of the study as efforts were made to source contact details through various means. This contributed to contact details for only half of the study population being included in the population and a smaller number of respondents in the study sample.
- **Challenges with establishing contact with beneficiaries and employers:** Reliance solely on email contact details for reaching out to both employers and beneficiaries was a limitation, as response rates were slow, contributing to the non-responsiveness of half of the beneficiaries.
- **Online connectivity issues:** Connectivity issues impacted interviews, particularly with one employer based on the African Continent, hindering the completion of the interview. Similarly, with the focus groups, the connectivity issues resulted in some beneficiaries not being able to join the session.

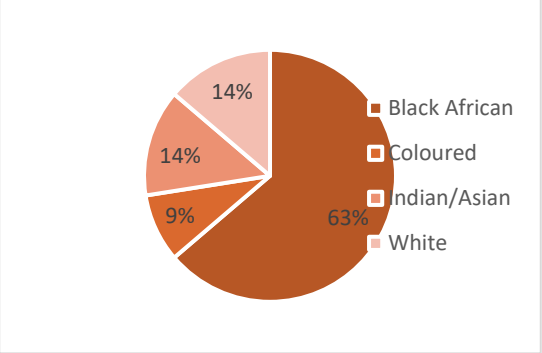
5 Key Characteristics of Beneficiaries

The study was focused on individuals supported through the Waste RDI Roadmap HCD programme. As indicated, the total realised sample of respondents was 80 beneficiaries. This section begins with an overview of some of the beneficiary respondents' key demographic and socio-economic characteristics.

5.1 Demographic Profile

The study sample was predominantly female (59%). The age distribution showed a relatively young cohort, with participants clustering around 32 years (mean), while only a tenth of the sample exceeded 40 years of age. Regarding nationality, South African citizens constituted the majority at 81%, while nationals from other African countries represented 13% of the sample. Black African participants comprised nearly two-thirds of the sample (64%), White and Indian/Asian participants each contributed 14%, and Coloured participants represented 9%. The study found a relatively small representation of persons with disabilities, with only 3% of participants reporting a disability.





The transition matrix (Table 1) illustrates several patterns in the residential mobility of the 73 graduates who completed their qualification and shows a strong tendency to remain in their original province or migrate to South Africa's economic hubs. Retention rates were high in Gauteng (14 out of 20), Western Cape (17 out of 21), and KwaZulu-Natal (10 out of 20).

The internal migration patterns tell an important story about economic opportunity distribution. The movement from KwaZulu-Natal to Gauteng and the Western Cape suggests that graduates are responding to the concentration of professional opportunities in these regions. Rather than indicating a concerning trend, this internal mobility demonstrates the natural flow of skilled professionals toward areas of economic activity and professional development opportunities.

The movement of ten percent of the graduates outside of South Africa, initially appearing as a potential concern with seven graduates (10%) leaving South Africa, demonstrates a more nuanced reality when examined through nationality. Four of these graduates were from the African continent who either returned to their countries or moved to opportunities elsewhere on the continent, while three South African nationals pursued opportunities abroad, reportedly in developed countries.

This pattern transforms what might initially appear as skills loss into evidence of successful regional capacity development, which is one of the HCD programme expected outcomes. The inclusion of non-South African graduates in the HCD programme and their subsequent employment either in their home country or on the continent exemplifies South Africa's effective execution of its regional educational mandate. The country effectively contributes to continental capacity building through initiatives like the Waste RDI Roadmap, which deliberately allocates resources for non-South African

students. When these graduates return home, they carry specialised skills and knowledge that benefit their countries, fostering regional development and cooperation.

The movement of three South African graduates abroad represents a relatively modest level of international professional mobility rather than a concerning skills exodus. In our interconnected global economy, some degree of professional migration is expected and can enhance South Africa's integration into worldwide knowledge networks, potentially facilitating valuable international collaborations and knowledge exchange.

Table 1: Province or location of residence following completion of qualification (n = 73)

		After completion of the qualification											
		EC	FS	GT	KZN	LP	MP	NC	NW	WC	Africa	World	Total
During completion of qualification	EC	4	0	1	0	0	0	0	0	0	0	0	5
	FS	0	1	0	0	0	0	0	0	0	0	0	1
	GT	0	0	14	0	0	0	1	0	3	0	2	20
	KZN	0	1	3	10	0	0	0	1	2	1	2	20
	LP	0	0	0	0	0	1	0	0	0	0	0	1
	MP	0	0	0	0	0	0	0	0	0	0	0	0
	NC	0	0	0	0	0	0	1	0	0	0	0	1
	NW	0	0	0	0	1	0	0	0	0	0	0	1
	WC	0	0	1	1	0	0	0	0	17	1	1	21
	Africa	0	0	0	0	0	0	0	0	0	1	1	2
	World	0	0	0	0	0	0	0	0	0	0	1	1
	Total	4	2	19	11	1	1	2	1	22	3	7	73

Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

**Majority currently live in the same province in which they completed (grey blocks)*

**There was significant movement out of KZN*

**There was significant movement out of South Africa to other countries (n = 7)*

Overall, the findings indicate that while most graduates remain within South Africa, particularly in its economic hubs, there is notable movement within and internationally. The international movement pattern demonstrates two important dynamics: the contribution towards regional capacity building through South African universities attracting and training students from other African countries who then return home with their acquired skills, and a relatively small scale of international professional mobility among South African graduates. The mobility patterns demonstrate South Africa's successful balance between developing domestic talent and contributing to regional capacity building. High retention rates in economic centres indicate robust domestic professional opportunities, while the movement of non-South African graduates throughout the continent reflects effective regional skills development. This dual achievement aligns with both national development objectives and regional cooperation goals, particularly through initiatives like the Waste RDI Roadmap, which strategically supports the development of both local and regional talent.

5.2 Socio-Economic Profile

Understanding the socio-economic background of programme beneficiaries serves as a critical foundation for interpreting their eventual career trajectories and labour market success. This contextual information helps us recognise how initial economic circumstances might influence, shape, or constrain employment opportunities and career choices.

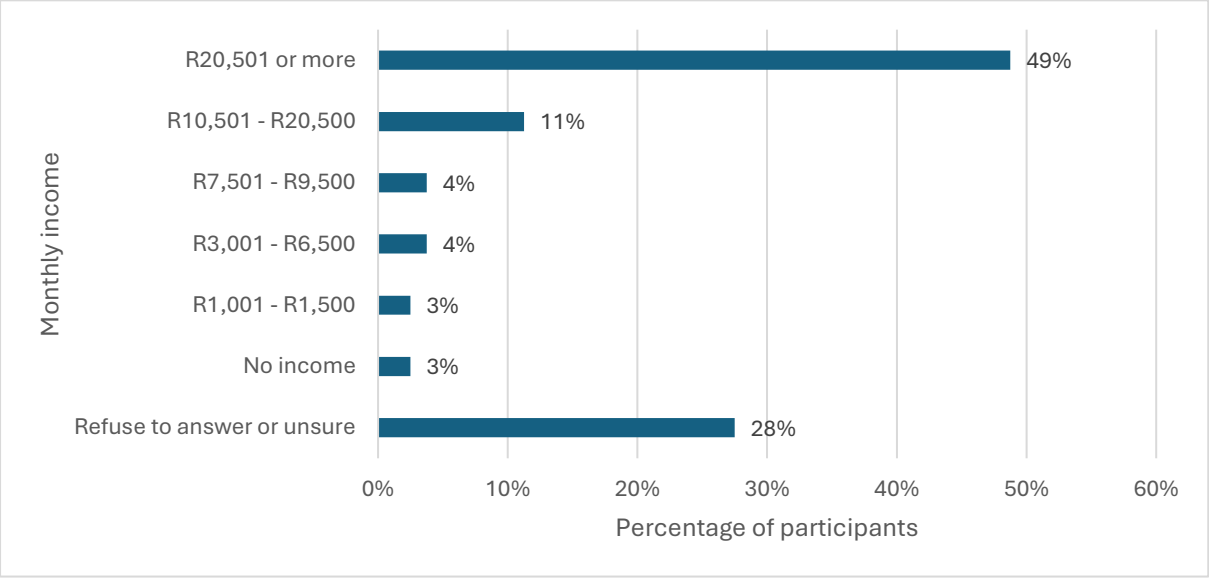
Two key trends emerge from the analysis. First, regarding household income sources, formal employment through salaries and wages is the primary income source for 84% of beneficiary

households (n = 67). A smaller but significant portion of households relies on alternative income sources, reflecting diverse income sources and economic livelihood strategies. To a lesser extent support from relatives (5%) and access to pensioners income (3%) reflects the extended family support and intergenerational income transfer. The sporadic instances of access to social grants, informal trading, part-time work, and remittances, reported by single respondents, demonstrate the complex ways some households navigate economic sustainability.

Second, the household income distribution of beneficiaries also reflects broader patterns of socioeconomic stratification in access to South Africa's higher education sector. As shown in Figure 3, nearly half of the respondents (n = 39; 49%) reported monthly household earnings exceeding R20,501. By South African standards, this places many beneficiaries within the middle to upper-middle income brackets. This finding aligns with national trends documented in Statistics South Africa's Education Series Volume (2019), which shows significant socioeconomic disparities in higher education access and progression. According to this data, 47% of youth aged 20-24 years holding bachelor's degrees (NQF level 7) came from the highest income quintile, compared to only 7% from the lowest quintile. The disparity extends to postgraduate education, with approximately 36% of individuals holding postgraduate qualifications (NQF levels 8-10) coming from the wealthiest household income quintiles. Fongwa's (2019) comprehensive study of 2,000 postgraduate students across five South African universities reinforces these patterns, finding that 70% of doctoral students originated from middle to upper-middle-income households.

Approximately 14% (with equal proportions (4% each) in the R7,501-R9,500 and R3,001-R6,500 brackets, and a small percentage (6% combined) report either minimal income (R1,001-R1,500) or no income at all) of our graduates come from households earning under R9,500 monthly—representing some progress in expanding access—this modest percentage underscores persistent barriers. These patterns endure despite various funding initiatives, suggesting that financial support alone cannot address all barriers to postgraduate education (Cloete et al., 2016). Students from lower income quintiles face compound challenges beyond financial constraints, including limited access to research resources and academic networks (Fongwa & Wilson-Strydom, 2021).

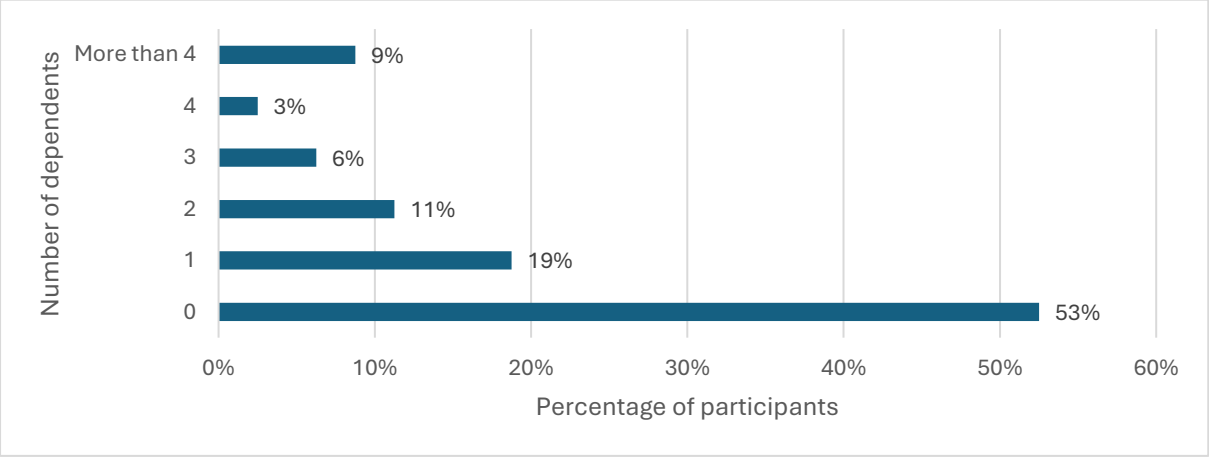
Figure 3: Current gross total monthly income for household (n = 80)



Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

Thirdly, the study further explored dependency patterns among the beneficiaries and found that slightly more than half of the beneficiaries (n = 42; 53%) reported having no dependents, while almost a third (29%) had two or more dependents. Of these, approximately a fifth of respondents (n = 15; 19%) reported supporting one dependent, while a tenth (n = 9; 11%) indicated responsibility for supporting two dependents and slightly less than one-fifth (18%) had three or more beneficiaries (Figure 4).

Figure 4: Number of dependents reported by respondents (n = 80)



Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

Findings in this section reflect deeper structural inequalities within South African higher education, where socioeconomic background continues to significantly influence both access to and successful completion of postgraduate studies despite policy interventions aimed at increasing equity in higher education access. While existing funding initiatives have facilitated some access, the data suggests that achieving substantive equity requires more comprehensive interventions that address multiple barriers simultaneously and account for diverse household circumstances and responsibilities. The observed patterns of income distribution and dependency obligations highlight the complexity of

factors influencing postgraduate participation. This analysis also suggests that effective policy interventions must extend beyond financial support to address the multifaceted barriers that perpetuate socioeconomic disparities in higher education access and success.

5.3 Institutional Distribution of Waste Sector Expertise in Higher Education

The institutional distribution of the Waste RDI Roadmap HCD Programme reflects both achievements and ongoing opportunities in diversifying waste management expertise across South Africa's higher education landscape. While traditional research universities maintain a strong presence, the programme has made significant strides in broadening institutional participation, suggesting a strategic commitment to developing nationwide research and training capacity in waste management.

The current institutional landscape shows a three-tiered distribution pattern. Traditional research universities, led by the University of KwaZulu-Natal (21%), Stellenbosch University (11%), and the University of the Witwatersrand (8%), form the first tier with established research strengths and infrastructure. UKZN's prominence, anchored by its SARChI Chair in Waste and Climate Change and specialised coursework Master's program, exemplifies how targeted investment can build centres of excellence.

A second tier of emerging research participants is taking shape, including the University of Johannesburg (8%), Nelson Mandela University (6%), and North-West University (5%). These institutions are developing specialised research focuses and building dedicated waste management capacity. Their growing participation demonstrates the programme's success in extending research capability beyond traditional centres.

The third tier comprises universities of technology and previously disadvantaged institutions, including Cape Peninsula University of Technology (3%), Walter Sisulu University (4%), and the University of Limpopo (1%). While their participation rates are currently lower, their inclusion represents a crucial step toward broader institutional transformation in waste management research and education.

This diversification carries strategic significance across multiple dimensions. Geographically, the programme now reaches multiple provinces, combining urban and regional perspectives in waste management research. The mix of institutional types - from research-intensive universities to technology-focused institutions - enables different approaches to waste management challenges. Previously disadvantaged institutions bring valuable perspectives on community-level waste management issues and help extend the programme's transformative impact.

Table 2: Institution where qualification/post-doctoral placement/internship was completed

Institution	No.	%
University of KwaZulu-Natal	21	27%
Stellenbosch University	11	14%
University of the Witwatersrand	8	10%
University of the Western Cape	7	9%

University of Cape Town	6	8%
University of Johannesburg	6	8%
Nelson Mandela University	5	6%
North-West University	4	5%
Walter Sisulu University	3	4%
University of Pretoria	2	3%
Cape Peninsula University of Technology	2	3%
Rhodes University	1	1%
Durban University of Technology	1	1%
University of Limpopo	1	1%
Central University of Technology	1	1%

Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

When examining the academic levels supported (Table 3), in keeping with the programme's emphasis on postgraduate education, most beneficiaries (62%) were funded for their Master's degrees. Doctoral studies account for 16%, and Honours degrees comprise 11% of beneficiaries This strong focus on advanced degrees supports the programme's strategic aim to develop high-level research and professional capabilities within the waste sector. The small but notable presence of post-doctoral placements (4%) indicates investment in advanced research capacity development.

Table 3: Qualification/post-doctoral placement/internship funded by the Waste Roadmap

Qualification	No.	%
Master's	49	62%
PhD	13	16%
Honours	9	11%
Bachelors	3	4%
Post-doctoral placement	3	4%
Other: Honours and Master's	1	1%
Other: Research assistant	1	1%

Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

Full scholarships constituted the largest category of funding support, with 49% of beneficiaries receiving them, while partial scholarship support was provided to a quarter (30%) (Table 4). This mixed funding approach, supplemented by targeted support provided to approximately one-fifth of beneficiaries (21%) for fieldwork (4%), day-to-day research expenses (1%) and other undisclosed support, suggests a flexible funding model designed to address various student needs and circumstances. The presence of diverse funding categories indicates recognition of the various financial barriers students may face in pursuing advanced qualifications.

Table 4: Nature of financial support provided (n=80)

Nature of support received	No.	%
Full scholarship	39	49
Partial scholarship	24	30
Fieldwork funding	3	4
Day to day research expenses	1	1
Other	13	16

Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

The awareness of funding sources for upskilling in the waste sector highlights the crucial role of academic networks in creating awareness of the HCD programme. More than two-thirds of beneficiaries (67%) learned about the funding opportunity through their lecturers, supervisors, or mentors. University-disseminated notices accounted for 10% of awareness, while peer networks through former or current beneficiaries contributed minimally (3%) to information dissemination. This pattern underscores the effectiveness of leveraging academic networks to ensure students are directly integrated into research projects with supervisors rather than relying on broader advertising strategies.

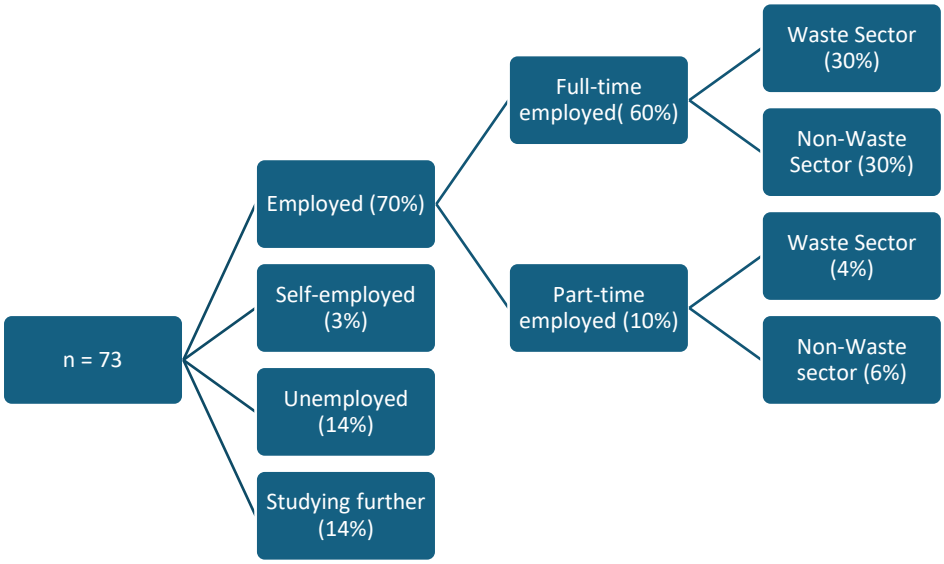
6 Beneficiary Labour Market Outcomes

A key feature of a tracer study is the ability to explore the STWT from education or training into the labour market, providing crucial insights into how education and training pathways translate into labour market outcomes. Understanding these transitions is vital for evaluating programme effectiveness and identifying potential areas for enhancement in preparing beneficiaries for successful pathways.

As reflected in Figure 5, the majority (60%) of respondents successfully secured full-time employment after completing their qualifications. Complementing this, 10% of beneficiaries entered part-time employment, while 3% demonstrated entrepreneurial initiative by establishing self-employment ventures outside the Waste Sector (no beneficiaries were self-employed in the Waste Sector). Fourteen (14%) of beneficiaries pursued full-time studies. The study also noted that 14% of all beneficiaries were unemployed at the time the survey was conducted.

In sum, 73% of graduates seeking jobs were able to find full-time or part-time employment. While this is lower than the graduate employment rate reported by Statistics South Africa (2024) of 90.2%, it is noted that disaggregation by job level and sector is not available. This information would provide a more appropriate benchmark against which to compare. Employability reports from individual institutions would also provide valuable data. For instance, the 2023 Graduate Employability Survey conducted by the University of Johannesburg showed that 67% of respondents (N = 7,132) were either employed or studying further, aligning well with the current study.

Figure 5: Current labour market destinations of beneficiaries



Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

6.1 Beneficiary Employment Outcomes Before and After Completion

For all respondents who completed their qualification (n = 73), the evidence as illustrated inTable 5 indicates their employment status before and after participation in the HCD programme. The data in the rows reflects their current employment status, while the data in the columns represents their employment status before participation in the Waste RDI Roadmap HCD Programme.

Studying full-time

Among beneficiaries who were full-time students before entering the programme (n = 32), 69% (n = 21) managed to secure various forms of employment post-qualification. Specifically, 19% (n = 6) of individuals entered full-time employment within the Waste Sector, while 34% (n = 11) found full-time positions in other sectors. Of the remaining graduates, six individuals chose to continue their academic journey through further full-time study. Only four individuals in this category reported unemployment post-qualification. Employed graduates are distributed across part-time roles in the waste and non-waste sectors, with one individual pursuing entrepreneurship through self-employment.

Full-time employment in the Waste Sector

The evidence demonstrates strong employment retention for those who entered the programme while already in full-time employment (n = 17), with most maintaining full-time positions either within the Waste Sector (n = 7) or in other sectors (n = 5). In addition, six respondents (8%) transitioned directly from studying full-time into full-time employment

Notably, one individual transitioned to further studies, indicating the programme might have opened pathways for academic advancement, while another moved into self-employment, possibly indicating recognition of entrepreneurial opportunity. Two respondents (3%) transitioned from part-time employment into full-time employment, and six (8%) who did not work transitioned into full-time employment.

Full-time Employment in Non-Waste Sectors

Of the 22 respondents (30%) employed full-time in non-waste sectors, 11 respondents (15%) transitioned from studying full-time, 5 respondents (7%) remained in full-time employment, and 5 respondents (7%) transitioned from part-time employment. Only 1 respondent (1%) transitioned from being previously unemployed.

Part-time employment

The trajectory of part-time employees (n = 10) also shows particularly positive movement, with seven individuals progressing to full-time employment, representing significant career advancement. Two maintained part-time positions, while one chose to pursue full-time studies, demonstrating that the programme could have catalysed this career development.

Self-employed

A single self-employed individual's transition to full-time employment in the Waste Sector offers an interesting case of formal sector integration, though the small sample size limits broader conclusions.

Unemployed

Perhaps the most encouraging results were the outcomes for previously unemployed beneficiaries (n = 13). The majority secured employment, with six obtaining full-time positions in the Waste Sector, demonstrating the programme's effectiveness in facilitating sector-specific employment. Additional transitions to non-waste sector employment and part-time roles further underscore the role of the programme in enhancing employability. While three individuals remained unemployed, the overall pattern suggests the programme significantly improved employment prospects for this vulnerable group.

Table 5: Labour market outcomes following completion of qualification (n = 73)

		After completion of qualification							
		Studying full-time	Full-time employment (WS*)	Full-time employment (non-WS)	Part-time employment (WS)	Part-time employment (non-WS)	Self-employed (non-WS)	Not working at all	Total
Before completion of qualification	Studying full-time	6	6	11	1	3	1	4	32
	Full-time employment	1	7	5	0	0	1	3	17
	Part-time employment	1	2	5	1	1	0	0	10
	Self-employed	0	1	0	0	0	0	0	1
	Not working at all	2	6	1	1	0	0	3	13
	Total	10	22	22	3	4	2	10	73

*WS: Waste Sector

Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

Gendered Transition Outcomes of Respondents

The above analysis was further disaggregated by gender (Table 6 and Table 7). Notably, 70% of male beneficiaries secured full-time positions compared to 53% of their female counterparts. This employment disparity becomes even more pronounced when examining unemployment percentages, where 21% of female beneficiaries reported being unemployed compared to just 3% of male beneficiaries.

Examining the transition patterns more closely, male beneficiaries demonstrated particularly strong outcomes in moving from pre-programme participation as unemployment to full-time employment, most notably, among previously unemployed male participants, all but one successfully secured employment following qualification completion. Female beneficiaries experienced more varied transitions, with several remaining unemployed post-qualification despite similar starting conditions.

Gender disparities in the waste management sector have been widely documented globally, reflecting a male-dominated sector across the waste value chain (UNEP-IETC & GRID-Arendal, 2019). Gender disparities in respect of employment patterns in South Africa are further confirmed by Statistics South Africa, namely, with female labour force participation rate (LFPR) being approximately 6% points lower than males, employment rate for females being 10% points lower than males and the gender gap for graduate's favours males over five years from 2017 to 2022 (Statistics South Africa, 2022).

Such gender disparities in labour market outcomes raise important questions about the typically male-dominated Waste Sector and about potential structural barriers or systemic challenges that might differentially affect female beneficiaries' employment prospects.

Table 6: Labour market outcomes for male beneficiaries following completion of qualification (n = 30)

		After completion of qualification							
		Studying full-time	Full-time employment (WS*)	Full-time employment (non-WS)	Part-time employment (WS)	Part-time employment (non-WS)	Self-employed (non-WS)	Not working at all	Total
Before completion of qualification	Studying full-time	3	2	4	1	2	0	0	12
	Full-time employment	0	3	2	0	0	0	1	6
	Part-time employment	0	1	3	1	0	0	0	5
	Self-employed	0	1	0	0	0	0	0	1
	Not working at all	0	4	1	1	0	0	0	6
	Total	3	11	10	3	2	0	1	30

*WS: Waste Sector

Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

Table 7: Labour market outcomes for female beneficiaries following completion of qualification (n = 43)

		After completion of qualification							
		Studying full-time	Full-time employment (WS*)	Full-time employment (non-WS)	Part-time employment (WS)	Part-time employment (non-WS)	Self-employed (non-WS)	Not working at all	Total
Before completion of qualification	Studying full-time	3	4	7	0	1	1	4	20
	Full-time employment	1	4	3	0	0	1	2	11
	Part-time employment	1	1	2	0	1	0	0	5
	Self-employed	0	0	0	0	0	0	0	0
	Not working at all	2	2	0	0	0	0	3	7
	Total	7	11	12	0	2	2	9	43

*WS: Waste Sector

Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

To summarise, these findings paint a nuanced picture of post-Waste RID Roadmap HCD programme participation trajectories. The predominance of full-time employment suggests that the programme facilitated the labour market entry of programme participants. However, the large number of respondents not retained in the Waste Sector remains a concern, given that the primary objective was to expand (and retain) skilled labour there. Yet the diversity of outcomes, including outside the waste sector, from part-time work to continued education to unemployment, indicates that the STWT encompasses multiple pathways and may require varying levels of support for different beneficiaries.

Most critically, the gender-disaggregated analysis shows concerning disparities in labour market integration. The substantial gap between male and female employment levels (70% for males vs 53%

for females in full-time employment) and the disproportionate unemployment levels (3% for males vs 21% for females) point to potential systematic challenges affecting female career progression in the sector.

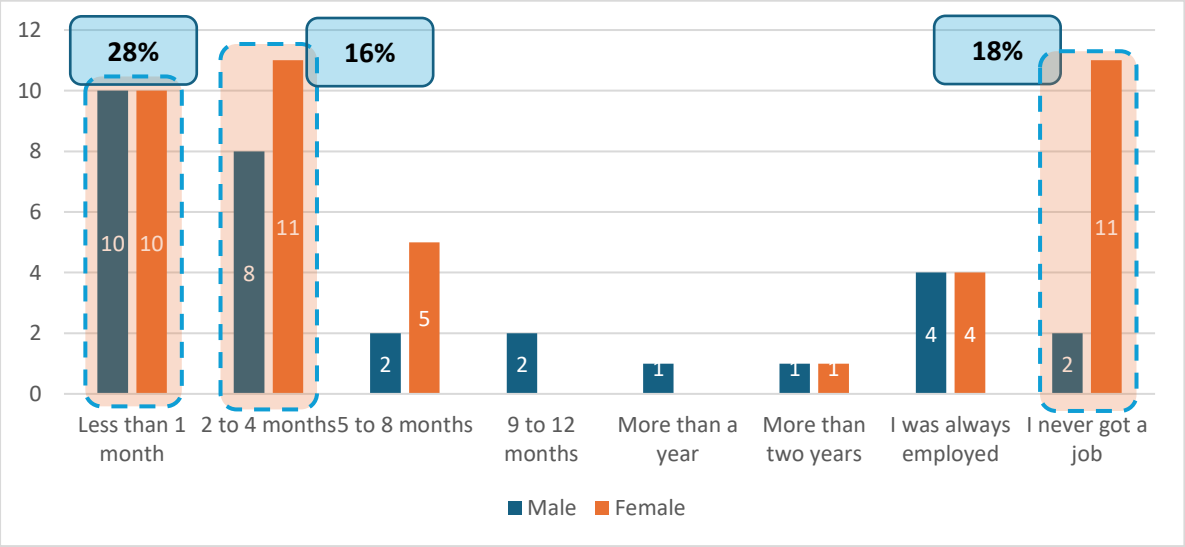
6.2 Beneficiary Time taken to Secure Employment

The number of months taken to acquire employment following their participation in the HCD programme is presented in Figure 6 **Error! Reference source not found.** and shows notable patterns, particularly when examined through a gender lens. Overall, the transition timeline varies among participants; almost a third of beneficiaries (28%; n = 20) secured employment within the first month of their waste sector post-qualification or internship, with no difference between male and female graduates. A further 16% quarter took 2-4 months, with a tenth (n=7) taking between 5 and 8 months to find employment. In comparison, 64.3% of respondents in the University of Johannesburg 2023 Graduate Employability survey (N = 7,132) reported finding employment within three months of graduating. However, a more nuanced examination by gender uncovers disparities in the STWT period.

Female beneficiaries generally experienced longer job search periods, with most requiring 2-4 months to secure employment compared to male beneficiaries. This extended transition period for women, compared to their male counterparts, suggests the presence of gender-specific challenges in the labour market entry process and a traditionally male-dominated sector. More concerning is the finding that most of those who never obtained employment were female beneficiaries (11 females compared to 2 males), pointing to persistent barriers to women's access to employment opportunities within the sector. Further exploration is needed to deepen our understanding of the factors influencing this pattern.

This pattern is especially problematic given the well-documented inverse relationship between unemployment duration and employment prospects - the longer an individual remains unemployed, the more challenging it becomes to enter the workforce. The shorter transition periods experienced by male beneficiaries might indicate better access to professional networks, more direct pathways to employment, or fewer structural barriers in their job search process.

Figure 6: Number of months to obtain employment since completing Waste Sector qualification or internship or placement (n = 72)



Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

Overall, 28% of graduates who secured immediate employment for both genders and 44% who secured employment within four months suggests moderate effective alignment between program training and industry needs. However, to further strengthen outcomes, it would be valuable to investigate the factors contributing to immediate employment success and examine whether specific qualifications or internship placements correlate with faster employment transitions. Additionally, understanding the quality and sustainability of secured positions could provide insights for program enhancement.

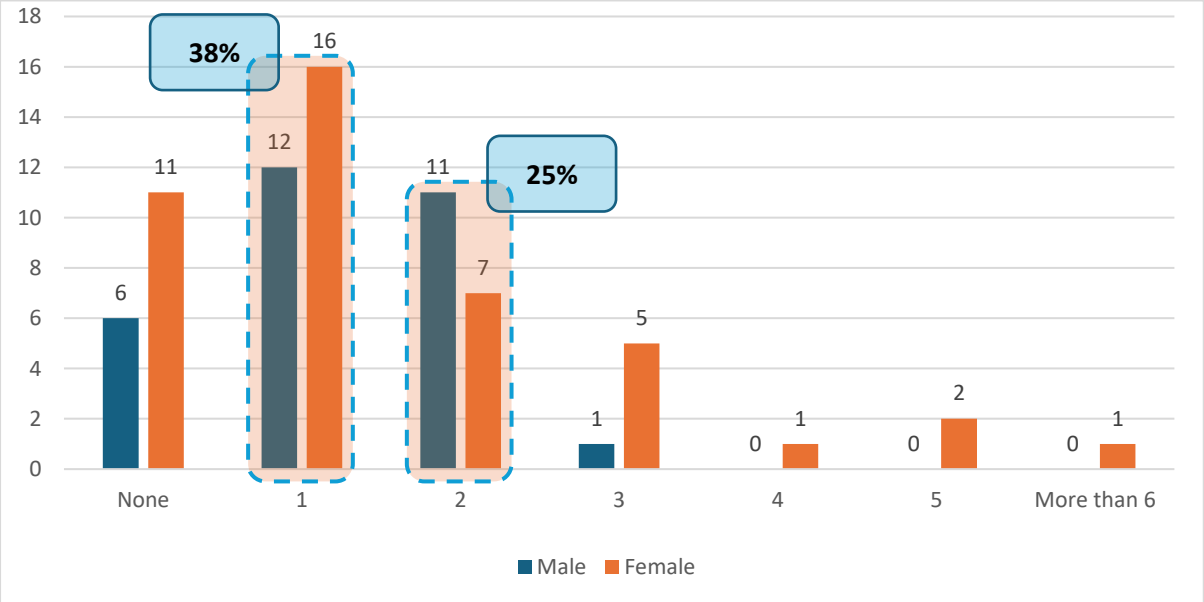
6.3 Beneficiary Number of Jobs Since Completion

Beneficiaries were also asked how many jobs they have held since completing the programme (Figure 7). Most beneficiaries (63%) experienced moderate job mobility, typically holding one job (n = 38). A further quarter (n=18; 25%) reported holding two positions since programme completion. This pattern balances career stability and professional growth, with beneficiaries either finding suitable long-term positions or making strategic moves to advance their careers.

The presence of beneficiaries with multiple job transitions is also interesting and requires a deeper investigation. It could indicate active career progression through different roles or organisations or that they are only securing employment with temporary/short-term contracts. The National Income Dynamics Study (NIDS) (2018) data revealed that young South Africans often remain in their first job for extended periods due to limited opportunities for advancement. Job hopping is less common compared to developed countries, where young workers frequently change jobs to gain experience and higher wages. However, these findings need to be contextualised within the relatively young age profile of the beneficiary cohort.

Approximately a third of the graduates (n=10; 36%) reported securing more than 3 jobs. An ILO study (ILO, 2022) found that young workers in developing countries often experience "churning" within low-quality jobs, with limited upward mobility, particularly true in Sub-Saharan Africa, South Asia, and Latin America.

Figure 7: Number of jobs had since completing Waste Sector qualification or internship or placement (n = 73)

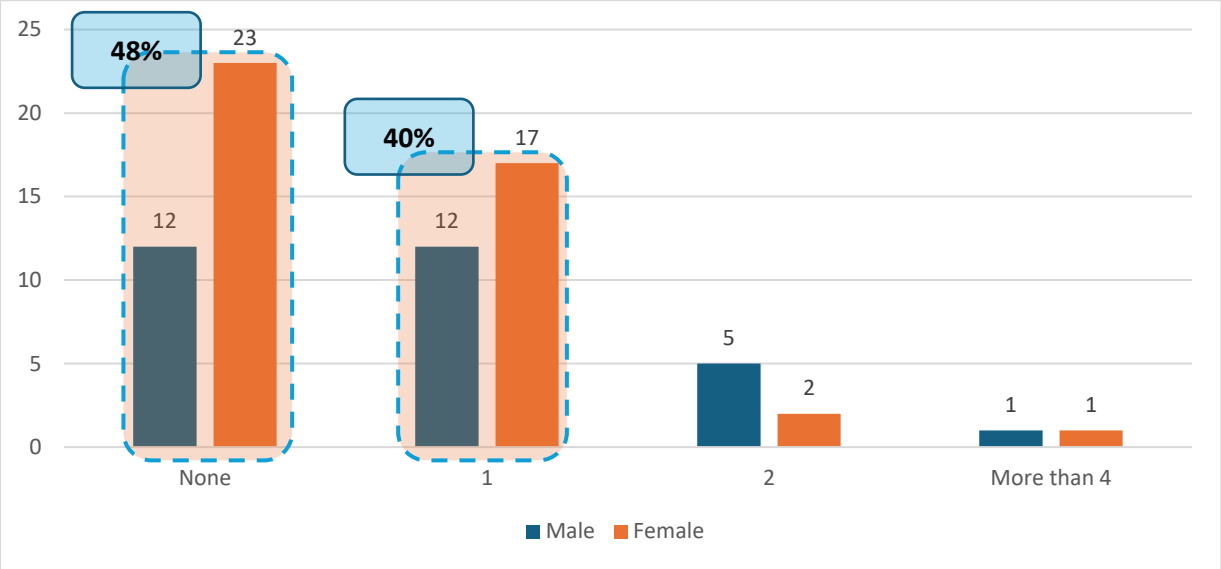


Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

Respondents were also asked about the number of jobs they had in the Waste Sector (Figure 8). Approximately half (n = 35; 48%) reported that none of their employment had been in the Waste Sector. Such a pattern might reflect several underlying factors: the transferability of acquired skills to other sectors, potential limitations in waste sector employment opportunities, or strong competition from other industries in attracting qualified talent. Nevertheless, a substantial 40% of beneficiaries (n = 29) secured at least one position within the Waste Sector. This suggests that, to a certain extent, the programme established viable pathways into the industry contributing to its human capital development objectives.

These contrasting employment patterns highlight important considerations about sector retention and career pathway development. The significant proportion of beneficiaries working outside the Waste Sector might indicate a need to examine factors such as sector attractiveness, career progression opportunities, and potential barriers to entry. At the same time, the moderate representation of beneficiaries who have secured waste sector employment underscores the programme's capacity to prepare participants for sector-specific roles while highlighting opportunities for enhancing retention.

Figure 8: Number of jobs that were in the Waste Sector (n = 73)



Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

6.4 A Profile of Employed in the Waste Sector

A key objective of the HCD programme is to support the upskilling of the Waste Sector. Critical to this is the retention of skilled Waste Sector workers. Of the 73 HCD beneficiaries who completed their qualification, 25 (34%) were employed in the Waste Sector. Notably, beneficiaries in full-time employment were equally distributed between males and females, whereas males exclusively reported part-time employment.

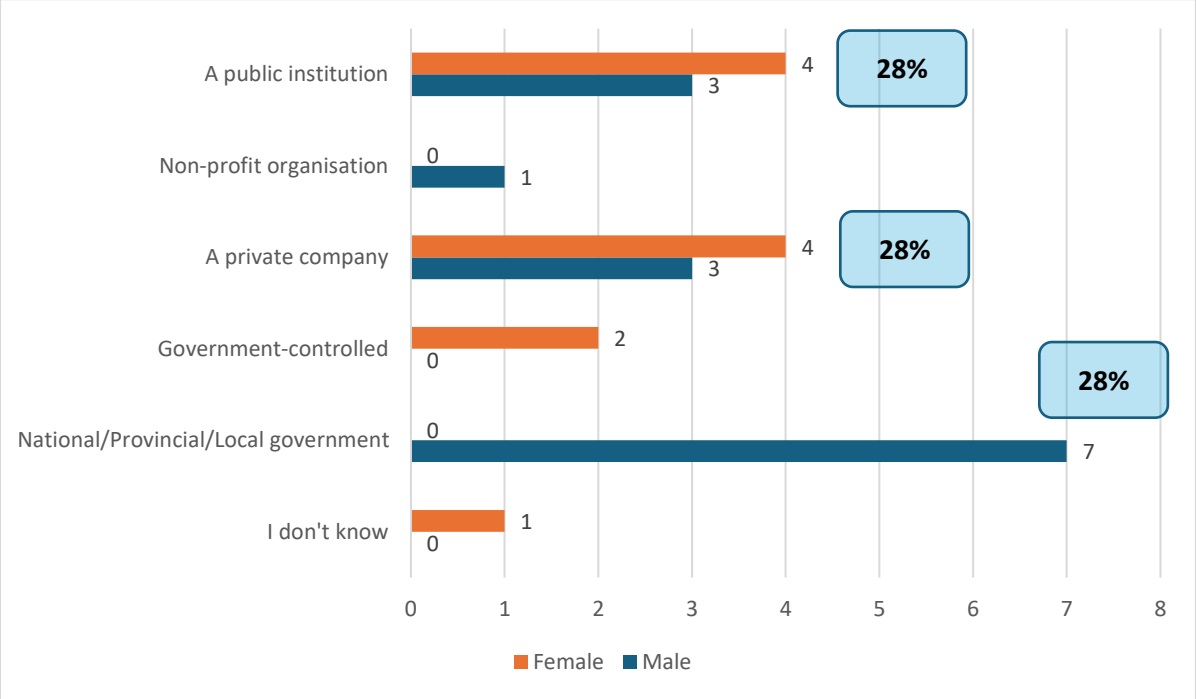
Of those employed in the Waste Sector, most (n = 21) worked in roles aligned with their qualifications. Only a small number (n = 5;20%) were employed at the institutions where they completed their qualifications, while most (n = 20; 80%) found employment at other institutions.

All respondents in the Waste Sector were employed under formal contracts, with 12 (48%) holding fixed-term contracts and 13 (52%) in permanent positions with no end date. This distribution reflects a relatively stable employment pattern among waste sector beneficiaries, particularly full-time ones.

Furthermore, most beneficiaries (n = 20; 80%) have secured full-time positions, with an equal distribution between male and female employees. Other forms of employment represent significantly smaller proportions of the sample. Part-time and temporary positions each account for 8% (n = 2) of employment. Casual employment represents the smallest category at 4% (n = 1).

Employers were classified into public institutions, private companies, and government entities. **Error! Reference source not found. Error! Reference source not found.** shows the classifications of these employers, with the most common being government institutions, public institutions and private companies (28%).

Figure 9: Classification of beneficiaries' current employer (n = 25)



Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

The largest proportion of respondents (n = 10; 40%) work in large enterprises employing more than 150 people, suggesting significant absorption of program graduates by well-established organisations in the sector. Mid-sized companies employing 50-149 people account for 16% (n = 4) of employment, while companies with 20-49 employees represent 12% (n = 3) of placements. Only 4% (n = 1) work in smaller companies with 2-4 employees. Notably, a substantial proportion of respondents (28%, n = 7) indicated they were unsure of their company's size. This distribution suggests that larger companies are the primary employers of program beneficiaries, with 56% working in companies employing 50 or more people.

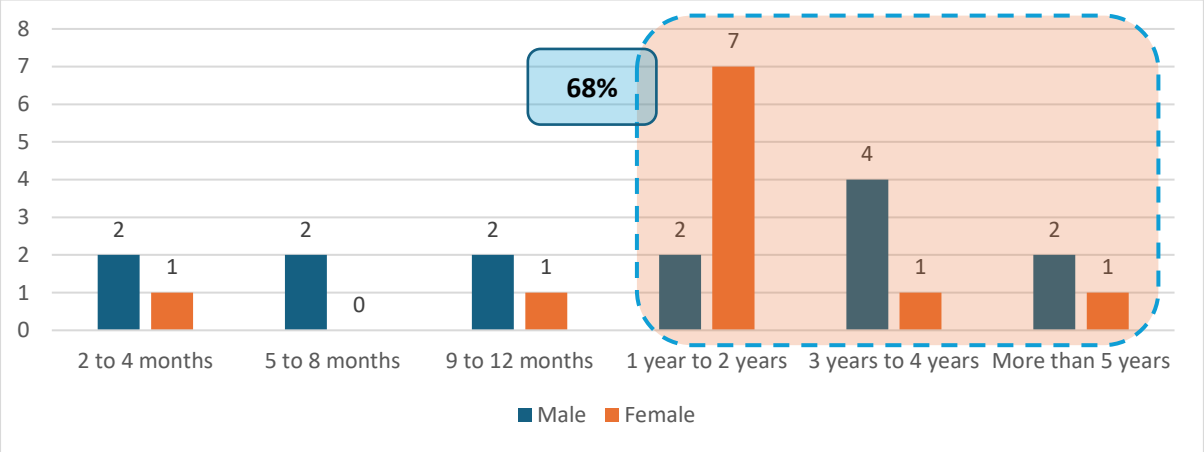
In terms of the specific Waste Streams their organisations are involved in, municipal waste emerges as the predominant single-stream focus, representing 20% of employment and notably staffed entirely by male beneficiaries (n = 5). Both organic waste and plastic waste streams each account for 16% of employment (n = 4 each). The waste electrical and electronic equipment (WEEE) stream shows limited representation with only one female beneficiary, comprising 4% of the sample.

Perhaps most tellingly, the largest proportion of beneficiaries (n = 11; 44%) work in positions that transcend traditional waste stream categories or operate in specialised niches. This group, almost evenly split between male (n = 5) and female (n = 6) beneficiaries, encompasses diverse areas including

engineering consulting, research, training and educational services, agricultural waste management, and waste minimisation. Some beneficiaries report working across multiple waste streams, indicating the integrated nature of many waste management operations.

There was variation in the duration of respondents' employment in their current role, with most being employed for 1-2 years (**Error! Reference source not found.**). In fact, overall, 68% had sustained their positions for more than a year. This is expected as the study transversed several graduation years and respondents thus entered the labour market at different times.

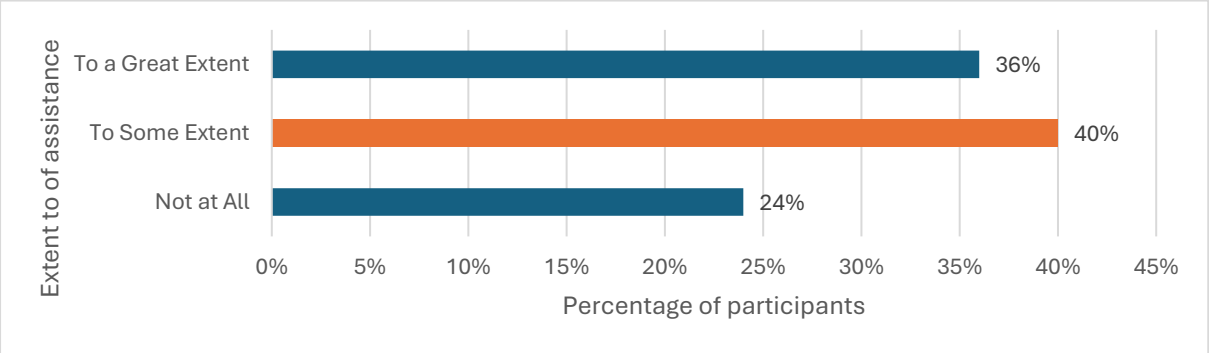
Figure 10: Beneficiary's employment duration in current job (n = 25)



Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

The contribution of the Waste RDI Roadmap HCD Programme in supporting respondents in their job acquisition was explored (**Error! Reference source not found.Error! Reference source not found.**). The Waste RDI Roadmap HCD Programme was reported to have contributed positively to job acquisition for most of the Waste Sector respondents, as elaborated in **Error! Reference source not found.** below. Specifically, 40% indicated that the programme *helped them to some extent*, while 36% stated it *helped to a great extent*. However, 24% reported *no contribution* from the programme in securing a job.

Figure 11: Extent to which Waste RDI Roadmap HCD Programme funding assisted beneficiaries in finding a job (n = 25)

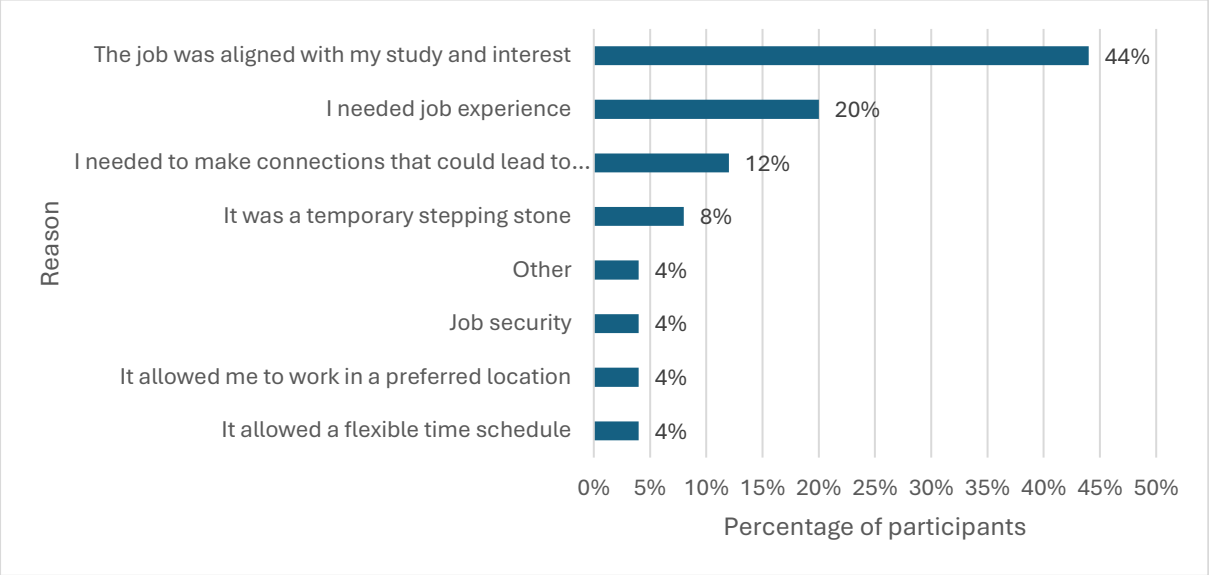


Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

Understanding employment acceptance motivations provides crucial insights into how graduates navigate career choices within the country's challenging labour market. The beneficiaries were then asked why they accepted the jobs they are currently holding. The strongest driver for accepting positions was alignment with academic preparation and personal interest (44%), followed by the need

to gain job experience (20%). This suggests that beneficiaries were able to secure meaningful employment aligned with their career aspirations rather than accepting positions purely out of necessity. The emphasis on building professional networks (12%) and viewing positions as stepping stones (8%) further indicates strategic career planning approaches. Other considerations including flexible scheduling, preferred location, and job security (4% each) played smaller but notable roles in decision-making.

Figure 12: Reasons for accepting current employment (n = 25)



Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

To fully understand the working conditions of the 25 who indicated to be employed, they were asked a series of questions to provide crucial insights into the quality of employment. Occupational protections and workplace policies show particularly high compliance rates. Nearly all respondents (24 out of 25) reported the existence of sexual harassment policies, with 21 indicating proper enforcement. Similarly, 23 beneficiaries confirmed receiving occupational health and safety protection, suggesting strong commitment to worker safety in what can be a hazardous sector.

Table 8: Working conditions and employment protection (n = 25)

Item	Yes	No	Don't know
Does your employer contribute to any pension/retirement fund for you?	13	11	1
Are you entitled to any paid vacation leave?	19	5	0
Are you entitled to paid sick leave?	24	1	0
Are you entitled to maternity leave…	16	5	4
Does your employer pay UIF contributions…	22	3	0
Are you entitled to medical aid benefits…	14	10	1
Does your employer deduct income tax from your salary	23	2	0
Does your employer have a sexual harassment policy…	24	1	0
Is the policy properly enforced…	21	0	2
Does your employer provide you with occupational health & safety protection…	23	2	0

Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

Basic statutory benefits show robust compliance: 24 beneficiaries have access to paid sick leave, 22 receive UIF contributions, and 23 have income tax deductions, indicating formal employment

arrangements. Paid vacation leave is available to 19 respondents, and maternity leave to 16, though notably 4 were unsure about maternity benefits.

However, some gaps emerge in non-statutory benefits. Just over half of respondents (n = 13) receive pension/retirement fund contributions, while 14 have access to medical aid benefits. This suggests that while employers generally meet mandatory requirements, there's variation in the provision of additional benefits.

Table 9: Relationship between current work and studies (n = 25)

Statement	Not at all	To a limited extent	To Some extent	To a great extent
To what extent is YOUR WORK related to what you learned during your studies/internship/postdoc placement?	4%	0%	28%	68%
To what extent have your CAREER EXPECTATIONS been met after completing your learning intervention?	4%	4%	36%	56%

Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

Looking at the alignment between learning interventions and workplace applications, the data shows remarkably positive outcomes, with more than two-thirds (68%) of beneficiaries reporting that their current work relates “to a great extent” with what they learned during their studies, internships, or postdoctoral placements. This strong alignment is further reinforced by an additional 28% indicating that their work relates “to some extent” with their educational preparation, while only 4% report no relationship between their studies and current work.

When examining career expectations, the findings remain positive, though slightly more nuanced. More than half (56%) of beneficiaries indicate their career expectations have been met “to a great extent,” with another 36% reporting expectations met “to some extent.” A small proportion reported less favourable outcomes, with 4% each indicating their expectations were met “to a limited extent" or “not at all." Nevertheless, the combined 92% reporting at least some fulfilment of their career expectations presents a compelling picture of program success.

These findings are particularly significant as they validate both the program's curriculum design and its practical implementation. The high degree of alignment between learning and workplace application suggests that the program is successfully preparing beneficiaries for actual sector demands rather than merely providing theoretical knowledge.

In terms of career outcomes after completing the learning intervention, respondents reported the following:

- A quarter (n = 6; 24%) *received a promotion* and a further quarter 24% (n = 6) *moved into a new role or position*.
- A fifth reported *receiving a pay raise (n = 5; 20%)*; and
- 12% (n = 3) experienced *no change* in their employment situation.

These findings paint a positive picture of employment quality in the waste sector, suggesting that the program is successfully facilitating access to secure, long-term employment opportunities rather than precarious work arrangements.

Drawing on findings from the focus groups (FGs), respondents reported that the ability to secure a job often depended on personal initiative, networking opportunities provided by supervisors, or exposure to industry-related conferences and workshops during the programme. Once in employment, promotions and pay raises were often linked to networking facilitated by supervisors or the prestige

of having CSIR-related experience on their resume rather than directly applying Waste Sector skills. Some respondents highlighted that working in related sectors (e.g., mining, environmental management) contributed to their career progression even if the jobs were not directly in the Waste Sector.

> *Recently, I got selected into the [ ] programme where there are a number of global researchers from different universities. I was selected specifically for my growing expertise in the waste sector focusing on food waste. We'll be having a second training session that will be hosted at the University of [ ]. These contacts and interactions with people in the waste sector, Professor [ ], Professor [ ] have had a great contribution in my growth and development.* – Employed in the Waste Sector FG

> *Having CSIR on my CV definitely has helped. People seem to be impressed with that.* – Employed in the Waste Sector FG

The barriers to employment noted by focus group respondents included gatekeeping in the Waste Sector, lack of mentorship, and limited practical experience provided by employers. A few respondents indicated they faced financial constraints, and some reported withdrawing from the programme due to personal or institutional challenges.

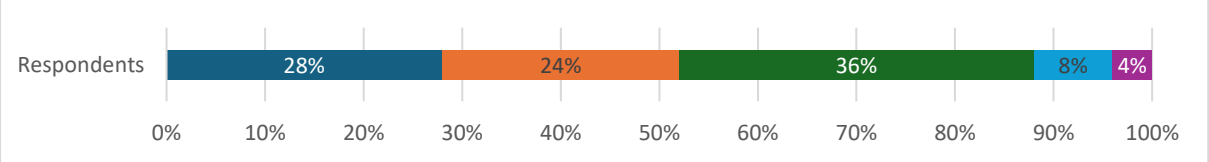
Most respondents reported that their work was related to what they had learned during their studies, either *to some extent* (n = 7) or *to a great extent* (n = 17). One respondent noted that their work was *not at all* related. In addition, most respondents *agreed* (n = 10) or *strongly agreed* (n = 13) that a waste-related qualification had allowed them to carry out job-related tasks effectively. Two were, however, *undecided*.

The majority of respondents reported receiving training from their employer (n = 23) and rated its impact on their skills and competencies as *significant* (n = 10) or *very significant* (n = 13). Despite this, only 18 responded that they believed their employer was focused on building their career in the Waste Sector, with 11 stating that the employer was not and one reporting not knowing if the employer was supportive.

About alignment with career, respondents reported that their career expectations after completing the learning intervention had largely been met, either *to some extent* (n = 9) or *to a great extent* (n = 14). One respondent reported their expectations had been met *to a limited extent* and one reported *not at all* met. Furthermore, most respondents described the relationship between their current job and desired career as *related* (n = 6) or *highly related* (n = 15). Three described it as *somewhat related* while one reported *unrelated*.

When asked about the likelihood of moving away from the Waste Sector, the majority did not deem this likely (n = 13**Error! Reference source not found.**).

Figure 13: Likelihood of respondent moving away from the Waste Sector (n = 25)



Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

There were, however, three respondents who noted that they were likely to move out of the sector with their reasons as follows:

> *Am open to any other funding*
>
> *It's just lack of job opportunities in the Waste Sector*
>
> *I enjoy the Waste Sector but for growth, I need to explore other areas as well*

6.5 A Profile of Employed in Non-Waste Sector

There were 26 respondents (43%) who were employed in the non-Waste Sector, either full-time (n = 22) or part-time (n = 4).

Respondents reported facing multiple challenges in securing employment in the Waste Sector, mainly stemming from systemic, experiential, and personal barriers. One prominent issue was a lack of relevant work experience and internships. Many jobs within the sector require significant prior experience, making it difficult for recent graduates and early-career professionals to qualify. This lack of practical exposure was compounded by limited opportunities for positions, particularly for those in research-focused roles.

A focus group participant noted the following:

> *I couldn't get any job in the sector because there's no real opportunity unless you prepare to develop the technology for the market.* – Employed in a non-Waste Sector FG

Some respondents cited gatekeeping in the sector, especially in research and municipal roles. Despite having advanced degrees, such as PhDs, they found that municipalities preferred to hire engineers or those with diplomas in environmental health. Networking limitations were another significant hurdle, as job seekers needed personal connections or mentors to access these roles. The absence of mentorship and support, especially for underrepresented groups like Black women, further restricted their entry into the field.

For some, personal factors and career interests influenced their job outcomes. They pursued studies in the waste sector as an extension of broader academic goals, such as urban studies, and did not necessarily seek direct employment within waste management.

In summary, participants encountered barriers such as employers requiring work experience, which they lacked, sectoral gatekeeping, limited networking opportunities, lack of mentorship, inadequate funding, and unappealing job conditions. These factors hindered their ability to secure employment within the waste sector, despite their academic qualifications and interest in the field.

6.6 A Profile of Self-Employed in the Non-Waste Sector

Only two respondents were self-employed, both in the non-Waste Sector. When asked why their businesses were in the non-waste Sector, one respondent reported that they were pursuing further studies to obtain a doctoral degree, while the other had started the business they had always wanted. The latter respondent, however, was considering initiating a business in the Waste Sector.

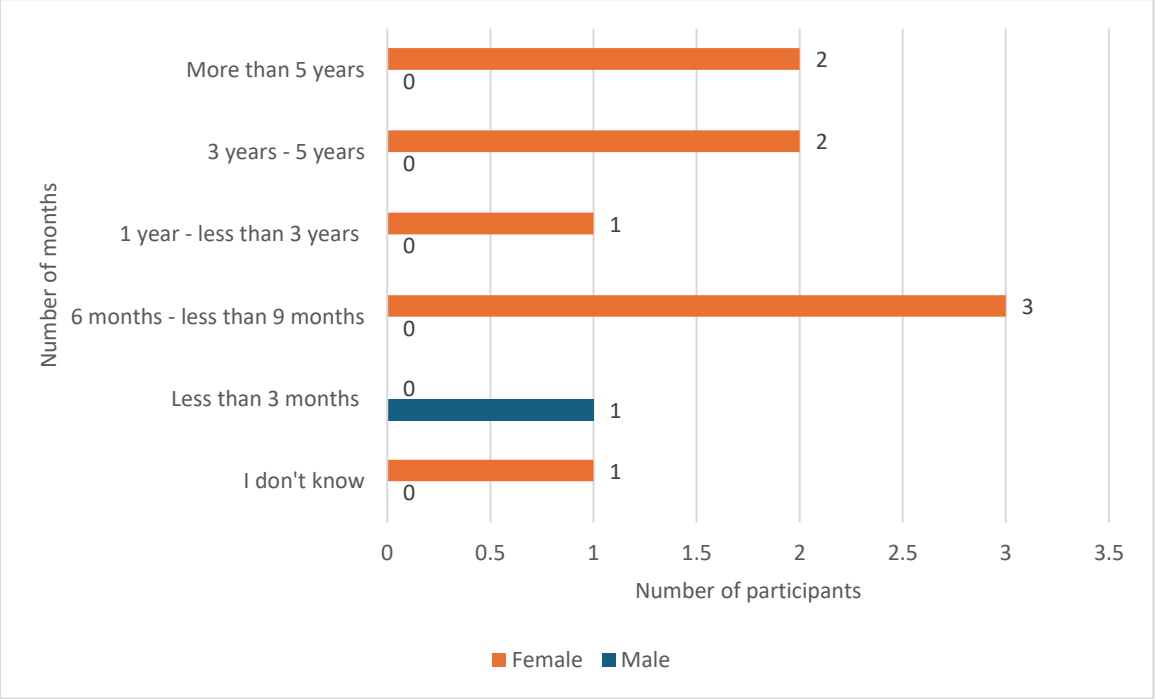
6.7 A Profile of Respondents who are Unemployed

Of the ten unemployed participants, they were primarily female (n = 9). Most were *unemployed and looking for work* (n = 9), while one was unemployed and currently not looking *but would accept if offered a suitable job*. The most common duration of months seeking employment for unemployed

females was 6-9 months, while male unemployed respondents reported less than three months (Figure 14). It is noteworthy that some female respondents (n=4) had been job-seeking for more than five years.

Given the unemployment situation, they were asked how they support themselves. Unemployed beneficiaries reported getting financial support from persons both in their household (n = 4) and outside of their household (n = 2), indicating a reliance on personal networks and safety nets. Other sources of support were cited (n = 4), including personal savings or government unemployment benefits.

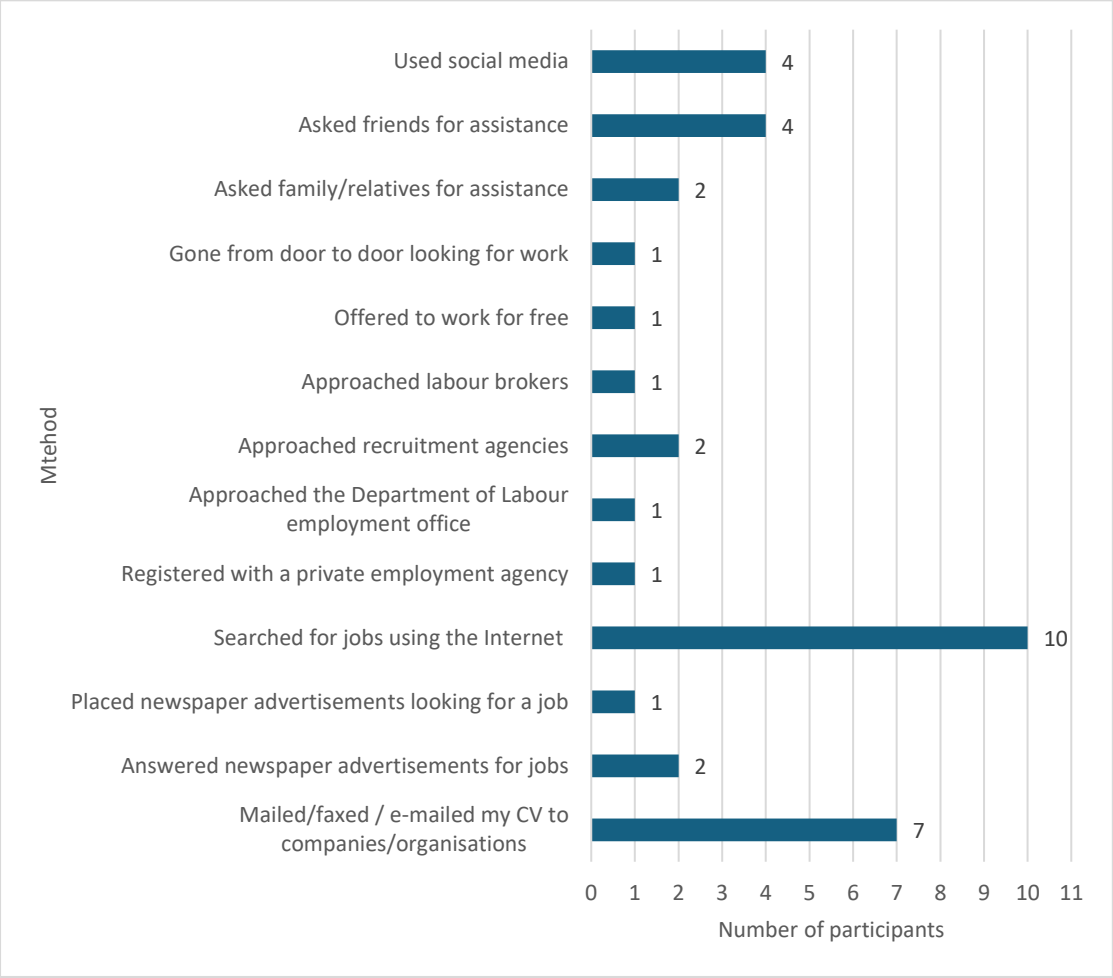
Figure 14: Number of months seeking employment (n = 10)



Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

A wide range of methods to search for jobs was utilised (Figure 15), but the most common was seeking online jobs (n = 10). Other methods included emailing CVs to companies, and some less common methods included approaching recruitment agencies, offering to work for free, going from door to door, and waiting on the side of the road. The methods that involved a more direct, in-person outreach or conventional approaches appear to be used by a smaller portion of beneficiaries. None of the respondents reported enquiring at workplaces/farms/factories/shops, waiting at the side of the road, or doing nothing.

Figure 15: Main methods used to search for employment (n = 10)



Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

Respondents were asked for what they think are the main reasons that they did not secure employment in the Waste Sector. A significant factor seems to be the lack of jobs available in the waste sector, suggesting that greater awareness can be made of graduate skills and benefits for employers:

- No Waste Sector jobs available (n = 4)
- I don't know where to find Waste Sector jobs (n = 2)
- Waste Sector employers are not interested (n = 1)
- Work is not appropriate for my skills (n = 1)
- Other (n = 2) including relocation and continuing with further studies

Employer disinterest and skills mismatch are also notable barriers, indicating challenges around recruitment and hiring practices in the sector.

6.8 A Profile of Respondents Pursuing Full-time Studies

Of the ten respondents who reported studying full-time, eight were doctoral candidates, one was a Master's student, and one was completing a postgraduate certificate. Eight respondents were enrolled at a South African university, one at a South African University of Technology, and one at a higher education institution outside of South Africa. Most respondents were completing studies in a Waste Sector-related field (n = 9), with only one stating that they were not.

The reasons provided for studying towards a Waste Sector-related qualification were (multiple options could be selected):

- To increase my knowledge and understanding of the Waste Sector industry (n = 7)
- To achieve a higher qualification in the Waste Sector (n = 5)
- To help me get a better job in the Waste Sector (n = 4)
- To further my interest in a particular subject area (n = 4)
- To develop skills in a different industry (n = 3)
- This is a gap identified in the industry, and I wish to fulfil that need (n = 2)
- To help me earn more money (n = 2)
- To improve my change of finding a job in the Waste Sector (n = 1)
- To improve my promotion opportunities (n = 1)

The analysis of beneficiaries' post-education aspirations reveals diverse career pathways within the waste sector, clustering around three main trajectories: academic/research pursuits, sector employment, and entrepreneurship. Some respondents expressed interest in advancing their academic and research careers. This is evidenced by aspirations to pursue postdoctoral fellowships, secure university lecturing positions, and continue research activities. Notably, these research ambitions are specifically focused on addressing identified knowledge gaps within the waste sector, suggesting a desire to contribute to sector development through scientific inquiry.

Employment in the waste sector emerges as another dominant aspiration, with several respondents explicitly stating their intention to gain practical industry experience. This includes interests in both public sector employment (government) and broader industry positions. The emphasis on "real experience" and "relevant" work suggests beneficiaries value practical application of their acquired knowledge. Some beneficiaries demonstrate entrepreneurial aspirations, specifically mentioning intentions to establish or continue research-focused businesses within the waste sector. This indicates potential for the program to contribute to sector growth through enterprise development. An interesting pattern emerges in how respondents frame their aspirations - many express dual or flexible career paths, such as combining sector employment with research or keeping options open between academic and practical sector work. This suggests beneficiaries recognize the value of diverse experience and maintain adaptable career perspectives. These varied aspirations align well with sector needs for both practical implementation capacity and continued research and development.

6.9 A Profile of Respondents who Withdrew from the HCD Programme

Seven respondents withdrew from the Waste RDI Roadmap HCD Programme prior to completion. During a focus group session with these respondents, insights were gained as to what had led to their withdrawal:

Challenges with supervisor communication: Working with supervisors caused frustration to the extent that they withdrew. Furthermore, the supervisor appeared unsure whether to include the intern as an author on a research report despite their contributions to the report.

> *"He kept sending me back and forth. This is not what I want. Do it like this. This is not what I want. Do it like this until I really became frustrated and I was like, OK. I really don't know what you want and I just need to quit."* – Withdrawn FG

Lack of support and monitoring: Linked to the above, participants indicated unhappiness with the lack of supervision provided by supervisors.

> *"You guys need to put more effort into supervising the supervisors who supervise us. Right, see, like the effort that you guys are putting in now to track us. And if you would put that same effort into tracking the program as it's still happening, right. I think if I had something like this, had somebody to talk to and voice out all my frustrations and everything that I'm going through, I think my outcome would have turned out differently"* – Withdrawn FG

> *"…I lost hope in the education system at first, and I saw myself discouraging people from studying. And say that you know what? It's so useless".* – Withdrawn FG

Financial and personal challenges: A participant's loss of a grandmother and food affordability challenges led to them exiting the programme. While the bursary offered R70,000.00 to cover fees, it did not cover living expenses.

Programme structure: It was reported by a beneficiary that the duration provided to complete their doctoral programme (one year) was considered too short. This is highlighted as most PhD programmes are substantially longer, suggesting a communication fail or error.

7 Beneficiary Perceptions of the HCD Programme

7.1 Quality of Mentorship

The literature overwhelmingly demonstrates that high-quality mentorship is a pivotal component of impactful internship programmes across various fields (Marinas et al., 2018; Beard & Morton, 2016; Weber, 2021; Chin et al., 2020). Effective mentorship, characterised by engaged and well-trained mentors, leads to more positive outcomes for both interns and host organisations. These outcomes include greater satisfaction with the internship, increased learning and skill development for interns, improved future employability, and higher retention rates for those later hired into full-time roles (Weber et al., 2021). Furthermore, Chin et al. (2020) explain that robust programmes and thoughtful mentor-mentee matching, alongside steady guidance and support, empower interns to apply academic knowledge to professional practice successfully. Given the documented importance of mentorship quality, the survey asked beneficiaries to evaluate the training and mentorship they received from *poor to excellent*. Encouragingly, an overwhelming majority (67 out of 73 beneficiaries) rated this aspect highly (Table 10).

Table 10: Quality of received training or mentorship (n = 73)

Rating	Male		Female		Total	
	No.	%	No.	%	No.	%
Poor	0	0%	0	0%	0	0%
Below average	0	0%	1	2%	1	1%
Average	2	7%	3	7%	5	7%
Above average	4	13%	11	26%	15	21%
Excellent	24	80%	28	65%	52	71%
Total	30	100%	43	100%	73	100%

Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

Similarly, the relevance of the knowledge gained was rated extremely favourable, with 70% stating that it was *very relevant* (Table 11). Unsurprisingly, most respondents also noted that the training or mentorship they received as part of the programme met their expectations *to some extent* (n = 14) or *a great extent* (n = 57).

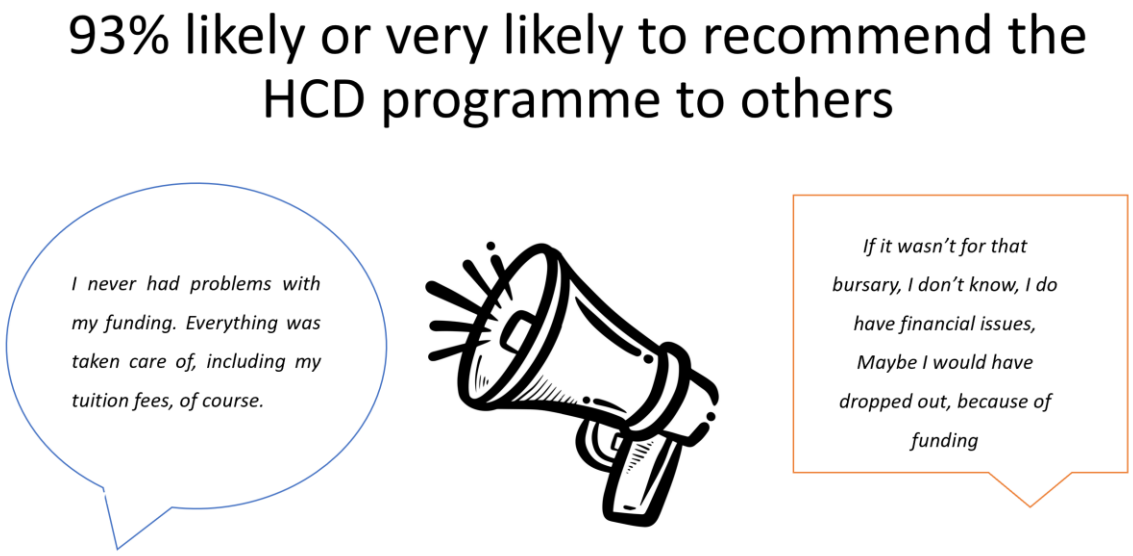
Table 11: Relevance of knowledge gained from training or mentorship (n = 73)

Rating	Male		Female		Total	
	No.	%	No.	%	No.	%
Not at all relevant	0	0%	1	2%	1	1%
Of little relevance	0	0%	2	4%	2	3%
Moderately relevant	3	10%	5	12%	8	11%
Relevant	6	20%	5	12%	11	15%
Very relevant	21	70%	30	70%	51	70%
Total	30	100%	43	100%	73	100%

Source: HSRC Waste RDI Roadmap Track and Trace Survey (2023-2024)

Finally, most respondents were *likely* or *very likely* to recommend the programme to others, while five were neutral.

7.2 Beneficiaries likelihood of recommending HCD Programme



7.3 Contribution to the knowledge economy

The HCD Programme evidenced positive contributions to the knowledge economy and upskilling of human capital in the Waste Sector by providing full and partial bursaries, for both single and multiyear postgraduate qualifications as well as stipends for internships. The HCD Programme yielded significant value and potential impact in various ways:

- Participants alluded to the support from lecturers and faculty advisors as a key enabler in identifying, accessing, and navigating the bursary application process and ensuring compliance with the conditions associated with the programme;
- Receiving bursaries alleviating the stress of financial challenges and other life obligations, thereby demonstrating that the funding was appropriately targeted to vulnerable populations;

If it wasn't for that bursary, I don't know, I do have financial issues, Maybe I would have dropped out, because of funding, and so on, but with that injection into the programme, I think it did meet the expectations that I really hoped for.

- Participants reported significant upskilling benefits from the programme, citing *improved knowledge* (11), *application of new knowledge* (8), and *overall improved outcomes* (9) as the top three benefits;

After obtaining the qualification I do believe that it's Making a positive contribution for career development and getting opportunities and it will continue to open those opportunities because I do have the right qualification and the correct skills acquired in that programme.

- Participants reported having acquired a range of useful non-qualification-related skills including Time management, project management, ICT skills, professionalism, project management, research, stakeholder engagement, teamwork & collaboration, communication, report writing and design thinking.
- While participants highlighted the immense value of gaining practical experience and networking opportunities, it was noted that the opportunities provided were insufficient.

All beneficiaries have reported overall positive, enriching, and transformative learning experiences. The relatively high levels of satisfaction reported are attributed to the well-structured programmes, curriculum and delivery. Participants echoed that it had earned them social recognition and has enabled them to have an impact (perceived), and benefit from increased opportunities for employment. They attributed these to the programme being provided at an appropriate level, offering practical experience and relevant coursework.

7.4 Labour Market History and Status

A common frustration reported by the respondents was the long duration of unemployment prior to graduation. Contributing factors included slow recruitment practices, industry infancy, lack of economic opportunity, inadequate qualification, and stifled industry growth.

Despite these factors, participants agreed that access to educational developmental opportunities has had an overall improved impact on employability.

7.4.1 Employed in Waste Sector

Participants in this category benefited from either a partial or fully funded bursary programme, and those who were subsequently employed in the Waste Sector reported improved economic opportunities, access to promotions and increased specialist recognition.

I've had people that are approaching me with opportunities to collaborate with waste management. So, it's been a lot of opportunities that people came knocking. So, I think having the degree and experience has given me the advantage of saying now you are ready for the work environment.

One participant who had struggled to find employment for a lengthy period previously attributed her success to her completion of the programme, stating:

The company was looking for someone that understood risk management, so with my qualification, it gave me a boost as I specialized in waste management. Previously, I did not understand waste management, I only had a basic understanding of general waste. So, when I added this degree of master's in environmental management, we specialized in waste management. I think it gave me a boost, having the qualification boosted me to be where I am now with the company that I'm with now.

Another participant was elated to share that the programme had deepened her practices in a manner that was recognised by her employer, resulting in a promotion.

The skills that I acquired during study is useful to my organisation, so that's why the promotion came.

7.4.2 Employed in Non-Waste Sector

A respondent who was supported by the programme through an internship noted that it had provided a stipend (their only source of income) as well as rich experiential opportunities for learning.

The programme stimulated their interest in the waste management sector, and they were keen to pursue further studies and leverage employment in the waste sector. The respondent stated:

I want to be a research scientist and so far, I've learned a lot from the project that I was working on. I hope that I can go back to school and get the funding because doing research is interesting, you get to discover things you don't know.

While the skills of these beneficiaries were currently not contributing to the waste sector, it had provided a rich learning experience, early career exposure to a work environment stimulated their agency, and increased their aptitude for learning, all of which may be beneficial for the human capital contributions to the Waste Sector if they did secure employment in the sector in the near future.

7.4.3 Pursuing Further Studies

Respondents reported that the choice to pursue further fulltime studies was partially due to the (perceived) lack of economic opportunity and employment in the Waste Sector. Factors which have this choice included career stage, age, peers, academics, and family, Intrinsic goals, research opportunities. Studying further also seemed more compelling where there are full bursaries available, inclusive of stipends and opportunities for travel, networking, and research engagements.

"I was expecting a bit of a follow up after the bursary, like some sort of Work integration, but not none of that happened. Just after I finished my master's, I was on my own to find work and which has been a huge challenge, so it was better to continue studying."

"I'm not really seeing the Waste Sector as the area that I could get immediate employment opportunities and that is part of the reason why I went the PhD route".

8 Employer Perceptions of the HCD Programme

The employer interviews provide valuable insights into the impact of the Waste RDI Roadmap HCD Programme and the challenges and opportunities for beneficiaries in the workplace. The following key themes emerged from these discussions, supported by quotes where applicable.

8.1 Varying levels of awareness across sectors

There was a diversity of levels of employers' awareness of the Waste RDI Roadmap HCD Programme, from a few with in-depth knowledge of the waste sector to those with no prior knowledge. Notably, private sector employers had limited prior knowledge of the CSIR HCD Programme before employing beneficiaries, while employers in the higher education and research sectors were well-acquainted with the initiative. For instance, one of the private sector participants said:

> *"We have not heard until we had we employed [beneficiary] onto our team. That's when we learn about the program and the council"*

On the other hand, the higher education and research sector participants who seemed well acquainted with the programme its objectives and had previously engaged in some collaborations with RDI said:

> *"I'm extremely aware because I was a grant holder of the research grant of the Road Map, so I was a beneficiary. There are not so many universities in South Africa's to start off, but those of us that do work in waste, in our network, we are all aware of the funding opportunities available to us and the research that can be conducted"*

The pathway to employment often involved professional networking, highlighting the importance of connections within this specialized field. One employer shared their experience:

"*She was recommended to us. We were looking for someone in that area of engineering and this was through referrals"*

8.2 Critical skills gap challenges in the sector

Analysis of the focus group discussions with waste sector employers further revealed several critical themes regarding human capital challenges, supported by their direct experiences. The acute skills shortage was starkly illustrated through recruitment challenges, as highlighted by one employer:

> *"So, we're looking at people with some background in waste and unfortunately, they were the only one out of the pool of about 300 applications who had experience in just waste".*

This market imbalance appears particularly severe in specialised subsectors, with employers citing heightened challenges in emerging areas such as e-waste management. As one participant emphasised:

> *"The e-waste sector is more neglected in my opinion than others, so that's why we're facing a challenge of getting skilled people in the industry."*

Employers also noted competitive pressures in talent acquisition, with one stating directly:

> *"We are competition with private industry. We cannot always compete with salaries offered by private industry."*

A dominant theme that emerged was the significant burden of training provision falling on employers due to institutional gaps. Multiple participants emphasised the complete absence of formal training

infrastructure, compelling reliance on in-house solutions. As one employer articulated: “The training we are doing is mainly in-house just because we do not have any training institutions.” This creates substantial operational challenges, with another participant noting: "Every time we employ someone that takes our time out to train them. So that's quite a challenge to all the electronic waste businesses now." The specialised nature of required skills compounds this challenge, particularly in handling hazardous materials. One employer vividly described this risk:

> *"When it comes to mainly electronic waste, you can't just take someone out there and say dismantle this washing machine or dismantle this laptop or a cell phone. Because inside the items they are toxins. That's why it's considered hazardous waste. It really can't harm your skin or can damage your eyesight or anything else."*

The analysis further revealed significant concerns regarding research and development capabilities within the sector. Employers expressed interest in conducting research but faced multiple barriers, including skills shortages and funding constraints.

The challenging nature of waste sector research was particularly emphasised for certain contexts, with one participant noting:

> *"Waste is not an easy field to do research, especially depending on where you go, like in the informal sector, I can tell you horror stories trying to do research there."*

Technical expertise gaps also extended to equipment maintenance, as illustrated by one employer:

> *"We got the machinery that are coming from China, of which even here in South Africa we don't have someone to service that machine when they are broken."*

These findings suggest a complex interplay between immediate operational challenges and longer-term sector development constraints. Employers were inclined to hire HCD Programme beneficiaries due to their appropriate academic qualifications and relevant experience. They expressed willingness to support employees' academic development and re-hire former employees to retain scarce skills.

8.3 Perceived positive benefits

Employers highlighted the value beneficiaries brought to their organisations through their skills, initiative, and ability to adapt quickly to work environments.

- The skills gained through the programme were considered practical and transferable, enhancing beneficiaries’ ability to perform well in their institutions. This is reflected in the comment below:

  “She went into a data analysis role, and she was very comfortable, and so the company benefited from such skills and exposure. I’m going to presume that that comes from her experience while she was working under your scheme.”

This also shows that employers appreciated beneficiaries' technical skills and expertise, particularly in some specialised areas, such as data analysis, emphasising how this skill directly benefited the company. Another employer highlighted the value of specific expertise in plant species, indicating that the program successfully matches specialised training with industry needs.

> *‘‘We were seeking an employee with specific expertise in plant species, etc. and [they] had this expertise”*

The improvement in audit performance mentioned by one employer provides concrete evidence of how graduates' technical skills translate into measurable organisational improvements.

> *"Since [the beneficiary] has been here, we have been doing so much better with passing all of our audits, not like before when we had challenges with that"*

Beyond technical skills, employers emphasize the quality and rigor that graduates bring to their work. This is particularly evident in the comment about "quality research" that contributes to policy-making decisions, suggesting that graduates are equipped to produce work that meets high professional standards and has practical policy relevance.

> ''*It allowed us to do quality research, you know, not wishy-washy research as I call it. It helps in gathering of information that can assist policymakers in decisions".*

- Beneficiaries' work contributed directly to improving waste management practices, promoting sustainability, and addressing community-level challenges as reflected below.

  She is a project leader of the waste recycling project at all the [ ] operations to reduce waste to landfill quantities to align with South Africa's 2030 zero waste to landfill goal.

  We are on a community level with our research and trying to understand what's really happening with waste in our communities.

Perhaps most significantly, employers note that graduates "set a good example," suggesting their positive influence extends beyond their immediate job responsibilities to contribute to organizational culture. This broader impact indicates that the program successfully develops not just technical experts, but workplace leaders who can influence and improve their professional environments.

> ''*they have set a good example into our company*''

8.4 Perceived challenges

Challenges include the emigration of beneficiaries, which results in a skills loss for the country, and the funding of initiatives. A strong recommendation was more educational opportunities and professionalisation in waste management, including developing specific courses and training programmes to enhance skills in the sector. Overall, employers demonstrated confidence in the HCD Programme: Employers expressed confidence in the HCD Programme, noting a clear link between the skills employed and the benefits experienced. They emphasised the value of investing in human capital and skilled labour for the success and growth of the Waste Sector.

8.5 Employer Validation Workshop Insights

The CSIR and HSRC hosted a validation workshop with Waste Sector stakeholders and employers of HCD Programme beneficiaries. It was aimed at presenting the findings of the study and seeking validation of the recommendations. o. Several employers expressed extremely positive views as illustrated below:

> *"We had a very positive experience as far as the cohort that's actually specifically focusing on the waste side of things, to the point that the two interns that were placed with us, we actually*

didn't even wait for the period to be completed, but it was shortly before that that we offered them permanent positions".

Employers furthermore raised a recommendation that universities or training institutions explore the practical capacitation of students in the Waste Sector through specialised training, rendering them ready for the workplace in terms of hands-on skills rather than only theoretical knowledge. This training could be in the form of short courses, webinars, placements, or programs for non-degree purposes that diversify beneficiaries' skillset and removes the potential barrier of lack of experience. For example, a university stakeholder noted that they have collaborated with local companies to provide students with placements for short-term training that helps them understand real-world applications beyond academic learning. However, some companies may offer stipends to students placed with them, but many do not which can make it difficult for students to sustain themselves if they cannot afford to volunteer.

Employers also noted that additional training in specialised topics as a cohort would give beneficiaries the opportunity to network with each other as well as bring fresh perspectives into their workplace.

9 Conclusions

The Waste RDI Roadmap HCD Programme demonstrates significant success in developing advanced skills and qualifications within South Africa's waste sector while also highlighting critical areas for improvement. The programmes outcomes reflect both its strengths and the broader challenges within South Africa's labour market and waste management sector.

9.1 Key Conclusions

9.1.1 Programme Effectiveness

The Waste RDI Roadmap HCD Programme demonstrates both significant achievements and areas requiring strategic intervention. The programme's 60% full-time employment rate among graduates reflects meaningful success in developing employable skills, while the 14% pursuing further studies indicates its role in building advanced research capacity. The quality of academic training emerges as a programme strength, with over 70% of beneficiaries rating their training and mentorship as excellent. However, transitioning from academic excellence to Waste Sector-specific employment remains challenging, particularly regarding practical experience and industry exposure. Employer feedback validates graduates' technical capabilities while highlighting gaps in practical application skills.

9.1.2 Labour Market Integration in the Waste Sector

While the overall employment rate of 70% (combining full-time and part-time employment) is noteworthy given South Africa's economic context, the relatively low retention rate within the Waste Sector (31%) indicates structural challenges in sectoral absorption and career pathway development. This suggests a need to better align programme outputs with industry needs and create more direct pathways to sector employment. Hands-on training to diversify beneficiary skills-set is also suggested to improve employability.

9.1.3 Gender Equity

Gender disparities emerged as a critical concern, with male graduates achieving 70% full-time employment compared to 53% for females. This 17-percentage point gap, coupled with female graduates' longer transition periods to employment, points to a sector that continues to be male-dominated as well as possible systemic barriers requiring targeted intervention. These disparities mirror broader patterns of gender inequality in South Africa’s labour market, which demand sector-specific solutions.

9.1.4 Geographic Mobility

Geographic mobility patterns reveal both opportunities and challenges. While major economic hubs retain graduates, the 10% international migration rate reflects both regional capacity development and some skills loss. Strengthening local career pathways remains essential.

9.1.5 Waste Sector Development

The programme significantly contributes to building advanced capabilities in waste management, evidenced by the high proportion of master's and doctoral graduates. However, the challenge of retaining these skilled professionals within the sector requires strategic attention.

Industry integration emerges as both a challenge and an opportunity. Employers value graduates' adaptability and initiative but cite limited practical experience as a barrier to employment. While academically robust, the programme's current structure requires stronger industry partnerships to bridge the theory-practice gap and enhance sector retention.

9.2 Assessment of the Waste RoadMap Human Capital Development Programmes Impact and Value

The Department of Science and Innovation's strategic investment in the Waste RDI Roadmap HCD Programme represents a significant commitment to developing South Africa's waste management capabilities. With an investment of R125 million over the period 2015-2024, the programme has yielded substantial returns in human capital development, institutional capacity building, and sector transformation.

The program's impact assessment reveals multiple dimensions of value creation: from developing high-level research expertise and fostering institutional diversity to advancing transformation goals and supporting regional development. Beyond quantitative metrics of graduation rates and employment outcomes, the programme has catalysed qualitative changes in organisational performance, sector compliance, and research capacity. This comprehensive assessment of the programmes impact demonstrates how targeted investment in human capital development can effectively advance both sector-specific objectives and broader national development goals.

The programmes core achievement in skills development is evidenced by its strong postgraduate focus, with 84% of qualifications at advanced levels. This includes 49 Master's degrees, 13 PhD qualifications, and several post-doctoral placements, reflecting the programmes commitment to developing high-level expertise within the sector.

The programme has made significant strides in transformation, achieving 64% Black African participation and 59% female representation. Its regional impact extends beyond South Africa's borders, with 13% of beneficiaries from other African countries contributing to continental capacity building. This geographic reach spans nine provinces domestically, creating a network of expertise across South Africa while supporting regional development.

Employment outcomes demonstrate the effectiveness of the programme in developing employable skills, with 70% of graduates securing either full-time (60%) or part-time (10%) employment. An additional 14% pursuing further studies indicates the programmes role in building advanced research capacity. While the 31% retention rate in the waste sector presents opportunities for improvement, those retained have made significant contributions to organizational performance and sector compliance.

The programme has strengthened institutional capacity through a three-tiered framework of participating institutions, developing specialized research nodes and fostering academic-industry linkages. This institutional development, combined with high satisfaction rates in training quality (71% rated excellent), demonstrates the programmes success in building sustainable research and training capacity.

9.3 Policy Implications

The policy implications emerging from this Waste RDI Roadmap HCD Programme evaluation point to necessary systemic changes across three interconnected domains: skills development, employment transition, and Waste Sector development. These recommendations are grounded in the programme's core objective of building South Africa's waste management capabilities while addressing identified challenges in the current implementation.

9.3.1 Skills Development Policy

In skills development policy, the findings underscore the critical need to reimagine the relationship between academic training and industry experience fundamentally. The current gap between theoretical knowledge and practical application demands a more integrated approach to postgraduate education in the Waste Sector. This integration should manifest through mandatory industry placements, joint supervision models, and industry-academic institution engagements to define sector priorities which can be translated into research topics for Masters and PHD students that address real-world Waste Sector challenges. The value of practical components in postgraduate education cannot be overstated; these should be formalised through credit-bearing modules and technical certifications that complement academic qualifications. Additionally, structured mentorship programmes emerge as a vital component of skills development, requiring formal frameworks that pair experienced industry professionals with emerging talent.

9.3.2 Employment Transition Policy

Employment transition policy requires particular attention to gender dynamics within the Waste Sector. The significant disparities in employment outcomes between male and female graduates demand targeted interventions that specifically support women's transition into the workforce. These interventions should include dedicated career development programs and professional networks that address the unique challenges faced by women in the waste sector. Beyond gender considerations, there is a pressing need to better articulate the relationship between qualifications and employment opportunities. This calls for developing professional registration pathways and competency frameworks that align academic achievements with industry requirements. Industry partnerships play a crucial role here, potentially through tax incentives for companies employing programme graduates and joint funding mechanisms for research commercialisation.

9.3.3 Waste Sector Development Policy

The Waste RDI Roadmap has prioritised the retention of skilled professionals within the Waste Sector. This requires creating robust pathways for practical experience through national internship programs and industry-funded research fellowships. The strengthening of coordination between academic institutions and industry partners needs formalisation and regular consultation mechanisms.

Gender-specific barriers within the sector demand particular attention through the implementation of equity targets and leadership development programs specifically designed for women professionals.

9.4 Programme Implications

Implementing these policy recommendations requires a phased approach. *Initially*, focus should be placed on establishing coordination mechanisms between stakeholders and launching pilot programs, particularly on mentorship and curriculum review. The *medium-term phase* should see the

implementation of revised curricula with enhanced practical components and the establishment of formal industry partnership frameworks. *Long-term success* will be measured through the full integration of academic-industry programs and the establishment of comprehensive professional development pathways.

Monitoring and evaluation of these policy interventions is crucial for ensuring their effectiveness. Regular tracer studies of program graduates, combined with industry satisfaction surveys and gender equity progress reports, will provide valuable feedback for continuous improvement. Success should be measured not just through employment statistics, but through indicators of sector transformation, including research commercialisation rates and professional development completion rates.

The success of these policy interventions depends heavily on sustained commitment from multiple stakeholders. Government departments must provide the regulatory framework and funding support, academic institutions must adapt their educational approaches, and industry partners must actively participate in skills development and employment creation. Professional bodies are crucial in establishing and maintaining standards while ensuring the Waste Sector remains attractive to emerging talent.

The HCD programme can better fulfil its mandate of developing South Africa's waste management capabilities through this comprehensive policy framework while addressing current implementation challenges. The focus on practical skills development, gender equity, and industry integration will contribute to building a more robust and inclusive waste management sector for the future.

9.5 Concluding Remarks

The Waste RDI Roadmap HCD Programme stands at a critical juncture in South Africa's environmental and economic development landscape. As the country grapples with waste management challenges and transitions toward a circular economy, the programme's role in developing specialised human capital becomes increasingly vital.

As the programme transitioned to DSI management in 2024, these achievements provide a strong foundation for future development. The demonstrated success in skills development, transformation, and institutional capacity building can be enhanced while addressing identified areas for improvement, particularly in sector retention and practical training components.

Priority must be given to strengthening information management systems, enhancing industry partnerships, and addressing gender-specific barriers to career progression. These improvements, coupled with existing programmatic strengths, will position the programme to better serve South Africa's waste sector development needs.

Success in this next phase requires sustained commitment from all stakeholders – government, academic institutions, industry partners, and beneficiaries. The programme's future effectiveness depends not only on maintaining its strong academic foundation but also on building robust pathways for practical skills development and sector integration.

The findings and recommendations presented in this report should catalyse strategic enhancement rather than criticism of current approaches. They offer a roadmap for strengthening a programme that is crucial in developing the specialized skills needed for South Africa's environmental sustainability and economic development.

10 Recommendations

Based on the findings of this study, several key recommendations have been identified to improve the Waste RDI Roadmap HCD Programme and ensure it continues to achieve its objectives effectively, efficiently, and sustainably. These recommendations are directed to both the funders and the implementers of the programme.

10.1 Improve HCD Programme and Waste Sector Road Map Awareness

Enhanced programme advocacy and awareness initiatives. Elevating the visibility of the Waste RDI Roadmap HCD programme and the broader Waste Sector is crucial, particularly in targeting both potential beneficiaries and employers. By showcasing success stories and the impact of Waste Sector professionals, we can inspire more students to consider this field as a career path and apply to the programme and encourage more employers to create opportunities for hosting beneficiaries through internships or employment opportunities. This will respond to the challenges of addressing climate change mitigation and job creation in the country.

Undergraduate outreach for career awareness. Initiating programmes that introduce undergraduate students to studies and employment in the Waste Sector can help cultivate an early interest. This can be achieved through launching targeted awareness campaigns that highlight the sector's significance in South Africa's environmental sustainability and economic development. Promoting the sector through the National Science Week initiatives implemented by the Department of Science and Innovation (DSI) could involve collaboration with schools to provide workshops, field visits, and guest lectures.

10.2 Expand Practical Experience and Industry Exposure

To bridge the theory-practice gap, the programme should institutionalise industry engagement through mandatory placement components within postgraduate programmes. This could include credit-bearing modules for practical experience and formal frameworks for industry co-supervision of research projects. Technical certification programs complementing academic qualifications would further strengthen graduates' practical capabilities. These enhancements would build upon existing internship and job shadowing initiatives while creating more structured pathways for industry exposure."

10.3 Promote Employment Transitions into the Waste Sector

A structured approach to employment transition should include targeted support programs for previously disadvantaged populations such as women and persons with disability entering the sector, addressing the identified gender disparities in employment outcomes. The development of professional registration pathways specific to waste management, coupled with clear competency frameworks, would create more defined career progression routes. Incentive mechanisms for companies employing program graduates could help increase sector retention rates.

10.4 Industry-Higher Education Coordination

The programme should establish structured consultation mechanisms between academic institutions and industry partners. Regular forums for curriculum review and industry input would ensure ongoing alignment between academic programs and sector needs. Frameworks for joint research project

identification and execution would strengthen knowledge transfer between academia and industry, while formal mechanisms for collaboration would ensure sustained engagement.

Initiatives in support of this coordination could include the following:

- **Career guidance and employment support.** To facilitate the transition from academia to employment, the programme should offer career guidance services, including CV writing workshops, job search strategies, and interview preparation. These services can be delivered through workshops, mentorship programmes, and industry partnerships to enhance graduates' employability.
- **Align education with industry needs.** Strengthening collaboration between academic institutions and the Waste Sector is vital for ensuring that graduates' skills match industry requirements. Initiatives such as joint research projects, industry seminars, and co-developed curricula can create a dynamic knowledge exchange. Incorporating South African case studies and addressing local waste management challenges through experiential learning will make education more relevant and practical.
- **Build partnerships for skills development.** Forming strategic partnerships with Waste Sector companies to offer internships, learnerships, and mentorship programmes can help bridge the gap between theory and practice. Industry-informed curricula and real-world learning experiences will enhance the employability of graduates while employers gain access to skilled, job-ready candidates.

10.5 Strengthening Mentorship and Networking Opportunities

The importance of high-quality mentorship cannot be overstated. Beneficiaries who received strong mentorship reported better outcomes and greater satisfaction with the programme. The programme is recommended to formalise a structured mentorship component, ensuring that mentors are trained and equipped to provide meaningful guidance. Part of this would be clearer guidelines for supervisor roles and responsibilities. Additionally, fostering networking opportunities through workshops, conferences, and industry events can help beneficiaries build professional relationships and increase their employability in the Waste Sector.

10.6 Enhancing Monitoring and Evaluation Framework and Information Management Infrastructure

Beyond tracking beneficiary information, the programme requires comprehensive monitoring and evaluation frameworks that include sector-specific indicators beyond employment statistics. This should include tracking industry adoption of research outputs, professional development completion rates, and regular assessment of sector transformation progress.

The evaluation revealed critical gaps in beneficiary tracking stemming from a decentralised information management approach across Higher Education Institutions (HEIs) as primary grant holders. A transformed information management system with standardised protocols across all participating institutions is essential to address this systemic challenge.

HEIs, as the primary point of contact during beneficiaries' academic journeys, must take central responsibility for:

- Maintaining comprehensive enrollment and progress records
- Collecting and validating contact information

- Tracking early career placement outcomes
- Recording supervision and mentorship activities

Success depends on recognising HEIs as key partners rather than mere data providers. The system must balance comprehensive data collection needs with institutional capacities and constraints. This system will transform from a tracking tool into a strategic asset supporting the programme' s broader objective of developing South Africa's waste sector workforce when properly implemented.

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