Matching Selected United Nations Sustainable Development Goals to the Societal Impact of Academic Laboratory at an Institution of Higher Learning: The Mineral Processing and Analytical laboratories

Antoine F. Mulaba – Bafubiandi[1,2,*], Gladys Motsidisi Manxila[1] and Vinoliah Maphangule[1]

***Abstract*—**Sustainable resources management for a durable positive performance has continuously been a huge challenge in environment changing organizations subjected to a dynamism as lately observed. Educational institutions are expected to play a crucial role exampling the implementation practices of the United Nations Sustainability goals as echoed in countries national development plans and programs. Tertiary Institutions are seen setting and developing education programs around the concepts of sustainability development. This paper discusses the assessment of the implementation of the sustainability goals as recommended by the United Nations, integrated in the South African national development plan and applied by the mineral processing laboratory and the analytical facility of the department of metallurgy at the university of Johannesburg Doornfontein campus (DFC). With an awarded ethics clearance certificate, this case study utilized a stratified sampling where respondents to the structured questionnaires were students, laboratory technicians, academic staff and administrative support staff to the technical division like campus director, maintenance staff and university operations staff. Five key areas including the energy usage, water consumption, possible greenhouse gases emissions in the laboratories. laboratory occupancy and financial expenditures and requirements were considered. The environmental sustainability and the performance of the analytical laboratories, which includes the costs of operation, costs of equipment replacements, costs of using the machines, costs of maintenance, costs of recycling or doing environmental processes etc., in the analytical and furnace laboratories. The research mainly focused on the analytical and the furnace laboratory and the following will be inspected: the carbon footprint, energy consumption, waste management as well as the resource management and stability within the laboratories. Goals 9 (Industry, innovation, and infrastructure) and 12 (Responsible consumption and production), were particularly targeted . The Grey Relational Analysis (GRA), a decision-making tool, was utilized to evaluate how well the laboratory performed in achieving goals 9 and 12. One of the five main parts of the Grey System is GRA. To acquire the data, a qualitative method and questionnaires were employed. The questions covered topics including waste management, water and energy use, and others. With the assistance of the experts, which included the lab technicians and the lectures, the topics addressed in the questions were selected. To determine the effectiveness of the questionnaires, a pilot study was conducted. The GRA results demonstrate which laboratory is most likely to achieve targets 9 and 12.

***Keywords*—**Sustainable development goals, responsible consumption and production, analytical laboratory, mineral processing laboratory.

Gladys Motsidisi Manxila1 and Vinoliah Maphangule1 were as a undergraduate student at the .Mineral Processing and Technology Research Center, Department of Metallurgy, School of Mining Metallurgy and Chemical Engineering, Faculty of Engineering and The Built Environment, University of Johannesburg under the supervision of Antoine F. Mulaba-Bafubiandi..

Antoine F. Mulaba-Bafubiandi is with the Mineral Processing and Technology Research Center, Department of Metallurgy, School of Mining Metallurgy and Chemical Engineering, Faculty of Engineering and The Built Environment, University of Johannesburg, POBox 17011 Doornfontein, Johannesburg, 2028, South Africa, He is also with the University of Mbuji-Mayi, Faculty of Applied Sciences, Mbuji-Mayi, POBox 225, Mbuji-Mayi, Kasai, Democratic Republic of Congo

I. Introduction

The Sustainable Development Goals (SD G’s) [1] (adopted by the United Nations General Assembly in September 2015) span the years 2016 to 2030 and are formally the goals of the United Nations' 'Transforming Our World: The 2030 Agenda for Sustainable Development,' an agenda that lays out the vision, principles, and commitments for a fairer and more sustainable world for all. The SDGs' practical and political importance, as well as the challenges they pose, can only be fully appreciated by understanding what came before them. The 17 Sustainable Development Goals (SDGs) and 169 targets that were announced demonstrate the scope and ambition of this new global agenda. They aim is to contribute to building on the Millennium Development Goals (MDGs) [2]. They seek to realize all people's human rights, as well as gender equality and the empowerment of all women and girls. They are interconnected and inseparable, balancing the three dimensions of sustainable development: economic, social, and environmental. The goals and targets will spur action in critical areas for humanity and the planet over the next 15 years. In this study, performance of the undergraduate analytical laboratories and the mineral processing laboratory

at the University of Johannesburg was assessed to track the achievement of the applicable SDGs in the laboratories

The Millennium Development Goals (MDGs) were a set of eight international development goals that were in place from 2000 to 2015 [2]. The first three goals addressed poverty, education, and gender equality; the following three goals addressed 'health outcomes,' which included child mortality, maternal health, and 'HIV/AIDS, malaria, and other diseases.' The final two goals addressed environmental sustainability and global development partnerships. These eight MDGs were backed up by 21 individual targets.

The According to the most recent Times Higher Education (THE) Impact Rankings, the institution ranking leads also to the assessment of the level of observance of the SDG’s. The rankings are a ground-breaking initiative that recognizes universities around the world for their social and economic impact in accordance with the United Nations Sustainable Development Goals [3.4].

As per [5,6,7,9,9, and 10], this paper discusses the findings from the assessment of the environmental performance of the university departmental undergraduate laboratories with regards to reaching United Nations sustainability goals as quantified through variables such as carbon footprint audit, energy usage, water consumption, hazardous and non-hazardous waste management audit principle and university regulations in the mineral processing laboratory to create improved and safe learning space for students.

II. MATERIALS AND METHODS

A. Site for the investigation and methods

The undergraduate mineral processing laboratory and analytical facility were conveniently chosen as the site for the project where the level of attainment of the United Nations Sustainable Development goals level was tested. were to be tested. In addition to the qualitative research instrument mainly focused on the use of questionnaires and structured interviews, the Grey Relational Analysis (GRA) methodology was used [11, 12, 13].

The Grey rational analysis (GRA) [14] is decision making approach founded on grey system theory that has been widely used to situations including quantitative and qualitative data as well as complicated criteria. The methodology of the GRA technique often used in organizational decision-making process, was applied in this study to track the level of attainment of goal 9 and goal 12 of the united nation sustainability development goals.

The mineral processing laboratory is divided into sections, which are: the crusher room, sample preparation section, flotation section, magnetic separation section, physical separation section and the milling section. The crusher room is where you find your cone crushers and jaw crushers used to crush the material into small particle. The sample preparation section is where sample is prepared and stored before it could be used (when it is delivered to the laboratory) and the physical separation section is where you conduct your shaking table. The different sections within the mineral processing laboratory were used as the alternatives and goals 9 and 12 each had criteria that need to be met by each area. To assess the attainment of the SDG 9 and 12 the table 1 and table 2 were used as criteria and scales respectively [12, 13].

TABLE I: CRITERIA FOR GOAL 9 AND 12

Criteria code	Goal 9 criteria	Goal 12 criteria
A	Funding	Energy consumption
B	Building capacity	Water consumption
C	Accessibility	Carbon footprint
D	Safety and Equipment	Waste management
E	Maintenance / servicing	Recycling

TABLE II. THE SCALE OR WEIGHTS FOR GOAL 9 AND GOAL 12.

Linguistic variables	Equivalent numeric ranking
Very high	5
High	4
Medium	3
Low	2
Very Low	1

B. Questionnaire Development

The purpose of the qualitative questionnaire was to get in-depth replies from respondents regarding their comprehension in terms of the United Nations Sustainability development goals compliance at the analytical laboratory s well as at the mineral processing laboratory..

C. Refinement Process

The question development process began with brainstorming sessions using the Delphi technique. A broad list of potential questions was generated to cover different facets of the research study. The initial questions were evaluated for clarity and relevance, then refined to ensure they were concise, easy to understand, and directly related to the study’s objectives.

A small group of 5 individuals who were familiar with the research study participated in a pilot test of the questionnaire. The feedback was collected to identify any confusing or ambiguous questions and adjustments were made accordingly. The refined questionnaire was reviewed by peers not directly involved in its creation, which ensured a fresh perspective and helped in fine-tuning the questions for comprehensibility and neutrality.

Input from external subject matter experts was sought to ensure that the questions adequately covered the key dimensions of the program and were phrased in a way that would encourage thoughtful responses. The questionnaire

underwent a final review to ensure that the questions aligned with the aim of the study and would yield the desired insights. The enhanced qualitative questionnaire was created to allow participants to express their genuine experiences and viewpoints, and by allowing participants to assess their survey experience on a scale of 1 to 10, which helped to fully comprehend the impact of the study.

D. Data Collection:

The questionnaires were administered by email, by telephone and or face to face. the responses were collected as they came in. Any technical issues or questions from participants were promptly addressed. An online Survey Platform that was used was Google Forms, using various Distribution Channels, he survey link was distributed through email invitation, social media posts on Facebook and WhatsApp. Participants accessed the link by directly clicking on the link and had a duration of 1-2 minutes.

E. Validity and Reliability

Measures taken to enhance the validity of the research findings, ensuring that they accurately represent the participants' perspectives and experiences. Multiple data collection methods were employed to triangulate verify and validate the findings. Findings, analysis process, and interpretations were discussed. To enhance the reliability of the findings, a thorough record of the analysis process, including decisions made, and evolving interpretations were maintained. Another researcher reviewed a portion of the data and categories to identify any discrepancies or areas that needed clarification. Sufficient time was spent engaging with the data to develop a deep understanding of the content.

F. Ethical Considerations

Ethical approval was obtained from the Faculty of Engineering and the Built Environment Ethical committee.

III. FINDINGS AND DISCUSSION

A. Response rate

Attempts were made over the last two decades to disprove the idea that lower response rates signify poor research validity. Several recent studies revealed that there is no evident association between response rate and validity. Response rates are still relevant, but they aren't reliable predictors of research validity on their own. In addition to reporting response rates, giving more detailed information on how representative participant, are in comparison to those who do not, based on important research and demographic variables, can assist in assessing the perceived risk. The results showed a high response rate (46.2%) from the final year students compared to 2nd, 3rd, and post graduate students. The low response rate from lab technician was obtained as only 3 lab technicians out of 9 responded to the questionnaires.

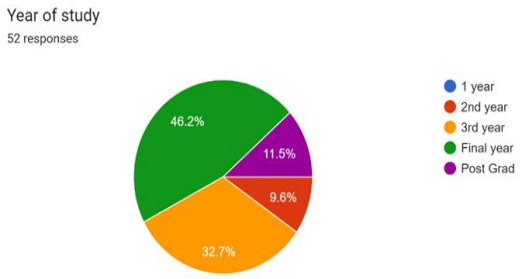

Fig. 1: Pie chat representing the responses rate for students and lab technicians.

B. The Grey Relational Analysis

The Grey rational analysis (GRA) is decision making approach founded on grey system theory that has been widely used to situations including quantitative and qualitative data as well as complicated criteria. The methodology of the GRA technique often used in organizational decision-making process, was applied in this study to track the level of attainment of goal 9 and goal 12 of the united nation sustainability development goals.

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TABLE III: THE SCALE OF CONTRIBUTION OF CRITERIA IN EACH LABORATORY SECTION

Laboratory section	**Goal criteria 9**					**Goal criteria 12**				
	A	B	C	D	E	A	B	C	D	E
Crusher room	3	1	3	1	1	5	1	2	1	1
Sample preparation section	5	4	5	4	5	1	1	1	2	3
Flotation section	5	3	1	3	4	3	2	1	1	1
Magnetic separation section	2	3	2	4	4	2	1	1	5	1
Physical Separation Section	3	5	2	3	3	2	5	1	4	1
Milling section	1	4	4	1	2	5	3	1	3	1

With the use of Grey relational generator, The difference matrix and the calculated grey relational coefficients, one obtains the percentage level of compliance as summarized in table 4.

TABLE IV. PERCENTAGE LEVEL OF ATTAINMENT OF UN SDG 9 AND 12 PER LABORATORY SECTION.

Laboratory section	Goal 9	Goal 12
Crusher room	40.00	60.00
Sample preparation room	93.33	48.00
Flotation section	62.00	38.00
Magnetic separation section	59.33	48.00
Physical separation section	60.00	54.67
Milling section	48.00	53.33

The results above show the performance of each section in the mineral processing laboratory. The calculations were done using the excel following the steps from GRA from the literature. The laboratory was divided into six sections which are the crusher room, sample preparation room, flotation section, magnetic separation section, physical separation section and the milling section. Each section was rated using the criteria in table 1 and table 2 respectively by the senior lab technician of the mineral processing laboratory. After calculation were done graph was draw to show on how the laboratory performs in terms of reaching the compliance to goal 9 and 12 of the united Nations sustainable development goals. From the graph it is observed that the milling section contributes 53,33 % of goal 9 and 48 % of goal 12, this results.

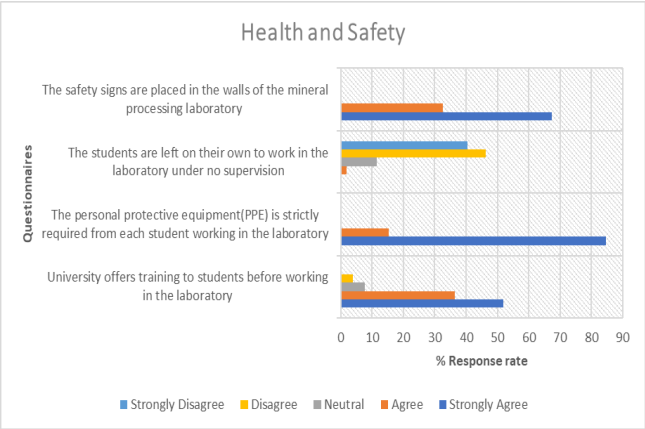

Fig. 2. illustrates the students’ responses to the questionnaires based on the health and safety in the laboratory and these responses was captured and represented in the form of graph using excel. The graphical representation of data allowed for easy interpretation and evaluation of data for any observed trends and patterns.

Health and safety aspect and area of the mineral processing laboratory was investigated. Fig. 2 is the set of questions that were asked to students. The first question being on safety signs the highest response rate was observed being 63,7 % which means 37 students strongly agree to the said statement while 17 just agree. The other question with the highest response rate was the one based on the PPE being worn in the laboratory which about 85% of the students were strongly agreeing to the statement. The student also disagreed to the fact that they are being left to work on their own in the laboratory. According to the lecturers, Lab technicians the safety signs are always placed in the laboratory and accidents rarely occur in the laboratory, and lastly, they are no accidents that occurred in the last 6 months.

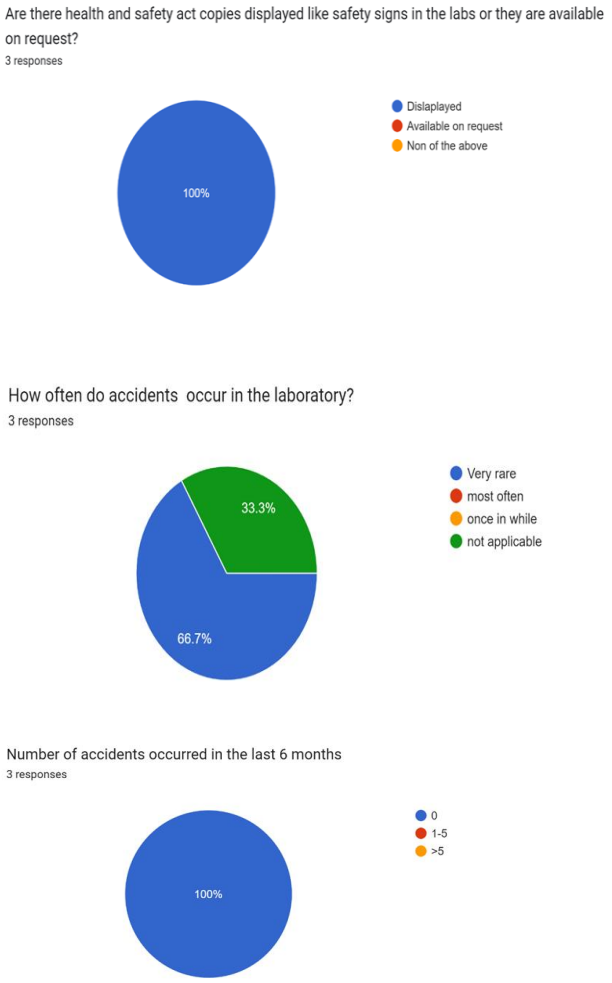

Fig. 3: Lecturers and lab technician responses to the health and safety of the mineral processing laboratory

From fig. 3 the lecturers / lab technicians were 100 % agreeing to the questions asked from the results above its safe to say that safety is prioritized in the mineral processing laboratory. This shows that the UN SDG 9 is met.

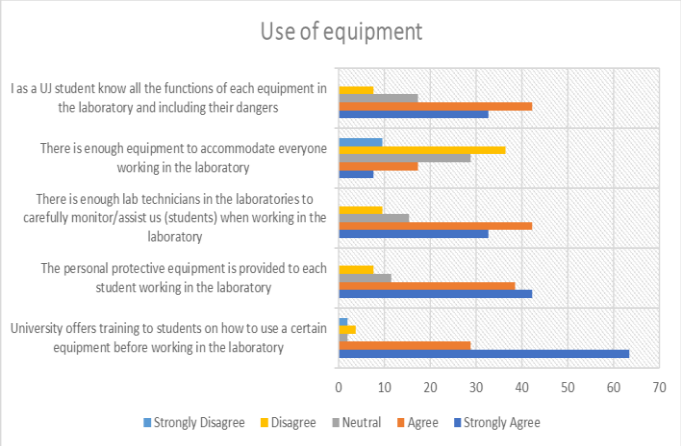

Fig. 4: Shows the students response rate with regards to the use of equipment in the laboratory.

From the bar graph above the first question that was asked to students was if they are know all the functions of each equipment in the laboratory and about 42.3 % were agreeing, 32.7 % were strongly agreeing while 7.7 % disagreed. The highest response was recorded on the question related to the university offering training to the students working in the laboratory where 65 % of the students were strongly agreeing to the statement. The highest response rate recorded was about 43% where the question was about having enough lecturers and lab technicians to help in the laboratory whereas the lowest response rates were recorded for strongly disagreeing (9,6%). The results showed highest number of students disagreeing that they are enough equipment to work in the laboratory, and about 29% were neutral about statement.

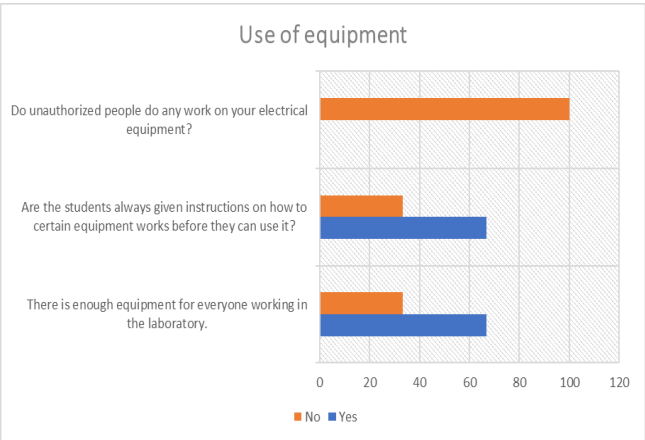

Fig. 5: The bar graph showing the lectures/ lab technicians response to the use of equipment in the laboratory.

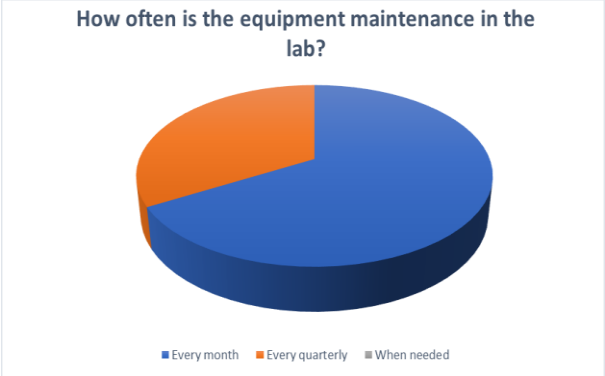

Fig. 6: Pie chart showing how often the equipment is maintained in the laboratory

The results show that no unauthorized people are allowed to operate the equipment in the laboratory. 66,7 % of the technicians agree that students are always given instruction on to use certain equipment while 33,7% says that is no always the case.

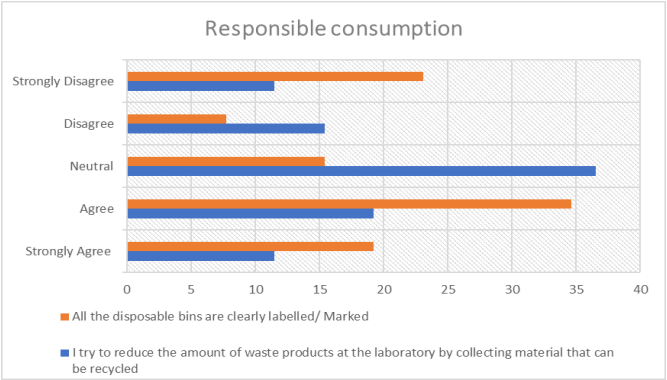

Fig 7. Responses on the responsible consumption and production goal.

The response rate percentage of students and technician with regards to the equipment availability in the laboratory. The response percentage was 66,7% for lectures that there is enough equipment in the laboratory whereas only 7,7 % of students agreeing the statement. However, the lab technician did indicate that one of things which are unsatisfactory about the lab is that they are no enough heaters and there is a need for gravity separator like Knelson or Falcon concentrator which shows that lack of equipment is a serious issue faced by the laboratory at a current moment. Lastly all the equipment that is not working is demarcated with a red tape then repaired by a qualified person.

IV. Conclusion

This study discussed in this paper was qualitative research in nature where structured interviews with questionnaires were used. The stratified participants consisted of students, technicians, and lecturers in-charge of the laboratories. The Grey Relational Analysis was additionally applied to clarify the problems in environmental sustainability and the

performance of the laboratories. The study revealed that both UN SDG 9 and 12 were complied with at 40 and 60 %% respectively.

Contribution of Authors

Antoine F. Mulaba - Bafubiandi initiated, conceptualized and supervised the research project. Gladys Motshidisi Manxila and Vinoliah Maphungule conducted the research work under the supervisor of Antoine F. Mulaba – Bafubiandi.

Declaration of Interest

The authors have no financial nor personal interest in the content of the work here presented.

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