Measuring sustainable ergonomics: A hybrid multi-criteria perspective on Occupational Health and Safety Indicators

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Chapter 1: Literature Review

This chapter aims to provide a comprehensive overview of Occupational Health and Safety (OHS) within the South African context, highlighting its significance to Human Factors/Ergonomics (HF/E). It will examine the intrinsic connection between sustainability and HF/E, elucidating how these concepts intersect and inform one another. Furthermore, the chapter will investigate the theoretical framework surrounding indicators, with a particular focus on OHS and HF/E indicators (EIs). It will also assess the evaluation criteria associated with these indicators. The chapter will conclude by articulating the central research question guiding this inquiry.

1.1. Introduction

Global megatrends, including globalisation and demographic changes, significantly impact individuals and organisations alike (Sarbat & Ozmehmet Tasan, 2020). While organisations aim to enhance quality of life and maintain profitability, there is often a neglect of employee well-being, particularly in health and safety matters (Chillakuri & Vanka, 2021). This oversight highlights a broader trend where profit motives overshadow the importance of human welfare (Sharma et al., 2023). However, in today's increasingly complex and dynamic work environment, a greater emphasis should be placed on integrating health, safety, and sustainable HF/E.

Since the mid-20th century, the field of HF/E has undergone significant evolution (Bolis et al., 2020). HF/E plays a critical role in ensuring safety and health within productive systems (Martinez et al, 2021). This scientific discipline prioritises the human element while maintaining a focus on organisational productivity. While Occupational Health and Safety Management (OHSM) examines people, technology, and work as distinct elements, HF/E adopts a holistic approach to human activity, integrating insights from multiple scientific disciplines (Martinez et al, 2021).

Thus, integrating OHS, and HF/E is important to create organisational systems that not only protect the well-being of employees but also enhance their productivity, satisfaction, and overall performance (Shikdar & Sawaqed, 2003). By bridging these fields, organisations can foster environments that prioritise human-centred design, reduce risks, increase safety for the people impacted by the system, and achieve sustainable operational success.

As organisations strive to balance economic growth with the essential objective of fostering ecologically and socially safe and healthy work environments, implementing an indicator system to measures OHS, HF/E and sustainability within an organisation can be highly beneficial (Sarbat & Ozmehmet Tasan, 2022). EIs, proposed by Sarbat and Ozmehmet Tasan (2024), present a valuable and effective approach.

This research seeks to build upon Sarbat and Ozmehmet Tasan's (2024) research to explore the broad landscape of OHS emphasising sustainable HF/E within the South African context. Specifically, this research aims to understand which EIs are considered the highest priority rank order by OHS practitioners when measuring health and safety in South African organisations. Through applying a weighting system based on five evaluation criteria, measurability, reliability, resilience, proactiveness, and policy relevance, against the EIs, this study seeks to determine which indicators are most and least influential thereby facilitating informed decision-making for sustainable practices.

1.2. Context

As one of the more industrialised countries in Africa, the South African economy is primarily dependent on the sizable semi-skilled and unskilled labour force and intense demands of the production process (Stats SA, 2021). Working environments, for a significant portion of the population, are characterised by hazardous conditions, necessitating stringent laws, meticulous practices, and unwavering focus to safeguard the well-being of all employees (Hermanus & Hermanus, 2001, Rikhotso et al., 2022). Consequently, since the early development of the mining industry there has been a growing emphasis on OHS in South Africa, as evidenced by the increasing focus on this issue in academic research (Fan et al., 2020; Pons-Vignon & Anseeuw, 2009; Zwi et al., 1988).

The Occupational Health and Safety Act (OHSA), established in 1994 in South Africa, is a crucial piece of legislation that outlines the health and safety rights and responsibilities of both employers and employees in the workplace (Munnoo & Smallwood, 2021). Notable progress has been made in the development and refinement of relevant legislation over the years which has helped to strengthen the legal framework governing OHS in the country (Rikhotso et al., 2022). However, despite these positive developments, the rush for economic growth can come at the cost of a safe and healthy workplace as subpar conditions and inadequate enforcement of regulations remain an issue (Coulson, 2018; Munnoo & Smallwood, 2021; Zwi et al., 1988).

Various obstacles have hindered the anticipated improvements in working conditions, including persistent economic inequality that limits access to better safety standards, weak enforcement mechanisms that allow non-compliance by employers, and a significant informal employment sector where labour protections are often absent (Pons-Vignon & Anseeuw, 2009). Additionally, many organisations lack the resources necessary to implement adequate health and safety measures, while trade unions face challenges such as fragmentation and limited bargaining power, further complicating efforts to advocate for workers' rights (Pons-

Vignon & Anseeuw, 2009). These factors collectively leave much to be desired in the pursuit of improved working conditions and OHS in South Africa (Shikdar & Sawaqed, 2003).

Historically, the field of psychology and OHS have overlapped, albeit limitedly, with studies in HF/E and industrial fatigue (Sauter & Hurrell, 1999). More recently, there has been a significant expansion in the role of psychology in the OHS field (Fan et al., 2020; Zanko & Dawson, 2012). Research has transitioned from attributing OHS concerns to individual fault (Heinrich, 1941; Kemery et al., 1987) into acknowledging the critical role of the work environment and organisational factors in promoting employee well-being and OHS (Quinlan et al., 2010). Furthermore, a positive safety culture, trust in management, and high-performance work systems have been identified as essential components of a robust OHS framework (Zacharatos et al., 2005; Neal & Griffin, 2006; Burke et al., 2011). A broader perspective has emerged, revealing the intricate relationships between individual, environmental, and organisational factors that influence OHS (Zanko & Dawson, 2012). Ultimately, OHS, HF/E and sustainability are important factors for organisations to consider, particularly in developing countries like South Africa.

1.3. Occupational Health and Safety (OHS), Human Factors/Ergonomics (HF/E) and Sustainability

The integration of OHS, HF/E and sustainability reflects an evolving understanding of workplace health and well-being. These domains, while distinct, intersect in ways that address critical challenges in workplace health, safety, and sustainability.

1.3.1. Occupational Health and Safety (OHS)

Without healthy and safe employees, organisations will not be able to function (De Cieri & Lazarova, 2021). Occupational health aims to identify and manage workplace hazards to ensure a secure and healthy environment, while occupational safety focuses on preventing physical injuries (Liu et al., 2019). OHS research has expanded its scope beyond solely focusing on physical safety to include emotional and psychological health and well-being, particularly in developing countries (Fan et al., 2020; Marhavilas et at., 2018; Wang et al., 2020). The COVID-19 pandemic further highlighted the need to focus on employee health and well-being when it comes to OHS as it significantly altered work system designs, leading to new challenges for organisations' occupational health and employee well-being (Firescu, 2021). Government regulations alone may be insufficient to effectively eliminate workplace hazards, but rather the successful implementation of OHS practices requires active support and engagement from those most directly affected, the workers themselves (Gunningham, 2005). Ultimately, OHS ensures the overall well-being of employees in the workplace by constructing a safe and healthy work environment that promotes physical, mental, and emotional prosperity (Yilmaz & Yildaz, 2021).

It has been argued that to improve OHS, organisations should prioritise two key areas: HF/E and sustainability (Firescu, 2021, Shikdar & Sawaqed, 2003). Sustainable development seeks to enhance the interplay among ecological, economic, and social systems, while HF/E focuses on optimising the relationship between humans and various system components. Although HF/E and sustainability originate from distinct foundations, they intersect significantly in the context of humans within their workplace practices (Bolis et al., 2020; Brown & Legg, 2011). The Activity Centred Ergonomics (ACE) approach further reinforces this intersection by explicitly linking HF/E to human development, emphasising the role of workplace activities in fostering individual and collective growth within sustainable systems (Barcellini et al., 2015).

1.3.2. Human Factors/Ergonomics (HF/E)

HF/E, as defined by the International Ergonomics Association (2000), is a scientific discipline focused on designing work systems, tasks, and jobs that align with the capabilities and limitations of workers. It focuses on prioritising and optimising human well-being both physically and mentally and plays a crucial role in addressing these challenges (Brown & Legg, 2011; McPhee, 2004). Additionally, addressing environmental degradation and social instability necessitates integrating HF/E principles into the design of workplaces, products, and services (Thatcher & Yeow, 2016). HF/E addresses OHS challenges by enhancing safety, satisfaction, and performance, directly and indirectly boosting overall outcomes (Shikdar & Sawaqed, 2004). Therefore, the integration of OHS and HF/E offers valuable insights for a comprehensive approach to enhancing workplace safety and promoting employee well-being.

1.3.2.1 Human Factors/Ergonomics (HF/E) and Occupational Health and Safety (OHS)

OHS and HF/E are distinct concepts with unique communities of practice, each contributing differently to workplace wellbeing. OHS traditionally focuses on regulatory compliance, risk management, and the prevention of workplace accidents and illnesses, while HF/E emphasises optimising the interaction between humans and systems to enhance efficiency, health and safety, and well-being (McPhee, 2004; Martinez et al., 2021; Liu et al., 2019).

Despite these distinctions, the two fields converge in their shared goal of improving worker wellbeing within organisations (Martinez et al., 2021). Both employ outcome indicators such as reduced injury rates, improved employee satisfaction, and enhanced productivity to measure their effectiveness (Shikdar & Sawaqed, 2003). This overlap underscores the importance of integrating their insights for a holistic approach to workplace safety and HF/E.

1.3.2.2. Human Factors/Ergonomics (HF/E) and sustainability

HF/E, a multidisciplinary field dedicated to addressing human needs, is closely linked to sustainability, which prioritises human well-being, healthy living, and environmental protection. Although HF/E and sustainability originate from different foundations, they converge around the issue of work, sharing common goals, such as the need for workplace improvements, and aligned values, particularly a focus on health and employee well-being (Bolis et al., 2014). Together, these two areas are vital for enhancing overall quality of life (Sadeghi Naeini, 2020). HF/E is pivotal in advancing individual well-being and system efficiency, particularly within the framework of sustainability (Thatcher & Yeow, 2016).

Since the early 1990s, and particularly since 2010, research has increasingly focused on the intersection of HF/E and sustainability as this can lead to more effective and enduring solutions for workplace design and processes (Sarbat & Ozmehmet Tasan, 2020). Research by Dekker et al. (2013) outlined the crucial role of HF/E in facilitating sustainability, while Sadeghi Naeini (2020), emphasises that this integration leads to a better quality of life. Bolis et al. (2020) found that when sustainability policies prioritise employee well-being, they facilitate the integration of HF/E as a fundamental component of an organisation’s sustainability strategy. Sarbat and Ozmehmet Tasan (2020) present a framework that outlines the relationship between HF/E and sustainability and Sinclair et al., (2021) addresses the sustainability of communities. Additionally, Fischer and Zink (2012), propose a model for sustainable work systems, and Thatcher (2013) introduces "green ergonomics," showcasing the benefits of this synergy.

Integrating sustainability into OHS and HF/E principles is vital for creating a holistic approach that not only enhances human well-being but also fosters environmentally responsible practices and economic efficiency in workplace design and management (Sarbat & Ozmehmet Tasan, 2020). Consequently, this research attempts to bridge a significant gap by further synergising and expanding the existing body of knowledge on sustainability and OHS and HF/E.

By striving to align work environments with the needs of workers while simultaneously boosting organisational efficiency, HF/E can encourage organisations to adopt a more expansive view of sustainability, moving beyond limited, unidimensional approaches. This involves integrating social and ecological sustainability alongside economic considerations to create a positive impact across the entire organisational system (Bolis et al., 2014).

1.3.3. Sustainability

Human activities are significantly undermining the resilience of both natural and social systems, posing a threat to human survival as a species. This challenge is often framed within the context of sustainability, highlighting a collective urgency among organisations and individuals to address the shortcomings in protecting their economic, ecological, and social environments (Thatcher & Yeow, 2016). Sustainability can be defined as the practices and lifestyles that allow every person on planet earth to enjoy good health, prosperity, and a sense of purpose, while also preserving the ecology and ensuring the long-term well-being of both people and the earth. (Johnston et al., 2007). It is a balanced approach that considers the social, economic, and ecological impacts of human action.

In recent years, the emphasis on sustainability has expanded beyond the use and preservation of physical and natural resources to include the use of human resources and well-being within organisations (Sharma et al., 2023). Sustainability is often viewed as a holistic trinity that encompasses all aspects of well-being, including environmental conservation, economic growth, and social advancement (Yilmaz & Yildiz, 2021; Sharma et al., 2023). This framework acknowledges the economy as crucial for human well-being and fulfilment, recognises the importance of the environment, given that the quality of life is significantly affected by the natural environment and resources, and values society, as individual and community fulfilment is vital (Yilmaz & Yildiz, 2021). However, while the economic dimensions of sustainability are often highlighted, the other two factors tend to be overlooked (Sharma et al., 2023).

To enhance social and ecological sustainability, the practice and values of HF/E can play a pivotal role by optimising the interaction between individuals and their work environments, thereby promoting well-being and productivity (Firescu, 2021; Lange-Morales et al., 2014, Lin et al., 2021). Achieving sustainability requires a systematic approach that addresses the intricate web of interdependencies and the multifaceted connections between human actions and various aspects of sustainability (Fischer et al., 2021). Ultimately, HF/E, with its specific objectives and areas of focus, can assist employers in promoting OHS within a sustainable framework (Chillakuri & Vanka, 2021; Martin et al., 2013).

Integrating HF/E and sustainability into a comprehensive OHS performance system (operationalised in this research as EIs), enables organisations to create and maintain healthier and safer work environments, ultimately benefiting the entire organisational ecosystem (Shikdar & Sawaqed, 2003).

Sarbat and Ozmehmet Tasan (2020, 2024) offer an in-depth examination of significant contributions to the field of sustainable HF/E, showcasing a range of influential studies. Despite this valuable groundwork, there remains a notable gap in research that effectively integrates the three core elements of sustainability, economic, ecological, and social, within the context of OHS and HF/E in South Africa.

To address this gap, this research seeks to develop a comprehensive framework that unifies these elements, thereby advancing the understanding and application of sustainable HF/E and OHS within the South African context.

1.4. Indicators

1.4.1. Theoretical Framework

Performance measurement is the process of setting indicators to assess and change organisational objectives, enabling continuous improvement and added value within an organisation (Tucker & Pitt, 2009). Regular monitoring of organisational performance is crucial, and indicators provide insight into organisational performance which is essential for success (Badawy et al., 2016; Chin et al., 2003). A performance measurement system comprising indicators can evaluate various functional areas of organisations, including economic, strategic, operational, quality, management, and employment-related issues (Sarbat & Ozmehmet Tasan, 2024). When integrated with OHS, this system can identify and prevent risks caused by unfavourable working conditions by monitoring and evaluating organisational processes holistically.

In the context of organisational performance measurement, an indicator refers to a quantitative or qualitative measure that illustrates the processes and performance of various functional areas of an organisation (Badawy et al., 2016, Scerri & James, 2010). These indicators provide essential information for monitoring and evaluating organisational performance (Mendoza & Prabhu, 2000).

While there are numerous frameworks in literature for measuring sustainability and its adaptations to various fields, there is a noticeable gap in research that integrates OHS and HF/E with sustainability within a unified structural framework (Sarbat & Ozmehmet Tasan, 2020). Sarbat and Ozmehmet Tasan's (2024) research seeks to bridge a critical gap by utilising comprehensive EIs that considers various dimensions and sub-dimensions of OHS. These sub-dimensions include three dimensions of sustainability; economic (loss and investment), ecological (conditions and contributions), and social (self-development and satisfaction). Ultimately, as outlined in the research presented by Sarbat and Ozmehmet Tasan (2024), this research seeks to expand upon their findings by identifying which EIs hold the highest priority for OHS professionals in terms of five key evaluation criteria in the South African context.

To maintain consistency and clarity, the indicator system for both OHS and HF/E will be referred to under the umbrella term of EIs. This terminology is derived from Sarbat and Ozmehmet Tasan's (2022, 2024) work, which aligns with the broader integration of these concepts. Moreover, the term "OHSIs/EIs" is cumbersome and may obscure the interconnected nature of these disciplines. By adopting the term EIs, this thesis aims to streamline the discussion while emphasising the shared outcomes and objectives of these fields. The synthesis of OHS and HF/E within the EI framework not only aligns with existing literature but also facilitates a more unified approach to sustainable HF/E in the South African context.

1.4.2. Occupational Health and Safety (OHS) and Ergonomics Indicators (EI)

EIs examine working conditions and incorporate OHS and HF/E principles into organisational operations, while sustainability indicators assess economic, ecological, and social aspects. Sarbat and Ozmehmet Tasan (2020) propose a comprehensive framework that incorporates sustainability into EIs which ultimately enhances the robustness of the OHS indicator system (Sarbat & Ozmehmet Tasan, 2020, 2022). By leveraging these indicators, organisations can create a powerful mechanism for driving positive change, fostering a workplace that prioritises the well-being of both people and planet (Sinelnikov et al., 2015). This approach lays the groundwork for a more resilient and sustainable future for organisations and their stakeholders.

Through systematic monitoring and evaluation, EIs provide a holistic measure of organisational performance, addressing risks associated with inadequate working conditions while considering employee needs, ecological impacts, societal realities, and economic factors. EIs can be utilised to anticipate, identify and mitigate risks related to poor working conditions, monitor performance, evaluate employee training and involvement, and motivate safe behaviour (Sinelnikov et al., 2015).

Leading indicators focus on proactive measures that reflect how well an organisation is managing OHS before incidents occur, such as employee well-being or HF/E interventions (Pawłowska, 2015). Lagging indicators measure past events, like accidents or attendance rates, but are less effective at identifying changes or causes in OHS performance (Pawłowska, 2015). While lagging indicators track failures, leading indicators help assess and prevent potential issues by focusing on positive safety management practices (Martinez et al., 2021)

According to Sarbat and Ozmehmet Tasan (2024), these indicators can only be deemed influential if they are ranked according to five evaluation criteria which are measurability, reliability, resilience, proactiveness, and policy relevance. While there is a growing body of academic literature on OHS, HF/E, and sustainability, there is a lack of research indicating the priority rank of these evaluation criteria in EIs, particularly within the South African context. Thus, this study aims to address this gap by ranking the EIs based on these five evaluation criteria.

Sarbat and Ozmehmet Tasan (2022) developed a Performance Measurement System (PMS) that integrates 23 EIs related to ecological, economic, and social sustainability within Turkish industries. Drawing from their extensive literature review (Sarbat & Ozmehmet Tasan, 2020, 2022), this study utilised these 23 EI indicators within the South African context.

The economic dimension comprises eight EIs categorised into two sub-dimensions: "Loss" and "Investment." Together, these sub-dimensions provide a comprehensive perspective on the financial aspects of sustainability, addressing both the costs incurred, such as those related to accidents and health issues, and the resources allocated to initiatives like workplace improvements, employee training, and safety programs (Sarbat & Ozmehmet Tasan, 2020, 2022, 2024).

The "Loss" sub-dimension includes four EIs, focusing on the loss of time from accidents/incidents/treatments/diseases, financial resources, and employee health due to factors such as accidents, injuries, medical treatments, and occupational diseases. These include "number of injury-free days per year," "Number of accident-free days per year," "number of cases of occupational diseases per year," and "percentage of total lost time due to accidents and injuries relative to the total hours worked per year".

The "Investment" sub-dimension includes four EIs that emphasise workplace investments, employee training, and personal development, particularly in the context of HF/E interventions and environmental, health, and safety (EHS) initiatives. These include "cost of EHS training of employees per year," "expenditure on research and development, technology, and innovation per year to enhance ergonomically and environmentally friendly designed processes," "annual investment cost for ergonomics interventions and EHS issues," and "expenditure on employee development per year".

There are eight EIs that fall under the social dimension of sustainability and are grouped into two sub-dimensions: "Self-Development" and "Satisfaction." Each sub-dimension includes four EIs Together, these sub-dimensions provide a holistic view of the social aspects of sustainability in the workplace (Sarbat & Ozmehmet Tasan, 2020, 2022, 2024).

The "Self-Development" sub-dimension focuses on initiatives aimed at enhancing employee growth through EHS training, suggested workplace improvements, and time dedicated to skill development. These include "annual number of activities made for the proper implementation of the procedures related to ergonomics interventions and EHS issues," "percentage of total time spent due to EHS training relative to the total hours worked per year," "percentage of employees receiving EHS training per year," and "number of suggested improvements made by employees per year."

The "Satisfaction" sub-dimension addresses employee well-being and fulfilment, considering factors such as working conditions and overall job satisfaction. These include "annual turnover rate of employees," "percentage of employees who are satisfied with their work," "percentage of employees participating in managerial decisions related to ergonomics interventions and EHS issues per year," and “number of complaints due to working conditions not covered by decent work per year”.

Seven proposed EIs fall under the ecological dimension of sustainability and are categorised into two sub-dimensions: “Conditions” and “Contribution”. Together, these sub-dimensions provide a comprehensive framework for addressing ecological sustainability in the workplace (Sarbat & Ozmehmet Tasan, 2020, 2022, 2024).

The "Conditions" sub-dimension includes four EIs, focusing on the physical aspects of the workplace, such as time spent under adverse conditions and complaints from employees and the community. These include "number of complaints due to physical conditions (noise, temperature, odour, dust, etc.) per year," "number of activities made for improving working conditions per year," "number of days when there are unfavourable physical conditions (noise, temperature, odour, dust, etc.) per year," and "percentage of employees working in unfavourable conditions leading to physical and mental health problems per year."

The "Contribution" sub-dimension includes three EIs, emphasising efforts to support EHS initiatives and ergonomically-designed processes through charitable activities, volunteer involvement, and recycling practices. These include "percentage of annual incentives and promotions made for stakeholders to contribute ergonomically and environmentally friendly designed processes," "percentage of recycled products/raw materials used in ergonomically designed processes per year," and "number of volunteers making charitable contributions to EHS issues per year."

These indicators are linked to OHS and HF/E as they assess issues such as poor workplace design, job misalignment, employee satisfaction hazardous and unsafe environments, and inadequate human-machine systems which can lead to health problems, injuries, and reduced productivity (Shikdar & Sawaqed, 2004). They are all direct measures of OHS and HF/E effectiveness. Overall, the indicators address key aspects of HF/E within the OHS framework, focusing on optimising the overall health and safety of employees.

1.5. Evaluation Criteria

Mendoza and Prabhu (2000) define an evaluation criterion as a characteristic or standard that conveys specific meaning and/or operationality to a principal without being a direct measure of performance. In other words, evaluation criteria provide a framework for assessing the success or sustainability of a relationship. To achieve optimal results, it is essential to assess and assign weights to each of the EIs to ensure they are priority ranked in their ability to be measured (Sarbat & Ozmehmet Tasan, 2024). By ranking the EIs based on these criteria, organisations can ensure that they are selecting the most appropriate and effective indicators (Pires et al., 2020). This ranking process promotes a more informed and strategic approach to performance measurement, ultimately leading to improved organisational outcomes. Applying evaluation criteria to the EIs offers a comprehensive approach to assessing their effectiveness in measuring OHS performance in organisations (Mendoza & Prabhu, 2000).

Sarbat and Ozmehmet Tasan (2024) explored several prominent papers in this specific research area, five evaluation criteria were identified and comprehensively consolidated, these included: measurability, reliability, resilience, proactiveness, and policy relevance. For further exploration of the criteria, consult Table A1 in the appendix of the study by Sarbat and Ozmehmet Tasan (2024). Utilising the Best Worst Method (BWM) methodology, respondents rated the relative importance of each criteria using a scale from 1 (equally important) to 9 (extremely more important). For a comprehensive understanding of the mathematical foundations of the method, refer to Appendix B in the study by Sarbat and Ozmehmet Tasan (2024). This process allowed for a more nuanced understanding of the relative importance of the criterion the analysis.

The following section provides a brief overview of the five evaluation criteria used in this research. Drawing upon the foundational work of Sarbat and Ozmehmet Tasan, (2024), these criteria represent the most effective framework for assessment of EIs. Each criterion has been selected for its relevance and applicability to the objectives of this study, ensuring a robust and nuanced evaluation process.

1.5.1. Measurability

Measurability is an evaluation criterion that refers to the ability to quantify and measure an indicator accurately (Young et al., 2013). Through measurability, indicators can be understood across contexts and scales and provide meaningful information about the performance of policies and programmes (Dhakal & Imura, 2003). Indicators that are not measurable may lead to subjective interpretations and hinder evidence-based decision-making. According to Lockie et al. (2002), measurable indicators should be mappable, statistically variable, comparable, reproducible, able to be aggregated, and able to be combined with others to form indices.

The sub-criteria for measurability in this study include timeliness, data accessibility, data availability, cost-effectiveness, clarity, simplicity, and usefulness (Sarbat & Ozmehmet Tasan, 2024).

1.5.2. Reliability

Reliability refers to the consistency or reproducibility of an experiment, test, or measurement procedure when repeated multiple times (Bringhenti et al., 2011; Pires et al., 2020). The concept of reliability has been associated with a system's ability to remain at or return to a stable state of equilibrium following disturbances or disruptions (Lopez-Ridaura et al., 2005). Furthermore, reliability is also described as the ability to capture both positive and negative issues in an unbiased manner (Kurka & Blackwood, 2013). This highlights the importance of reliability in ensuring that indicators provide a comprehensive and accurate representation of what is being evaluated.

A reliable criterion is one that is grounded in trusted and accurate information derived from the organisation under assessment, thereby ensuring a faithful representation of the entity's sustainability performance (Young et al., 2013).

The sub-criteria for reliability in this study include validity, accuracy, and relevance (Sarbat & Ozmehmet Tasan, 2024).

1.5.3. Resilience

Like reliability, measures of resilience have consistently incorporated the ability of a system to withstand and recover quickly from shocks or stress, ultimately maintaining stability (Lopez-Ridaura et al., 2002). Resilience is defined as the extent to which a system can promptly restore the production of goods and/or services that fulfil stakeholder objectives following a disruptive event (Lopez-Ridaura et al., 2005). Resilient indicators are characterised by their ability to adapt to changing conditions, maintain relevance across different scales, and effectively involve stakeholders in their development (Lopez-Ridaura et al., 2005).

The-sub criteria for resilience in this study include flexibility, sensitivity, adaptability, responsiveness, and applicability (Sarbat & Ozmehmet Tasan, 2024).

1.5.4. Proactiveness

Proactiveness as an evaluation criteria for indicators enables stakeholders to identify emerging trends and opportunities, anticipate future challenges, and take action to address them (Pires et al., 2020). In this context, it is essential to differentiate between reactive and proactive indicators, as they serve as decision-making and monitoring tools (Guy & Kibert, 1998). Proactive indicators, in particular, act as a warning rather than measuring an existing state, allowing stakeholders to take preventative measures (Guy & Kibert, 1998). Indicators that lack proactiveness may result in reactive approaches that fail to address the root cause.

The sub-criteria for proactiveness in this study include timeliness and predictability (Sarbat & Ozmehmet Tasan, 2024).

1.5.5. Policy Relevance

In terms of evaluating indicators, the policy relevance criterion suggests that indicators should be assessed based on their ability to provide useful information for policymaking and their alignment with emerging societal and physical developments (Pupphachai & Zuidema, 2017). The policy and programme dimension of performance management encompasses a set of indicators that assess an organisation's effectiveness in setting and achieving its objectives, as well as its adherence to established policies (Young et al., 2013). This can be achieved through monitoring and tracking relevant trends and changes in the policy context, as well as evaluating the impact of policy interventions on these developments.

The sub-criteria for policy relevance in this study include complementarity and connectedness (Sarbat & Ozmehmet Tasan, 2024).

1.6. Conclusion

Despite the existence of the OHSA and various legislative frameworks aimed at improving workplace conditions, significant gaps still remain in the implementation and effectiveness of OHS practices within South African organisations. The literature indicates that many organisations still prioritise profit over employee well-being, potentially leading to inadequate health and safety measures (Chillakuri & Vanka, 2021). Research highlights persistent issues such as economic inequality, weak enforcement of regulations, and a large informal employment sector where labour protections are often absent (Pons-Vignon & Anseeuw, 2009). These factors contribute to hazardous working conditions that can compromise employee health and safety. Furthermore, the lack of resources and fragmented trade unions further complicate the advocacy for improved OHS practices in South Africa (Pons-Vignon & Anseeuw, 2009).

The historical context of OHS in South Africa, particularly in the mining sector, shows a growing emphasis on health and safety, yet the actual implementation of effective practices continues to be inconsistent (Fan et al., 2020; Zwi et al., 1988). This suggests that while there may be frameworks in place, the practical application and prioritisation of OHS indicators are lacking. Therefore, South African organisations need to identify and prioritise effective OHS indicators that align with sustainable HF/E to enhance employee well-being and organisational performance.

Ultimately, a thorough understanding of health and safety is essential for South African organisations, especially given the unique challenges presented by the country's industrial landscape (Shikdar & Sawaqed, 2003). Integrating sustainability into an HF/E-focused OHS framework transcends mere academic interest; it is a crucial strategy for enhancing employee well-being, protecting the environment, and improving organisational performance.

By emphasising evaluation criteria such as measurability, reliability, resilience, proactiveness, and policy relevance, organisations can establish a robust set of EIs that not only addresses health and safety issues but also cultivates a culture of continuous improvement and sustainable practices. This holistic approach ensures that employee well-being remains a central priority in organisational objectives, ultimately leading to a healthier workforce and a more sustainable future (De Cieri & Lazarova, 2021; Yilmaz & Yildaz, 2021)

This research aims to contribute to the ongoing discourse on OHS by providing actionable insights into sustainable HF/E. By doing so, it seeks to cultivate ecologically healthier workplaces, stimulate economic growth, foster socially safe environments, and ultimately promote a more sustainable future for all stakeholders involved.

1.7. Research Question

Which EIs have the highest priority rank order for OHS professionals in South Africa, considering the combined evaluation criteria of measurability, reliability, resilience, proactiveness, and policy relevance?

Chapter 2: Methods

2.1. Introduction

This chapter provides a comprehensive overview of the study's aim and underlying rationale. It explores the research design, sampling strategy, and sample size, as well as the study's procedures. Additionally, it details the instruments used for data collection, addresses ethical considerations, and outlines the quantitative analysis methods implemented.

2.2. Aim

This research seeks to systematically identify and apply five weighted evaluation criteria to rank 23 EIs for white-collar practitioners in the health and safety sector, specifically targeting those within the OHS sector who are knowledgeable about HF/E and sustainability who may benefit from such a systemic approach. By employing these weighted criteria, the study aims to differentiate between the most and least important EIs. The primary objective is to ascertain the relative importance of each EI, thereby enhancing the understanding and application of these indicators to improve health and safety outcomes.

2.3. Rationale

From ancient philosophers to current psychologists, decision-making has undergone much research in the quest for understanding human behaviour and well-being (Greco et al., 2016). It is therefore a construct that is complex in nature, rich in history, and multifaceted in composition. The decision-making process is crucial in all aspects of life, particularly within organisations that face complex work systems and associated risks. Effective management of this process requires a systemic approach that emphasizes human well-being and workplace safety (Waterson et al., 2015).

This study adopts a Multi-Criteria Decision Making (MCDM) methodology to facilitate this complex and critical decision-making process (Omoruyi et al., 2023). MCDM models, which combine mathematical and computational tools to provide subjective evaluations of performance criteria, have been growing since the 1990s and are used to support strategic decisions in various fields (Zavadskas et al., 2016). MCDM is a valuable tool in solving issues that are characterised with multiple actors, criteria, and objectives as it enables the decision maker to give attention to all the criteria available and make an appropriate decision as to their priority (Kumar et al., 2017). The MCDM evaluation process involves choosing criteria, ranking or weighting them, followed by defining and comparing the alternatives to each other for choosing the best one(s) or ranking them to obtain their prioritisation.

This study builds upon the research conducted by Sarbat and Ozmehmet Tasan (2024), who utilised two hybrid MCDM methods; The Best-Worst Method (BWM) and the Preference Ranking Organization METHod for Enrichment Evaluations (PROMETHEE).

Together, these methodologies facilitated a comprehensive ranking of the EIs based on their measurability, reliability, resilience, proactivity, and policy relevance. The analysis was based on the insights from members of the South African Institute of Occupational Safety and Health (SAIOSH) who are professionals in OHS and may also have an understanding of HF/E and/or sustainability. The focus on OHS professionals, rather than HF/E specialists, was due to this study forming part of a broader research project that specifically targeted OHS professionals. This approach allowed the researcher to identify the highest priority EIs as perceived by respondents engaged in OHS within South African industries.

2.3.1. Best-Worst Method (BWM)

The BWM is a MCDM method that uses structured pairwise comparisons to compare complex evaluation weights (Omoruyiet al., 2023; Rezaei, 2015; van de Kaa et al., 2019). Unlike traditional models such as the Analytic Hierarchy Process (AHP), BWM is recognized for its efficiency, reliability, and consistency, often yielding unique solutions (Rezaei, 2015). This method simplifies the comparison process by utilising predefined benchmarks allowing experts to concentrate on reference comparisons (Pamučar et al., 2020). Specifically, this involves identifying the benefits of the top criterion in relation to all other criteria, as well as assessing how the other criteria compare to the least favourable one. This focus enhances decision-making efficiency and mitigates the inconsistencies commonly associated with conventional AHP methodologies (Mi et al., 2019).

The BWM offers several notable advantages: it requires fewer comparisons by relying on reference points rather than a complete comparison matrix; it utilises a straightforward 1-9 scale, making evaluations more intuitive; and it enhances consistency by eliminating redundant comparisons, resulting in more reliable outcomes (Mi et al., 2019). Despite being a relatively recent development, the BWM has gained popularity due to its robustness, high efficiency, user-friendliness, and compatibility with other MCDM methods (van de Kaa et al., 2019).

The BWM stands out as a powerful method for decision-making, demonstrating effectiveness across global contexts. Its versatility is highlighted by a diverse range of applications addressing critical real-world challenges, including, supply chain management (Ahmadi et al., 2017; Dwivedi et al., 2021; Gupta & Barua, 2016; Khan et al., 2022; Kusi-Sarpong et al., 2019; Rezaei & Fallah Lajimi, 2019; Salimi & Rezaei, 2018; Torbati et al., 2018), sustainability and environmental issues (Bai et al., 2019; Garg & Sharma, 2020; Mahmoudi et al., 2019; Nie et al., 2018), technology (Ghaffari et al., 2017; Khan et al., 2023; van de Kaa et al., 2018), transportation (Guo & Zhao, 2017; Kumar et al., 2020; Raj & Srivastava, 2018), finance (Askarifar et al., 2018; Salimi & Rezaei, 2018; Yadollahi et al., 2018), and energy (Kheybari et al., 2019; You et al., 2017).

Despite its successful application in numerous studies worldwide, there remains a notable gap in the literature regarding the use of the BWM specifically within the South African context, with only a few studies exploring its potential in this region (Omoruyi et al., 2023). This highlights an opportunity for further research to investigate the applicability and effectiveness of the BWM in addressing local challenges.

2.3.2. Preference Ranking Organization METHod for Enrichment Evaluations (PROMETHEE)

Developed by Brans et al. (1986), PROMETHEE is an outranking method, which is a sub-category of MCDM methods (Brans & De Smet, 2016). It is used to rank and select a finite set of alternatives based on criteria that are generally conflicting. PROMETHEE is based on the preference function for each criterion separately, leading to better decision-making (Behzadian et al., 2010). Having the ability to handle both qualitative and quantitative data, this interactive method is known for its simplicity, clarity, and stability, and it is adaptable to real-world problems, making it easily comprehensible for decision-makers (Behzadian et al., 2010; Brans et al., 1986; Maity & Chakraborty, 2015). Its user-friendly nature and robust mathematical properties contribute to its widespread success in various applications (Brans & De Smet, 2016).

The PROMETHEE method has been widely utilised for decades to address MCDM problems across a diverse range of application areas (Behzadian et al., 2010). Notable fields of application include water resources management (Abu-Taleb & Mareschal, 1995; Mutikanga et al., 2011; Özelkan & Duckstein, 1996; Simon et al., 2004), energy management (Angilella & Pappalardo, 2021; Doukas et al., 2006; Topcu & Ulengin, 2004; Wolters & Mareschal, 1995), financial management (Albadvi et al., 2007; Bouri et al., 2002; Gökalp, 2015; Hababou & Martel, 1998; Kalogeras et al., 2005; Mousavi & Lin, 2020), environmental management (Al-Rashdan et al., 1999; Beynon & Wells, 2008; Briggs et al., 1990; Kapepula et al., 2007; Makan & Fadili, 2020; Queiruga et al., 2008; Vego et al., 2008), as well as logistics, transportation, and construction (Akram et al., 2023; Balali et al., 2014; Dulmin & Mininno, 2003; Oubahman & Duleba, 2021, 2024; Polat, 2016; Raveh, 2000; Temiz & Calis, 2017). Additionally, it has found applications in manufacturing and assembly (Abdullah et al., 2019; Anand & Kodali, 2008; Cavalcante & De Almeida, 2007; Govindan et al., 2015, 2017; Safari et al., 2012; Venkata Rao & Patel, 2010). These represent only a selection of the numerous articles available in each field, highlighting the extensive application of PROMETHEE across various domains. However, despite its widespread use in global contexts and across many fields, the application of PROMETHEE in South Africa remains limited, indicating a potential area for further research and exploration (Mathye & Scholz, 2023).

2.4. Research Design

A quantitative, relational, and non-experimental research design was adopted for this study. This design was chosen because it allows the selection of a representative sample from a given population to make causal inferences (Creswell & Creswell, 2017; Lowhorn, 2007). The research utilised specialised analytical methods, including the hybrid MCDM methods, PROMETHEE and BWM, to prioritise EIs against predefined evaluation criteria (Sarbat & Ozmehmet Tasan, 2024).

The non-experimental design aligns with the research objective to identify relationships rather than establish causality. While non-experimental designs are associated with lower internal validity, they provide stronger external validity and generalisability of results (Shadish et al., 2002). Recognising these limitations, careful selection of variables and rigorous data analysis were employed to enhance the robustness of the findings.

The exploratory nature of the research framework is particularly suited to this relational design, allowing for an in-depth analysis of the variables of interest and their interconnections. This approach yields valuable insights into the prioritisation of EIs in the South African context.

2.5. Sample and Sampling Strategy

2.5.1. Sample

The sample consisted of OHS professionals in South Africa, sourced through SAIOSH. As the largest OHS professional body in Africa, SAIOSH serves as the official registration body for OHS professionals in South Africa under the NQF Act, Act 67 of 2008. Committed to minimising workplace incidents and advancing safety across diverse industries, SAIOSH also serves as a vital space for information, professional development, and networking in the OHS sector (Jansen van Vuuren, 2020). Demographic information, including age, experience, and knowledge about ergonomics and/or sustainability, was collected from those professionals and is summarised in Table 1. Additionally, Table 2 provides a summary of gender, education level, and department/industry of those respondents.

Table 1. *Respondents Information: Descriptive Statistics (n=125)*

	Mean	**Std. Deviation**	**Minimum**	**Maximum**

Age	47.86	11.36	27	76
Experience (in years)	11.95	10.26	1	45
Knowledge of HF/E	4.95	1.39	1	7
Knowledge of sustainability	5.02	1.39	1	7
Knowledge of HF/E and sustainability	4.94	1.32	1	7

Note: Three questions for asking knowledge levels were designed using a scale from 1 (i.e., little knowledge) to 7 (i.e., much knowledge).

Table 2. *Respondents Information: Frequency Distribution (n=125)*

	Descriptor	Frequency N	Percentage %
Gender	Male	77	61.6%
	Female	46	36.8%
	Other	2	1.6%
Education level	Associate’s degree	54	43.2%
	Bachelor's Degree	36	28.8%
	Master's Degree	13	10.4%
	Other	22	17.6%
Department/ Industry	Resource-Intensive and Infrastructure Sectors (Manufacturing, Mining, Construction, Oil, Gas, and Petroleum, Forestry and Nature Conservation)	69	55.2%

Knowledge and Service Sectors (Higher Education, Consulting, Legal, Health and Safety)	30	24%
Public and Connectivity-Oriented Sectors (Government/Public Sector, Telecommunications, Supply Chain and Operations)	17	13.6%
Other	9	8%

The total sample size for this study was 125, which satisfies the Central Limit Theorem, allowing for the application of parametric assumptions (Field, 2024). As introduced above, the sample comprised white-collar professionals, including senior managers, department heads, and employees within South Africa's OHS sector.

Table 1 presents the age, experience and knowledge characteristics of the respondents. Ages range from 27 to 76 years, with a mean of 48 years, indicating a diverse age distribution. Experience varies from 1 to 45 years, averaging 12.14 years. Knowledge levels in HF/E (mean score of 4.95) and sustainability (mean score of 5.02) are moderate and consistent, as reflected by low standard deviations. The combined knowledge in both areas also shows a mean score of 4.94, highlighting a balanced awareness among respondents. Overall, the findings indicate that the respondents are diverse, indicating a moderate yet consistent level of knowledge in the HF/E, sustainability and HF/E and sustainability. As these scores are based on self-report measures, they may reflect individuals' perceived rather than actual knowledge, potentially introducing bias and affecting the validity of the findings.

As presented in Table 2, most of the respondents (61.6%) were male, reflecting the demographic composition of the OHS field in South Africa (Rikhotso et al., 2022). The gender distribution across various OHS sectors reveals that industries in South Africa such as construction, manufacturing, and trade predominantly employ males, while community service and finance sectors have a higher representation of females (Rikhotso et al., 2022). This disparity reflects a historical context in the South African labour market, where certain jobs were traditionally reserved for men (Rikhotso et al., 2022).

Responders exhibited diverse educational qualifications: 43.2% held associate degrees, 28.8% had bachelor's degrees, 10.4% earned master's degrees, and 17.6% possessed other diplomas or certifications. This indicates a well-educated sample capable of addressing OHS complexities.

The respondents represented various industries, with 55.2% from resource-intensive and infrastructure sectors. Additionally, 24% were from knowledge and service sectors, while 13.6% came from public and connectivity-oriented sectors. This diversity underscores the broad applicability of OHS principles and the growing recognition of workplace safety across traditionally less hazardous fields. Overall, these findings reflect a dynamic OHS landscape, with professionals prepared to tackle diverse challenges and enhance safety standards across multiple industries.

2.5.2. Sampling Strategy

Sampling is a fundamental aspect of research methodology, as it involves the systematic selection of a subset of individuals from a larger population to ensure that the findings are both meaningful and generalisable (Lunsford & Lunsford, 1995). In this study, a purposive, non-probability, voluntary sampling method was employed, which is particularly effective for identifying individuals who possess specific characteristics pertinent to the research objectives (Etikan et al., 2016). This sampling strategy is advantageous not only for its convenience and cost-effectiveness but also for its ability to facilitate the collection of rich, contextually relevant data, thereby enhancing the rigour and depth of the research findings (Laher & Botha, 2012).

2.6. Procedure

This study received ethical approval from the Human Research Ethics Non-Medical Committee (HREC) of the University of the Witwatersrand (approval number: MAORG-24-02). Furthermore, authorisation was obtained from the management of SAIOSH to distribute the survey among its members (Appendix E). The Membership and Communications Department of SAIOSH facilitated the distribution of the online survey, ensuring effective outreach to the target population. The survey was administered using the REDCap platform, which was selected for its efficiency, cost-effectiveness, and enhanced security features (Lefever et al., 2007). Participation in the survey was entirely voluntary, thereby upholding the ethical standards required for research involving human subjects.

The digital survey was launched on August 21, 2024, and remained accessible until September 11, 2024. To enhance participation rates, reminder emails were distributed to members throughout the survey period. Additionally, respondents were incentivised with the award of one Continuing Professional Development (CPD) point for completing the entire survey. Although a total of 705 individuals initiated the survey, only 125 respondents completed it in full, resulting in a final sample size of n=125. Despite the observed attrition rate, this sample size was considered sufficient for the study's analytical objectives, particularly given the targeted and specialised nature of the respondent group.

The survey instrument, developed by Sarbat and Ozmehmet Tasan (2024), was designed to capture respondents' demographic information, rank the importance of evaluation criteria, assess EIs, and gather overall evaluations. This comprehensive approach ensured that the data collected would yield valuable insights aligned with the research objectives of this work.

Data collected from the survey was initially compiled using Microsoft Excel and subsequently analysed using IBM's Statistical Package for Social Sciences (SPSS). Following this preliminary analysis, the BWM and PROMETHEE were employed to conduct a more in-depth examination of the data to address the specific objectives of the study.

To inform respondents about the study's requirements and to assure them of anonymity and confidentiality, a Participant Information Sheet (PIS) was incorporated digitally as a cover letter (Appendix A). Respondents were required to provide consent before proceeding with the survey; they also had the option to withdraw from the study at any point. Only upon providing informed consent, respondents were able to complete the survey. The collected data was then subjected to thorough inspection and cleaning to eliminate errors and incomplete responses. The cleaned dataset was securely stored on a password-protected computer, accessible exclusively to the research team.

2.7. Research Instruments

Building on the survey created by Sarbat and Ozmehmet Tasan (2024), the following information was obtained in four parts:

2.7.1. Respondents Information

The first section requested demographic data from the respondents such as gender, country, age, level of education, broad industry, occupation and level of expertise and knowledge (Table 1 and 2). Respondents rated their expertise and knowledge on a scale of 1 to 7 (1 = Little knowledge, 7 = Much knowledge) in the areas of HF/E and sustainability. To guide their assessments, they were provided with the definitions of HF/E from the International Ergonomics Association (IEA, 2000) and sustainability (Johnston et al., 2007).

2.7.2. Evaluation Criteria

The second section of the survey focused on evaluating criteria for assessing indicators. Respondents were asked to identify the "most important" criterion (measurability, reliability, resilience, proactiveness, and policy relevance) and then compare its importance to the other criteria using a scale of 1 to 9. A score of 1 indicated equal importance to the most important criterion, while a score of 9 reflected that the selected criterion was significantly more important. Respondents were instructed not to assign 1 to any criterion other than the one they had chosen as the most important. Additionally, respondents identified the "least important" criterion from the same set and compared it to the others using a similar 1 to 9 scale. A score of 1 indicated equal importance to the least important criterion, while 9 signified that a criterion was much more important. Intermediate values represented varying degrees of importance. This process clarified the relative importance of each criterion, offering valuable insights into their impact on decision-making and supporting more effective prioritisation. The BWM model was employed to assign weights to these five criteria in a hybrid multi-criteria analysis (Chapter 3, Section 3.3, Table 5)

2.7.3. Ergonomics Indicators (EIs)

This section of the survey comprised 23 statements designed to evaluate the 23 EIs based on the five evaluation criteria outlined earlier. For each EI, respondents rated their level of agreement with statements designed by considering the five evaluation criteria using a 7-point Likert scale (1 = Strongly Disagree, 7 = Strongly Agree).

2.7.4. General Evaluation

This section consisted of two questions assessing respondents' overall evaluation of EIs, a 7-point Likert-type scale was used (1 = Strongly Disagree, 7 = "Strongly Agree). Additionally, respondents provided comments and suggestions related to the survey.

2.8. Ethical Considerations

The researcher undertook the process of securing ethical approval from the Human Research Ethics Committee (HREC) at the University of the Witwatersrand, which involved several key steps. Initially, the researcher completed the Statement of Principle for Postgraduate Supervisions (Appendix B). Following the completion of the research proposal, the faculty reviewer provided a Narrative Report (Appendix C), which included recommendations for minor revisions, confirmed that the research posed a low risk, and endorsed the proposal for ethical review. Subsequently, conditional ethical clearance was granted by the HREC (MAORG/24/02) (Appendix D).

Formal approval to conduct the study was sought and received from the leadership of SAIOSH (Appendix E). As outlined in Chapter 2, Section 2.6, informed consent was obtained from respondents through an electronic format (Appendix A). This participant information sheet emphasised that participation was entirely voluntary, allowed respondents the option to withdraw at any point, and assured them that their information would remain confidential. Additionally, it detailed the purpose and nature of the study, as well as the estimated time commitment required from respondents. They were also informed that they could reach out to any member of the research team if they had questions or needed further information.

To uphold confidentiality and anonymity, the researcher implemented stringent measures to safeguard respondents' identities. This included refraining from requesting any specific identifying information regarding the respondents or their organisations. The analysis and reporting of the collected data were conducted in an aggregated numerical format to safeguard the privacy of the respondents. Specific information regarding the organisations or individual employee responses was not disclosed in this report. Instead, only summarized data were presented, and the results were explicitly stated to be used solely for research purposes. Importantly, there were no anticipated risks to respondents involved in the study.

2.9. Data Analysis

The demographic variables were categorical and by virtue, descriptive statistics, in the form of percentages and frequencies, were used to consolidate, arrange, and describe the data. (Field, 2024) (Chapter 2, Section 2.5.1, Table 1 and Table 2). To ensure internal consistency of the survey instrument, Cronbach's Alpha coefficients were calculated (Table 3). Mann-Whitney U tests, Kruskal-Wallis tests, and Chi-Square Tests of Independence were used to analyse the data, as appropriate (Appendix F).

The final phases of analysis involved the use of two Hybrid MCDM methods: The first being BWM which was used to assign weights to the consolidated evaluation criteria (Chapter 3, Section 3.3, Table 5). Following this, PROMETHEE was used to prioritise the indicators that served as candidates for the systemic approach (Chapter 3, Section 3.4, Table 8, 9, 10 and 11). This was achieved by incorporating the weights and other defined parameters into the PROMETHEE method (Chapter 3, Section 3.4).

The survey developed by Sarbat and Ozmehmet Tasan (2024) predominantly utilised a 7-point Likert-type scale for most questions, except for the 1-9 scale employed for the BWM.

The preference for Likert-type scales stems from their structure, which consists of individual questions accompanied by distinct Likert-type response options, rather than relying on a composite scale (Boone & Boone, 2012). These scales facilitate the collection of quantitative estimates of subjective characteristics, generating numerical data that can be summarised and visualised in a manner consistent with other quantitative data (South et al., 2022). This approach enabled a detailed analysis of the 23 EIs, which was crucial for accurately capturing the importance rankings of each indicator. The selection of a 7-point scale was chosen based on its reliability because increasing the number of response options beyond seven yields only marginal improvements in reliability, which do not justify the additional complexity (Sarbat & Ozmehmet Tasan, 2024). The results were subsequently synthesised using hybrid multi-criteria analysis.

2.9.1. Best-Worst Method (BWM)

BWM was conducted using Excel Solver (https://bestworstmethod.com/) to weight the five evaluation criteria based on data collected from respondents. The Aggregation of Individual Priorities (AIP) approach was used to aggregate the weights, as the Aggregation of Individual Judgments (AIJ) approach was not appropriate for BWM due to differences in the best and worst criteria selected by different respondents (Sarbat & Ozmehmet Tasan, 2024). The consistent results were determined using the input-based consistency ratios (CR^I) (Liang et al., 2020) (Chapter 3, Section 3.3, Table 5), and the normalised geometric mean was used to aggregate these consistent results (Sarbat & Ozmehmet Tasan, 2024).

2.9.2 Preference Ranking Organization METHod for Enrichment Evaluations (PROMETHEE)

This ranking was facilitated using the PROMETHEE method using Visual PROMETHEE (VP) software (http://en.promethee-gaia.net/). Sarbat and Ozmehmet Tasan (2024) identified 23 EIs, and the PROMETHEE method employed a seven-point Likert scale to assess the applicability of the systematic approach incorporating these indicators (1 = strongly disagree, 7 = strongly agree). Appendix C of the study by Sarbat and Ozmehmet Tasan (2024) provides valuable insights into the mathematical background of the method and is recommended for further review. The indicators were derived from three previously published studies and serve as the foundational components of this systematic approach (Sarbat & Ozmehmet Tasan, 2020, 2022, 2024).

Cronbach's alpha coefficients were calculated for the 23 EIs, each comprising five questions that aligned with the evaluation criteria. This analysis was performed using IBM SPSS Statistics (Version 26) to assess the internal consistency reliability of the scales. The resulting Cronbach's alpha coefficients are presented in the table below (Table 3).

Table 3. *Cronbach's Alpha*

EI	Cronbach's Alpha Coefficients
EI1	.86
EI2	.71
EI3	.88
EI5	.91
EI6	.92
EI7	.75

EI8	.91
EI9	.92
EI10	.90
EI12	.92
EI13	.91
EI14	.88
EI15	.93
EI16	.93
EI17	.94
EI18	.86
EI19	.83
EI20	.90
EI21	.91
EI22	.85
EI23	.85
EI24	.87
EI25	.92

The Cronbach's alpha coefficients all exceeded 0.70 indicates that the survey achieved an acceptable level of internal consistency reliability.

2.10. Conclusion

This methodology section offers a thorough exploration of the fundamental components of the research. It emphasises the rationale for utilising the BWM and PROMETHEE. Additionally, it outlines the research design, sampling size and strategy, procedural framework, research instruments used, ethical considerations addressed, and the quantitative analyses performed. The final analysis is presented in the Results Chapter.

Chapter 3: Results

3.1. Introduction

This chapter presents the results of the study, providing a detailed analysis of the data collected. It begins by examining the descriptive statistics to establish a foundational understanding of the dataset. It then delves into the findings derived from the BWM and PROMETHEE analyses, highlighting the rankings of the EIs according to the five consolidated evaluation criteria. Finally, the chapter concludes with an exploration of the overall evaluations provided by the respondents.

3.2. Descriptive Statistics

The frequencies and percentages of the categorical demographic information were analysed, (Chapter 2, Section 2.5.1, Table 1). In addition, since the instrument utilises Likert-type scales, it can be considered interval (Field, 2024). Therefore, the mean and standard deviations were used to measure central tendency and the dispersion of the data where relevant (Chapter 2, Section 2.5.1, Table 2).

Subsequently, a series of statistical analyses were conducted using IBM SPSS Statistics (Version 26) to characterise the data. These analyses included the Mann–Whitney U test, the Kruskal-Wallis test, and the Chi-Square Test of Independence (Appendix F). Each test utilised data collected from the first and third sections of the survey, examining the relationships, specifically between education levels and industries, with the most and least important EIs to determine whether preferences or rankings varied significantly based on these demographic factors. The findings from the statistical analysis Mann-Whitney U tests, Kruskal-Wallis tests, and Chi-Square Tests of Independence predominantly indicated a lack of statistical significance.

This outcome may be attributed, in part, to the limited sample sizes utilised in the study (n=125). Additionally, the survey's response rate was relatively low at 17%, which could be influenced by several factors, including the survey's length. These results suggest that there were no statistically significant differences observed, indicating that the sample is largely homogeneous with minimal variability. Detailed findings and results of these analyses can be found in Appendix F.

3.3. Best-Worst Method (BWM) Results

The BWM, a MCDM tool, was employed to prioritise five evaluation criteria identified by Sarbat and Ozmehmet Tasan (2024): Measurability, reliability, resilience, proactiveness, and policy relevance.

Of the 125 respondents, the responses of 14 individuals who rated the most and least important criterion as the same were initially excluded from determining the criteria weights through BWM. This resulted in a total of 111 valid responses for analysis. The remaining responses were then evaluated using the input-based consistency ratios (CR^I) established by Liang et al. (2020). Consequently, 79 responses were identified as inconsistent and excluded, leaving 32 consistent responses that were suitable for use in the BWM analysis.

Based on the rationale behind the BWM, each respondent was asked to identify both the most and least important criteria from a predefined list for evaluating criteria, revealing variability in their selections. Focusing on the data from the 32 respondents whose answers were consistent, the BWM method was applied to this subset to calculate the weights of each criterion, reflecting their relative importance. A summary of the variability of the weights are presented below in Table 4.

Table 4. *Summary of the Variability of Weights of Evaluation Criteria*

	Measurability	Reliability	Resilience	Proactiveness	Policy Relevance
Min	.06	.04	.04	.04	.03
Max	.42	.43	.48	.42	.44
Mean	.27	.23	.17	.18	.15
SD	.12	.11	.12	.10	.12

This approach aligns with the Aggregation of Individual Priorities (AIP) methodology, which aggregates individual weights into a collective assessment. AIP is particularly effective for consolidating data from respondents viewed as separate individuals (Forman & Peniwati, 1998).

The aggregation process involved calculating the normalised geometric mean of the weights assigned to each criterion. Among the 32 respondents, measurability emerged as the most important criterion, with a weighted average importance of 28.4%. It was followed by reliability (23.7%), proactiveness (17.95%), resilience (16.45%), and policy relevance (13.49%). These results are summarised in Table 5.

The derived weights were then utilised in two decision matrices: a median aggregated matrix (Table 6) and a weighted average aggregation matrix (Table 7), providing a comprehensive foundation as inputs for further analysis using PROMETHEE.

The two matrices differ in data aggregation methods and scales: Scenario 1 (Table 6) uses the median for ordinal data from a 7-point Likert-type scale, defining criteria as qualitative with a Type IV-Level preference function for smaller deviations (Chapter 3, section 3.4). Scenario 2 applies the weighted average for quantitative data, defining criteria as numerical with a Type V-Linear preference function for precise differentiation. Using both matrices ensures the methodology aligns with the data's scale, providing a comprehensive evaluation. (Chapter 3, section 3.4)

Table 5. BWM results using the consistent data

Respondents	Measurability	Reliability	Resilience	Proactiveness	Policy Relevance	CRI
R_01	0.42	0.24	0.12	0.07	0.16	0.20
R_10	0.12	0.24	0.42	0.07	0.16	0.20
R_16	0.13	0.38	0.04	0.27	0.18	0.26
R_26	0.38	0.18	0.27	0.13	0.04	0.21
R_27	0.21	0.14	0.29	0.33	0.03	0.21

R_30	0.37	0.10	0.23	0.26	0.04	0.29
R_34	0.25	0.41	0.16	0.05	0.12	0.04
R_39	0.15	0.11	0.04	0.26	0.44	0.25
R_41	0.24	0.42	0.07	0.12	0.16	0.20
R_42	0.07	0.39	0.12	0.16	0.25	0.20
R_44	0.42	0.12	0.16	0.24	0.07	0.20
R_48	0.18	0.04	0.13	0.38	0.27	0.29
R_50	0.25	0.16	0.40	0.06	0.12	0.20
R_53	0.12	0.15	0.48	0.20	0.05	0.22
R_58	0.38	0.28	0.18	0.05	0.11	0.22
R_60	0.35	0.23	0.17	0.17	0.08	0.11
R_65	0.42	0.14	0.04	0.11	0.28	0.29
R_70	0.41	0.18	0.11	0.27	0.04	0.22
R_79	0.26	0.38	0.05	0.18	0.13	0.21
R_80	0.38	0.27	0.04	0.13	0.18	0.26

R_81	0.29	0.04	0.20	0.08	0.39	0.15
R_82	0.39	0.25	0.17	0.13	0.06	0.21
R_89	0.40	0.25	0.16	0.12	0.06	0.20
R_90	0.42	0.24	0.16	0.12	0.07	0.20
R_91	0.41	0.24	0.16	0.12	0.07	0.07
R_107	0.18	0.38	0.27	0.04	0.13	0.21
R_108	0.14	0.21	0.08	0.42	0.14	0.20
R_109	0.26	0.13	0.39	0.17	0.05	0.18
R_111	0.19	0.13	0.04	0.28	0.38	0.13
R_113	0.13	0.43	0.14	0.21	0.09	0.20
R_114	0.06	0.13	0.17	0.25	0.39	0.21
R_121	0.28	0.38	0.11	0.19	0.05	0.29
Geometric mean	0.24	0.20	0.14	0.15	0.11	
Normalised geometric mean	0.28	0.24	0.16	0.18	0.13	

Table 6. *The Decision Matrix for Scenario 1: Ordinal Scale Aggregation Method: Medians of the Responses ('Qualitative'-coded in VP Software)*

	Evaluation Criteria Weights				
	0.28	0.24	0.16	0.18	0.13
Ergonomics Indicators	Measurability	Reliability	Resilience	Proactiveness	Policy Relevance
EI1	6	6	5	5	6
EI2	6	6	5	6	6
EI3	6	6	5	5	6
EI5	6	6	5	5	6
EI6	6	6	5	5	5
EI7	6	6	5	6	6
EI8	6	6	5	5	5
EI9	6	5	5	5	5
EI10	6	5	5	6	5
EI12	6	5	5	5	5
EI13	6	5	5	5	5
EI14	6	6	5	6	5
EI15	5	4	5	5	4
EI16	6	5	5	5	5
EI17	5	5	5	5	5
EI18	6	6	6	6	6
EI19	6	5	5	6	6
EI20	6	5	5	5	5
EI21	6	6	5	6	6
EI22	6	6	5	5	5

EI23	6	5	5	5	5
EI24	6	5	5	5	5
EI25	6	5	5	5	5

Table 7. *The Decision Matrix for Scenario 2: Quantitative Scale Aggregation Method: Weighted Averages of the Responses ('Numerical'-coded in VP Software)*

	Evaluation Criteria Weights				
	0.28	0.24	0.16	0.18	0.13
Ergonomics Indicators	Measurability	Reliability	Resilience	Proactiveness	Policy Relevance
EI1	5.98	5.38	4.99	4.92	5.13
EI2	6.08	5.43	5.06	5.14	5.24
EI3	5.87	5.21	4.90	4.94	5.22
EI5	5.66	5.21	4.82	4.78	5.01
EI6	5.40	5.02	4.62	4.85	4.85
EI7	6.02	5.42	4.97	5.23	5.24
EI8	5.70	5.25	4.82	5.06	5.02
EI9	5.43	4.98	4.70	4.88	4.85
EI10	5.79	5.22	4.94	5.06	4.95
EI12	5.40	4.83	4.72	4.75	4.80
EI13	5.19	4.67	4.46	4.50	4.74
EI14	5.80	5.27	5.10	5.43	5.11
EI15	4.96	4.41	4.40	4.47	4.26
EI16	5.22	4.88	4.65	4.86	4.91
EI17	5.00	4.56	4.46	4.62	4.62
EI18	6.12	5.59	5.24	5.32	5.49

EI19	5.95	5.32	4.94	5.18	5.12
EI20	5.45	4.99	4.72	5.02	4.87
EI21	5.66	5.22	4.80	5.20	5.17
EI22	5.94	5.38	4.95	4.94	4.82
EI23	5.49	5.06	4.86	5.04	4.89
EI24	5.39	4.98	4.72	4.68	4.87
EI25	5.04	4.75	4.50	4.75	4.70

3.4. Preference Ranking Organization METHod for Enrichment Evaluations (PROMETHEE) Results

The weights derived from the BWM were utilised to prioritise the EIs using the PROMETHEE method, incorporating the indifference and preference thresholds obtained from the Preference Function Assistant within the VP software. Aggregated quantitative data were processed using VP software, with a Linear preference function (Type V) chosen for its effectiveness in evaluating criteria. The method uses two thresholds: the indifference threshold (q), set as the standard deviation of differences, and the preference threshold (p), calculated as the sum of the standard deviation and the average difference. Criteria weights were determined using the BWM. Two scenarios, qualitative and numerical, were analysed, with results outlined in Table 5, enabling a comprehensive evaluation of alternatives.

For qualitative-coded (Scenario 1, aggregated with mean): Indifference thresholds (q): .37, .57, .29, .50, .56. Preference thresholds (p): .54, 1.179, .37, .94, 1.12. For numerical-coded (Scenario 2, aggregated with weighted average): Indifference thresholds (q): .28, .25, .18, .20, .22. Preference thresholds (p): .70, .60, .43, .49, .51.

Before applying the method, the Aggregation of Individual Judgments (AIJ) approach was implemented to consolidate the data. These PROMETHEE Flow Tables represent the outputs of the analysis, showcasing the rankings of all the EIs based on the net outranking flows (Φ) calculated from pairwise comparisons. In the PROMETHEE framework, a higher Φ indicates a more significant EI, meaning that the "Rank" in the flow tables reflects the prioritised importance of each indicator.

Two distinct scenarios were developed for the prioritisation process from data collected by all respondents (n=125). In Scenario 1, the decision matrix for PROMETHEE (Table 6) was constructed by aggregating the respondents' data using the median. This approach is supported by Beliakov et al. (2007), who emphasise the median's effectiveness for data measured on an ordinal scale (Sarbat & Ozmehmet Tasan, 2024). Scenario 2 generated a different decision matrix for PROMETHEE (Table 7) by aggregating the same respondents' data using the weighted average. The weighted average is a widely recognised method for data aggregation (Beliakov et al., 2007). In this case, the aggregated data were calculated by multiplying each Likert-type score by the number of respondents who selected that score, summing these products, and then dividing by the total number of respondents (Sarbat & Ozmehmet Tasan, 2024). The results of these scenarios are detailed in Tables 7 and 8.

The rankings, as shown in the 'Rank' column, were calculated based on the Φ for each alternative indicator.

In the PROMETHEE method, a higher Φ indicates a more favourable alternative (Sarbat & Ozmehmet Tasan, 2024). Based on this principle, the EIs with positive Φ values, as presented in Tables 7 and 8, emerge as viable candidates for a systemic approach. Although different aggregation methods were applied across two scenarios, the resulting rankings of the indicators remained largely consistent, with only two alternatives, EI6 (Annual investment cost for ergonomics interventions and EHS issues) and EI23 (Percentage of employees who are satisfied with their work), showing variations in their Φ values between the scenarios top ranking (Table 8 and 9).

Ultimately, when comparing the rankings from Scenario 1 and Scenario 2, it can be concluded that EIs with positive Φ can be strong candidates for a systemic approach that integrates HF/E and sustainability (Sarbat & Ozmehmet Tasan, 2024).

In this context, the rankings from Table 9 (Scenario 2) are prioritised for analysis and interpretation, as it provides clearer insights based on the weighted aggregation method. While the positive and negative rankings in Scenarios 1 and 2 are mostly consistent, EI6 (annual investment cost for ergonomics interventions and EHS issues) and EI23 (percentage of employees who are satisfied with their work) stand out as exceptions. EI6 is ranked positively in Scenario 1 but negatively in Scenario 2, while EI23 is ranked negatively in Scenario 1 but positively in Scenario 2. Scenario 2 will be the primary focus for the remainder of the discussion, and both EI6 and EI23 will be included among the selected candidates. Consequently, a total of 14 EIs were identified for this approach. This inclusion acknowledges both EI6 and EI23 as positively ranked indicators. A similar procedure to that outlined by Sarbat and Ozmehmet Tasan, (2024) was adopted to guide the selection of EIs for this systematic approach.
The results, based on the two scenarios, are presented in Tables 8 and 9 below. Tables 10 and 11 show the top three and bottom two indicators based on the evaluation criteria.

Table 8. *The PROMETHEE Flow Table for Scenario 1 (Aggregation using Medians)*

Rank	EIs	Net Outranking Flow (Φ)
1	EI18	.44
2	EI2	.27

2	EI7	.27
2	EI21	.27
5	EI14	.20
6	EI19	.14
7	EI1	.08
7	EI3	.08
7	EI5	.08
10	EI10	.07
11	EI6	.01
11	EI8	.01
11	EI22	.01
14	EI9	-.11
14	EI12	-.11
14	EI13	-.11
14	EI16	-.11
14	EI20	-.11
14	EI23	-.11
14	EI24	-.11
14	EI25	.11
22	EI17	-.41
23	EI15	-.61

Table 9. *The PROMETHEE Flow Table for Scenario 2 (Aggregation using Weighted Averages)*

Rank	EIs	Net Outranking Flow (Φ)
1	EI18	.62
2	EI2	.41
3	EI7	.39
4	EI14	.36
5	EI19	.30
6	EI1	.27

7	EI22	.21
8	EI3	.21
9	EI21	.18
10	EI10	.18
11	EI8	.14
12	EI5	.05
13	EI23	.01
14	EI20	-.07
15	EI9	-.12
16	EI6	-.16
17	EI24	-.19
18	EI12	-.23
19	EI16	-.25
20	EI25	-.45
21	EI13	-.52
22	EI17	-.59
23	EI15	-.76

Table 10. *Most Important Indicators*

		Net Outranking Flow (Φ)	Net Outranking Flow (Φ)
EI Number	EI	Scenario 1	Scenario 2
EI18	Percentage of employees receiving EHS training per year	.44	.62
EI2	Number of injury-free days per year	.27	.41
EI7	Cost of EHS training of employees per year	.27	.39

Table 11. *Least Important Indicators*

		Net Outranking Flow (Φ)	Net Outranking Flow (Φ)
EI Number	EI	Scenario 1	Scenario 2
EI17	Percentage of annual incentives and promotions made for stakeholders to contribute ergonomically and environmentally friendly designed processes	-.41	-.59
EI15	Number of volunteers for making charitable contributions to EHS issues per year	-.61	-.76

Scenario 2 was selected as the preferred approach due to its use of a weighted average aggregation method, which provides greater clarity in distinguishing between the alternative EIs. This numerical aggregation logic allows variations between alternatives to be more observable, as it accounts for both the preference and indifference thresholds in evaluating one EI's dominance over another. These thresholds are more distinctive in Scenario 2, enhancing the interpretability and robustness of the ranking results. This makes Scenario 2 a more suitable choice for effectively capturing and comparing the relative strengths of the alternatives.

A summary of the rankings are presented in Table 12. To enhance clarity, Φ from Scenario 1 are displayed alongside those from Scenario 2, enabling a clearer comparison of the two scenarios. While this comprehensive view aids understanding, Scenario 2 rankings and values will remain the primary focus throughout the discussion.

Table 12. *The Ergonomics Indicators with Their Rankings and Φ Values Obtained from Hybrid Multi-Criteria Analysis and their Classifications from scenario 2 (including Scenario 1 Φ for clarity)*

Rank	Φ Scenario 2	Φ Scenario 1	EI Number	EI	Main Dimension	Sub Dimension	Indicator type
1	.62	.44	EI18	Percentage of employees receiving EHS training per year	Social	Self-Development	Leading
2	.41	.27	EI2	Number of injury-free days per year	Economic	Loss	Lagging
3	.39	.27	EI7	Cost of EHS training of employees per year	Economic	Investment	Leading
4	.36	.20	EI14	Number of activities made for improving working conditions per year	Ecological	Conditions	Leading
5	.30	.14	EI19	Percentage of total time spent due to EHS training relative to the total hours worked per year	Social	Self-development	Leading

6	.27	.08	EI1	Number of accident-free days per year	Economic	Loss	Lagging
7	.21	.01	EI22	Annual turnover rate of employees	Social	Satisfaction	Lagging
8	.21	.08	EI3	Percentage of total lost time due to accidents and injuries relative to the total hours worked per year	Economic	Loss	Lagging
9	.18	.27	EI21	Annual number of activities made for the proper implementation of the procedures related to ergonomics interventions and EHS issues	Social	Self-Development	Leading
10	.18	.07	EI10	Number of complaints due to physical conditions (noise, temperature, odour, dust, etc.) per year	Ecological	Conditions	Lagging

11	.14	.01	EI8	Expenditure on employee development per year	Economic	Investment	Leading
12	.05	.08	EI5	Number of cases of occupational diseases per year	Economic	Loss	Lagging
13	.01	-.11	EI23	Percentage of employees who are satisfied with their work	Social	Satisfaction	Leading
14	-.07	-.11	EI20	Number of suggested improvements made by employees per year	Social	Self-Development	Leading
15	-.12	-.11	EI9	Expenditure on research and development, technology, and innovation per year to enhance ergonomically and environmentally friendly designed processes	Economic	Investment	Leading

16	-.16	.01	EI6	Annual investment cost for ergonomics interventions and EHS issues	Economic	Investment	Leading
17	-.19	-.11	EI24	Number of complaints due to working conditions not covered by decent work per year	Social	Satisfaction	Lagging
18	-.23	-.11	EI12	Number of days when there are unfavourable physical conditions (noise, temperature, odour, dust, etc.) per year	Ecological	Conditions	Lagging
19	-.25	-.11	EI16	Percentage of recycled products/raw materials used in ergonomically designed processes per year	Ecological	Conditions	Leading
20	-.45	-.11	EI25	Percentage of employees participating in managerial	Social	Satisfaction	Leading

				decisions related to ergonomics interventions and EHS issues per year			
21	-.52	-.11	EI13	Percentage of employees working in unfavourable conditions leading to physical and mental health problems per year	Ecological	Conditions	Lagging
22	-.59	-.41	EI17	Percentage of annual incentives and promotions made for stakeholders to contribute ergonomically and environmentally friendly designed processes	Ecological	Contribution	Leading
23	-.76	-.61	EI15	Number of volunteers for making charitable contributions to EHS issues per year	Ecological	Contribution	Leading

3.5. Overall Evaluation

In Chapter 2, Section 2.7.4, respondents' assessment on the research was outlined by evaluating all relevant indicators using a 7-point Likert scale (1 = "Strongly Disagree", 7 = "Strongly Agree). This scale measured the perceived usefulness and competence of the systematic approach that incorporates these indicators. Below is a discussion of the findings derived from this analysis, with the results summarised in Table 13.

The first question assessed the appropriateness of EIs for systematically measuring and monitoring the performance of various organisational processes. Respondents rated this question on a scale from 1 to 7, yielding a mean score of 5.64 (SD = 1.160). This average, exceeding the midpoint of 4 (indicating "Neither agree or disagree"), suggests a favourable perception of the indicators, supported by a relatively low standard deviation.

The second question examined the suitability of EIs concerning HF/E and sustainability for evaluating organisational processes and making necessary adjustments. Respondents again rated this question on a 1 to 7 scale (1 = "Strongly Disagree", 7 = "Strongly Agree), resulting in a mean score of 5.59 (SD = 1.251). Like the first question, this score, above the midpoint, indicates a positive assessment of the indicators, accompanied by a low standard deviation.

Table 13 indicates that 95% of respondents (118 out of 125) rated the first question within the 'agreement' range of the scale. For the second question, this figure is slightly lower, with 92% of respondents (115 out of 125) expressing agreement. These results collectively indicate that the systematic approach, which integrates the EIs presented in the survey, is both relevant and applicable to South African organisations.

Table 13. *The summary of the evaluation of respondents on the first and second question (n=125)*

	First Question		Second Question	
	Frequency N	Percentage %	Frequency N	Percentage %
Strongly Disagree	4	3%	3	2%
Disagree	1	1%	4	3%
Somewhat Disagree	2	2%	3	2%
Neither Agree or Disagree	0	0%	0	0%
Somewhat Agree	32	26%	30	24%
Agree	69	55%	66	53%
Strongly Agree	17	14%	19	15%

3.6. Conclusion

The findings revealed that measurability was consistently prioritised as the most important criterion by members of SAIOSH. This underscores the importance of data-driven and consistent metrics in OHS evaluations. Conversely, policy relevance was ranked as the least important criterion, suggesting a potential gap between organisational practices and policy-driven safety initiatives.

Further analysis of the indicators revealed that EI18 ("percentage of employees receiving EHS training per year") emerged as the most critical indicator. This finding emphasises the importance of education and proactive measures in fostering safe and sustainable workplace environments. In contrast, the indicator EI15 (“number of volunteers for making charitable contributions to EHS issues per year”) was identified as the least significant. This suggests that, while community engagement is valuable, it may not directly contribute to immediate improvements in workplace safety and health outcomes.

Chapter 4: Discussion

4.1. Introduction

This research explored, through the consideration of evaluation criteria, the prioritisation of EIs within the OHS landscape in South Africa, emphasising the integration of sustainability principles into OHS and HF/E practices. Building upon the foundational work of Sarbat and Ozmehmet Tasan (2024), the study utilised the hybrid MCDM methodologies, namely, the BWM and the PROMETHEE, to rank 23 EIs considering five evaluation criteria: measurability, reliability, resilience, proactiveness, and policy relevance. These criteria were selected to ensure a robust and systematic evaluation of the indicators' applicability in OHS practice.

This chapter will summarise the key findings and the economic, social and ecological dimensions of the EIs. It will discuss their practical and theoretical implications. Additionally, it will address the limitations of the research and provide recommendations for future studies.

4.2. Key findings

The results of this study provide critical insights into the prioritisation of EIs within the context of OHS in South Africa. The findings reveal a pronounced emphasis on economic indicators, followed by social factors, while ecological indicators are the least important. This underscores a systemic inequality in recognising the value of ecological indicators in the decision-making processes of OHS professionals.

While recent literature emphasises the need to expand the focus of sustainability to include the sustainable use of human resources and well-being (Sharma et al., 2023), the data suggests that ecological considerations are still undervalued in practice. Although the framework of sustainability is viewed as a holistic trinity encompassing ecological conservation, economic growth, and social advancement (Yilmaz & Yildiz, 2021; Sharma et al., 2023), the low prioritisation of ecological factors indicates a significant gap in the integration of these dimensions within OHS (Fischer et al., 2021). This oversight may hinder the potential for organisations to fully realise the interconnected benefits of a comprehensive OHS and HF/E approach, which is essential for promoting overall well-being and productivity (Firescu, 2021; Lin et al., 2021).

Ultimately, there is an intrinsic connection between sustainability and HF/E, emphasised through the importance of integrating ecological, social and economic dimensions into an OHS performance system (Bolis et al., 2020; Thatcher & Yeow, 2016). HF/E works alongside sustainability by focusing on improving human well-being (Bolis et al.,). However, the results suggest that, despite the theoretical frameworks advocating for a balanced approach, the practical application remains skewed towards economic and social dimensions. This is reflected in the positive values attributed to the majority of economic EIs, contrasted by the negative values associated with ecological EIs, indicating a significant lack of commitment to ecological sustainability within the OHS framework.

In conclusion, the findings of this study underscore the necessity for a balanced approach to OHS that prioritises ecological, economic and social HF/E and sustainability factors. As organisations navigate the complexities of OHS, the integration of ecological practices into their OHS frameworks will be crucial for achieving comprehensive HF/E and sustainability and fostering healthier work environments.

4.3. Weighting of criteria

The results from the BWM analysis (Chapter 3, section 3.2, Table 5) revealed that among 32 SAIOSH members with consistent data, "measurability" emerged as the most important criterion, receiving an aggregated normalised value of 28.4%. This reflects its ability to provide reliable, consistent, and comparable data, which are crucial for evidence-based decision-making (Pires et al., 2020; Young et al., 2013). Measurable indicators ensure clarity and simplicity, enabling organisations to track performance effectively across contexts and over time. In contrast, "policy relevance" was identified as the least important criterion, with an aggregated normalised value of 13.5%. Although important for aligning indicators with broader societal and policy goals (Pupphachai & Zuidema, 2017), respondents may have not prioritised policy relevance due to its perceived abstractness and lower immediacy in application within resource-constrained environments. This highlights a preference for actionable metrics over broader contextual alignment in the specific OHS context examined. Ultimately, the respondents prioritised the ability to quantify outcomes, while the relevance of policies was considered less critical in their decision-making process.

4.4. Human Factors/Ergonomics (HF/E) indicators

The integration of economically, socially, and ecologically sustainable indicators into OHS and HF/E frameworks has profound implications for organisations. Economically sustainable indicators help reduce costs linked to workplace incidents, absenteeism, and health issues, while also ensuring investments in employee training and workplace improvements (Sarbat & Ozmehmet Tasan, 2024). Socially sustainable indicators enhance employee satisfaction, engagement, and participation, contributing to higher productivity, a safer workplace culture and impacts on the perception of the physical and cognitive work environment (Yilmaz & Yildaz, 2021). Ecologically sustainable indicators align workplace practices with resource conservation, reducing the organisation's environmental footprint and fostering long-term resilience (Moldan et al., 2012). Together, these three factors create a balanced system that supports employee well-being, reduces ecological risks, and enhances economic viability (Fischer & Zink, 2012).

4.4.1. Economic dimension

EIs, within the main economic dimension, were ranked relatively high, with six out of eight indicators achieving notable relative ranking positions, specifically EI1 ("number of accident-free days per year"), EI2 ("number of injury-free days per year"), EI3 ("percentage of total lost time due to accidents and injuries relative to the total hours worked per year"), EI5 ("number of cases of occupational diseases per year"), EI7 ("cost of EHS training of employees per year"), and EI8 ("expenditure on employee development per year"). This result underscores the predominant emphasis of South African organisations on Loss and Investment, which assesses sustainability from an economic perspective, as respondents prioritised indicators within these sub-dimensions (Sarbat & Ozmehmet Tasan, 2020, 2022). Notably, the high ranking of EI1 and EI2 may also reflect a limited understanding of human factors and ergonomics (HF/E) among participants, as ideologies such as "zero injuries" can unintentionally discourage reporting and transparency, potentially undermining safety efforts. As previously discussed, EI6 ("annual investment cost for ergonomics interventions and EHS issues"), an Economic Indicator within the Investment sub-dimension, is considered positively ranked based on its positive Φ value in Scenario 1. Thus, it can be said that the only indicator that received a low ranking (i.e., negative Φ values in both Scenario 1 and Scenario 2) is EI9, which pertains to annual expenditures on research, development, technology, and innovation aimed at enhancing ergonomically and environmentally friendly processes.

The high rankings of economic EIs highlights a significant emphasis on the financial implications of poor HF/E and unfavourable working conditions. These include productivity losses, time lost due to accidents and injuries, medical expenses, and legal liabilities, as well as investments in workplace improvements, such as training programs, employee development initiatives, and HF/E interventions (Sarbat & Ozmehmet Tasan, 2020). This suggests a prioritisation of both mitigating losses and enhancing HF/E investment. However, the low ranking of expenditure on research, development, technology, and innovation (EI9) indicates a preference toward short-term financial gains at the expense of long-term advancements, such as HF/E practices. Moreover, South African industries, particularly in mining and manufacturing, focus heavily on economic growth to address pressing socio-economic challenges, inadvertently sidelining ecological sustainability efforts (Pons-Vignon & Anseeuw, 2009).

4.4.2. Social dimension

In the Social dimension, five out of seven EIs related to the Self-Development and Satisfaction sub-dimension were ranked relatively highly (Sarbat & Ozmehmet Tasan, 2020, 2022), namely EI18 ("percentage of employees receiving EHS training per year"), EI19 ("percentage of total time spent due to EHS training relative to the total hours worked per year"), EI21 ("annual number of activities made for the proper implementation of the procedures related to ergonomics interventions and EHS issues"), EI22 ("annual turnover rate of employees"), and EI23 ("percentage of employees who are satisfied with their work"). These indicators address critical organisational issues such as training, suggested workplace improvements, effective implementation of procedures, employee participation in managerial decisions, job satisfaction, and the promotion of decent work. This reflects the efforts made by organisations in South Africa to enhance some aspects of HF/E and social sustainability.

In contrast, the lower-ranked EIs within the social dimension pertain to employee participation in managerial decision-making and the generation of improvement suggestions. Specifically, these were EI20 (“number of suggested improvements made by employees per year”) and EI25 (“percentage of employees participating in managerial decisions related to ergonomics interventions and EHS issues per year”). This disparity may suggest a potential lack of engagement and empowerment, possibly stemming from a top-down decision-making culture that leads employees to feel that their contributions are undervalued. Drawing on Rasmussen’s (2011) concept of vertical integration, this highlights the importance of incorporating feedback loops from frontline workers into system design and control. Without such integration, the system lacks the adaptive capacity needed for sustainable and effective ergonomics and safety interventions.

4.4.3. Ecological dimension

In the Ecological dimension, only two EIs, EI10 (“number of complaints due to physical conditions [noise, temperature, odour, dust, etc.] per year”) and EI14 (“number of activities made for improving working conditions per year”), were ranked highly. This suggests that there is a need for increased efforts to promote ecological preservation and improved working conditions, particularly concerning the remaining six indicators in this dimension. These include; EI12 (“number of days when there are unfavourable physical conditions [noise, temperature, odour, dust, etc.] per year”), EI13 (“percentage of employees working in unfavourable conditions leading to physical and mental health problems per year”), EI15 (“number of volunteers making charitable contributions to EHS issues per year”), EI16 (“percentage of recycled products/raw materials used in ergonomically designed processes per year”), EI17 (“percentage of annual incentives and promotions made for stakeholders to contribute ergonomically and environmentally-friendly designed processes”) and EI24 (“number of complaints due to working conditions not covered by decent work per year”).

The disparities in the rankings of EIs within the ecological dimension reveal a notable contrast between the two highly ranked indicators within the Conditions sub-dimension, EI14 (“number of activities made for improving working conditions per year”) and EI10 (“number of complaints due to physical conditions [noise, temperature, odour, dust, etc.] per year”), and the five lower-ranked indicators. The top-ranked indicators reflect a proactive (and numerical) approach to enhancing workplace conditions and addressing employee concerns.

Conversely, the relatively low ranking of indicators such as EI15 (“number of volunteers for charitable contributions to EHS issues per year”) and EI16 (“percentage of recycled products/raw materials used in ergonomically designed processes per year”) suggest a lack of commitment to broader ecological and social responsibilities. This indicates that OHS professionals in organisations may prioritise ecological efforts that yield immediate, measurable benefits while neglecting sustainability and employee engagement in environmental initiatives.

4.4.4. Overall findings

The findings of this study reinforce and expand upon the existing literature that emphasizes the critical need to integrate HF/E with sustainability in OHS frameworks (Bolis et al., 2014). Specifically, the results validate Sarbat and Ozmehmet Tasan’s (2024) observation of a prevailing bias towards economic and social factors in the prioritisation of EIs, revealing that ecological considerations are often neglected in organisational contexts. This trend mirrors a broader pattern in sustainability discourse, where the pursuit of economic growth and profit maximisation frequently overshadows essential social and ecological well-being issues

(Sharma et al., 2023; Yilmaz & Yildiz, 2021). Advocating for a paradigm shift in OHS frameworks is essential to achieve a balanced approach that prioritises economic, social, and ecological dimensions in HF/E (Thatcher & Yeow, 2016).

The analysis of EIs across the economic, social, and ecological dimensions reveal a strong emphasis on Loss and Investment strategies among South African organisations, highlighting their proactive approach to enhancing operational efficiency and sustainability. The high rankings in the social dimension of Self-Development and Satisfaction reflect a commitment to employee well-being through training and participation, fostering a healthier work environment in a social way (Sarbat & Ozmehmet Tasan, 2020). However, the limited high-ranking indicators in the ecological dimension indicate a need for greater focus on environmental sustainability.

Overall, while commendable efforts are evident in the economic and social realms, a more balanced approach that integrates robust ecological practices is essential for achieving sustainability in South African organisations (Du Plessis & Grobler, 2014). Notably, 57% (8 out of 14) of the EIs are classified as leading indicators presenting an encouraging opportunity for organisations in South Africa to implement measures that minimise risk and enhance overall performance. The current findings indicate that OHS professionals may prioritise immediate working conditions while neglecting broader ecological responsibilities, which could ultimately undermine the long-term sustainability of their practices. Addressing these trade-offs requires a nuanced approach that incentivises social and ecological investments while maintaining economic viability.

4.5. Practical and theoretical implications

This analysis provides valuable insights into the priorities of OHS professionals regarding sustainable HF/E and OHS. The findings indicate that economic dimensions are prioritised over ecological dimensions, with social dimensions occupying an intermediate position in the hierarchy of importance. This suggests a prevailing emphasis on financial considerations in the decision-making processes of OHS professionals, while ecological factors are comparatively less emphasised, and social factors are recognised as important but secondary to economic concerns.

This research contributes to the growing body of knowledge in sustainable HF/E and OHS by presenting a structured framework for evaluating and prioritising EIs within the South African context. These EIs are valuable in assessing various functional areas, including working conditions, occupational health, and employee development, thereby supporting sustainable process performance measurement in HF/E (Sarbat & Ozmehmet Tasan, 2022). Furthermore, it highlights the rising significance of sustainability within both organisational and inter-organisational frameworks (Chillakuri & Vanka, 2021). It underscores that OHS professionals are becoming more aware of the connection between organisational sustainability efforts and the larger systemic context. This heightened awareness allows for more informed decisions across a range of functional areas, such as finance, strategy, and operations, while also considering the human elements involved (Bolis et al., 2020)

Ultimately, the integration of sustainability dimensions, economic, ecological, and social, within the context of OHS and HF/E reflects a paradigm shift towards a more holistic approach to workplace safety and well-being (Sharma et al., 2023). By bridging theoretical constructs with practical applications, the study provides actionable insights for organisations aiming to align their OHS practices with sustainable development goals.

4.6. Limitations

Inevitably, there are several limitations in this study that must be acknowledged. A fundamental limitation is the reliance on the EIs used in the survey designed to measure the applicability of a systematic approach integrating HF/E and sustainability. The selection of these indicators is based on a literature review by Sarbat and Ozmehmet Tasan (2022, 2024), which may introduce an element of subjectivity into the proposed framework. While the indicators are not exclusively tailored to HF/E, they still serve as valid measures of the intended outcomes associated with HF/E principles. However, this may restrict the comprehensiveness of the indicators, as alternative or specific HF/E indicators could be equally or more pertinent in the South African context.

Additionally, the framework's robustness depends not only on the choice of indicators but also on the evaluation criteria used to assess them. The evaluation criteria chosen by Sarbat and Ozmehmet Tasan (2024) were informed by thorough research but were not derived from a predefined framework. This absence of a structured methodology raises questions about the transparency and justification behind the establishment of these five evaluation criteria, potentially affecting the validity of the assessment process.

Another key limitation of this study is the relatively small sample size of 125 respondents, which may not fully capture the diversity of the broader population of OHS professionals in South Africa. Additionally, the survey's completion rate of only 17% raises concerns about potential bias; those who chose to complete the survey may possess different perspectives or experiences compared to those who either abandoned it midway or did not participate at all. This limitation could significantly impact the generalisability of the findings, making it challenging to draw definitive conclusions about the essential elements prioritised by all OHS professionals in the region. The length and complexity of the survey may have contributed to respondent fatigue, potentially leading to incomplete responses or disengagement. This could result in a lack of depth in the data collected, as respondents may not have fully considered their answers for every question. Additionally, the reliance on self-reported data can introduce biases, as respondents may provide socially desirable answers rather than their true opinions or experiences.

Moreover, there is a limitation in the number of consistent respondents who provided consistent data for the BWM analysis (n=32). Only 25.6% of the responses met the consistency criteria, which may impact the reliability of the findings. However, research suggests that having 4 to 10 experts (decision-makers or respondents) can produce reliable enough results in an MCDM analyses (Kusi-Sarpong et al., 2019; Rezaei et al., 2018). The optimal number of experts required for MCDM analysis varies across studies, with some successfully conducting BWM using five or fewer experts (Govindan et al., 2015, Gupta & Barua, 2016) Therefore, the inclusion of 32 respondents in this study is considered adequate for producing meaningful findings.

4.7. Recommendations for future Research

To address the limitations of this study, future research should consider expanding the sample size and achieving a higher response rate to improve the generalisability of the findings. Potentially including members of SAIOH and ESSA. Conducting longitudinal studies would be particularly valuable for understanding the dynamic evolution of EIs prioritisation over time, especially in response to global challenges such as climate change and rapid technological advancements. This is especially relevant within the South African context, where continuous fluctuating socio-economic and regulatory factors may influence these priorities (Pons-Vignon & Anseeuw, 2009).

In addition, adopting qualitative research methods, such as interviews or focus groups, could complement quantitative analyses by providing nuanced insights into the contextual factors shaping EI prioritisation. Specifically, to try and understand why the ecological factors are considered unimportant. Furthermore, these methods could help address the challenges of the survey design, ensuring greater clarity and a shared understanding regarding the research objectives and key concepts.

Conducting a longitudinal study could provide valuable insights into how the prioritisation of EIs evolves over time. By tracking changes in perceptions and practices among OHS professionals, researchers can identify trends and shifts in priorities that may be influenced by external factors such as regulatory changes, economic conditions, or emerging health and safety challenges. This approach would contribute to a deeper understanding of the dynamics within the field of OHS.

Moreover, given that this research is part of a collaborative effort between Türkiye and Pakistan, future studies could benefit from comparative analyses of results across these contexts, identifying both commonalities and region-specific challenges.

4.8. Conclusion

Given that numerous global challenges arise from human activity, it is incumbent upon organisations to pursue solutions through both technological innovation and behavioural change. In this context, the field of OHS and HF/E, encompassing the economic, social, and ecological dimensions of sustainability, are intrinsically connected to these issues and carries a vital responsibility for advancing human well-being and tackling global challenges.
The findings of this study serves this aim by underscoring the importance of systematically identifying and applying weighted evaluation criteria to rank EIs for practitioners in the OHS

sector in South Africa. By employing these weighted criteria, the research successfully differentiated between the most and least important EIs, thereby enhancing the applicability of these indicators in a systematic approach. Such a systematic approach offers a significant contribution to improving health and safety outcomes by equipping professionals with prioritised, evidence-based tools tailored to their expertise in OHS, HF/E and sustainability.

As the South African organisational landscape evolves, the methodology and insights provided in this research offer a robust foundation for addressing the complex challenges of OHS. The prioritisation framework as a systematic approach for OHS practitioners herein serves as a practical guide for organisations to enhance their safety practices and align them with sustainable development goals, ultimately fostering safer and more productive work environments.

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Appendices

Appendix A- Participant Information Sheet (PIS)

Confidential

Page 1

Digital Survey: Measurement of the Perception of the Applicability of a Systematic Approach Integrating Ergonomics and Sustainability in Organisations

This survey is a part of joint research project between South Africa, Türkiye, and Pakistan. This aim of this survey is to understand which health and safety indicators are considered the highest priority rank order for the respondents when measuring health and safety in organisations. The purpose is to examine the relationships between five evaluation criteria against the indicators, with the goal of determining which indicators are most significant in elucidating the fundamental aspects of the evaluation criteria and should thus be considered as important to incorporate for future intervention and practice, where the most significant indicators would be suggested using in a systematic approach. The following criteria are measurability, reliability, resilience, proactiveness, and policy relevance.

The target group of this survey are OHS practitioners, members of SAIOSH, working in companies who have knowledge of ergonomics and/or sustainability and are potential users of such a systematic approach. More specifically, potential respondents are senior managers, department managers, or employees working in various departments in companies.

If you choose to participate in the survey, all your responses will be kept confidential at all stages of the research. The results from the survey may be used in related scientific papers for research purposes only.

Participation in the survey is voluntary. The questions will start on the second page, and the response time for all questions is approximately 20 minutes. Please send us an email at dc1864842@gmail.com if you have any questions or wish to receive summarized feedback on the results of the survey.

Prof. Dr. Andrew THATCHER, University of the Witwatersrand, Johannesburg, South Africa

Student Dena COHEN, University of the Witwatersrand, Johannesburg, South Africa

Res. Assist. Dr. Irem SARBAT, Dokuz Eylul University, Izmir, Turkiye

Asim AMJAD, Ph.D. Scholar & Lecturer, National University of Sciences and Technology, Islamabad, Pakistan & University of the Punjab, Lahore, Pakistan

Prof. Dr. Shahid Ikramullah BUTT, National University of Sciences and Technology, Islamabad, Pakistan

Prof. Dr. Mujtaba Hassan AGHA, National University of Sciences and Technology, Islamabad, Pakistan

Please complete the survey below.

Thank you!

---

1) Do you consent? ○ Yes ○ No

Appendix B- Statement of Principles For Postgraduate Supervision

16. STATEMENT OF PRINCIPLES FOR POSTGRADUATE SUPERVISION

IN A CONTEXT OF ACADEMIC FREEDOM AND WITHIN A FRAMEWORK OF INDIVIDUAL AUTONOMY AND THE PURSUIT OF KNOWLEDGE THIS AGREEMENT IS WRITTEN IN THE BELIEF THAT THERE IS A RECIPROCAL RELATIONSHIP AND MUTUAL ACCOUNTABILITY BETWEEN SUPERVISOR AND STUDENT.

THE SUPERVISOR AND THE STUDENT:

1. Will establish agreed roles and clear processes to be maintained by both parties. In the case of joint supervision everyone's role needs to be clarified.
2. Will meet regularly and as frequently as is reasonable to ensure steady progress towards the completion of the proposal, research report, or dissertation or thesis. This time varies but the normal minimum requirement for face-to- face contact, spread across each year of registration is: 10 contact hours for an Honours project, 15 contact hours for a Masters by research report and 24 contact hours for a Masters by dissertation and a PhD.
3. Will keep appointments, be punctual and respond timeously to messages.
4. Will keep one another informed of any planned vacations or absences as well as changes in his or her personal circumstances that might impact on the work schedule. Unplanned absences or delays should be discussed as soon as possible and arrangements should be made to catch up lost time.
5. Will ensure that research on animal or human subjects is conducted according to the procedures and the requirements of the relevant University Ethics committee.
6. Will together complete progress reports on the research project, as requested by each Faculty Graduate Studies Committee.

THE SUPERVISOR:

1. Undertakes to provide guidance for the student's research project in relation to the design and scope of the project, the relevant literature and information sources, research methods and techniques and methods of data analysis.
2. Has a responsibility to be accessible to the student.
3. Will be prepared for meetings with the student. This includes being up-to-date on the latest work in his/her area of expertise.
4. Will expect written work as jointly agreed, and will return that work with constructive criticism within a timeframe (a suggestion of 2-4 weeks) jointly agreed at the outset of the research.
5. Will provide advice that can help the student to improve his/her writing. This may include referrals for language training and academic writing. The supervisor will provide guidance on technical aspects of writing such as referencing as well as on discipline specific requirements. Detailed correction of drafts and instruction in aspects of language and style are not the responsibility of the supervisor.
6. Will support the student in the production of a research report, dissertation or thesis. Provision should be allowed for adequate, mutually respectful, discussion around recommendations made.
7. Will assist with the construction of a written time schedule which outlines the expected completion dates of successive stages of the work.
8. Will ensure the student has the opportunity to present work at postgraduate/staff seminars/national/international conferences as appropriate.
9. Will assist with the publication of research articles as appropriate.
10. Will discuss the ownership of research conducted by the student in accordance with the University guidelines and rules on intellectual property, co-authorship and copyright.
11. Will ensure that the research is conducted in accordance with the University's policy on plagiarism.
12. Will ensure that the student is made aware in writing of the inadequacy of progress and/or of any work where the standard is below par. Acceptability will be according to criteria previously supplied to the student.
13. Has a duty to refuse to allow the submission of sub-standard work for examination, regardless of the circumstances. If the student chooses to submit without the consent of the supervisor, then this should be clearly recorded and the appropriate procedures followed.

THE STUDENT:

1. Undertakes to work independently under the guidance of the supervisor. This includes reading widely to ensure that the literature pertinent to his/her chosen topic has been identified and consulted.
2. Is obliged to make appointments to see the supervisor and will arrange meeting times well in advance.
3. Will think carefully about how to derive maximum benefit from these contact sessions by planning what he/she wants in these sessions.
4. Should submit written work for discussion with the supervisor well in advance of a scheduled meeting. The kind and frequency of written work should be agreed with the supervisor at the outset of the research.
5. Undertakes to submit written work that is relatively free of basic spelling mistakes, incorrect punctuation and grammatical errors. Responsibility for the accuracy of language, the overall structure and coherence of the final research report, dissertation or thesis rests with the student.
6. Undertakes to heed the advice given by the supervisor and to engage in discussion around suggestions made. Ultimately the student has to take responsibility for the quality and presentation of the work.
7. Should strive, within reasonable bounds, to maintain a focus on his/her research area and to work within the agreed time schedule.
8. Will prepare material for presentations at seminars and conferences.
9. Undertakes to submit papers for publication.
10. Agrees to honour agreements about ownership of the research and in accordance with the University's guidelines and rules in relation to co-authorship, copyright and intellectual property.
11. Will ensure that the work contains no instances of plagiarism and that all citations are properly referenced and that the list of references is accurate, complete and consistent.
12. Agrees to work in accordance with the criteria of acceptability as supplied by the supervisor.
13. Undertakes not to place the supervisor under undue pressure to submit work for examination until the supervisor is satisfied that it has reached an acceptable level of quality.

I confirm that I have read and understood this statement and agree to be guided by its principles

Name of Student: Dena Cohen

Student's signature: ____________________

Name of Supervisor: __Andrew Thatcher___ ___

Supervisor's Signature: ____________________

Name of Co-Supervisor: ____________________

Co-Supervisor's Signature: ____________________

Broad area of study: _Psychology____________________

____

Provisional submission date: _15 February 2025_________

Degree: _MA____________________

School: __HUMAN & COMMUNITY DEVELOPMENT__

Faculty: _HUMANITIES____________________

Date: __14 JUNE 2024____________________

Specific agreements pertaining to: ownership and joint publication, funding, etc. may be attached and signed.

GRIEVANCE PROCEDURES. It should be acknowledged that during the course of the research, both students and supervisors can feel aggrieved. In this event, matters should be dealt with as swiftly as possible by the parties involved and, if necessary, the appropriate Postgraduate Coordinators and Committees. There is, in addition, a University Grievance Policy to help guide deliberations. It is available on www.wits.ac.za/prospectivepostgraduate

Appendix C- Methods and Ethics Reader Narrative Report

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

SCHOOL OF HUMAN AND COMMUNITY DEVELOPMENT
PSYCHOLOGY

Masters in Social and Psychological research

Research Proposal:
Methods and Ethics Reader Narrative Report 2024

Student:	**Dena Cohen**
Student number:	**1864842**
Degree:	MA in Organizational Psychology
Supervisor:	**Prof Andrew thatcher**
Proposal reader:	**Mr Milton Gering**
Title of research:	Measuring sustainable ergonomics: A hybrid multi-criteria perspective on Occupational Health and Safety Indicators
Date of presentation:	**28/05/2024**

SECTION A: METHODS NARRATIVE REPORT

COMMENTS:

Well done Dena, this looks like a solid study with a tight design. Looks to be the correct level for an MA and given that you already have the organization's permission I don't foresee any issues. I've made some comments directly on the proposal. Most of them are small superficial changes to writing style, formatting, referencing etc. but are worth addressing so that the reviewers don't have to say anything about these things.

The only substantive change I suggest is to use REDCap rather than google forms. It is a more secure platform and will ensure confidentiality. Some institutions are insisting on this, and I believe that Aline does suggest this as well.

Outcome:

If the proposal is acceptable as is, or with changes to supervisor's satisfaction, please complete this section below and indicate the same on the Faculty proposal submission form.

Umthombo Building – 2nd Floor, Room U211, Braamfontein East Campus, Private Bag 3, WITS 2050
T +27 11 717 4503/53 | E psych.SHCD@wits.ac.za | www.wits.ac.za/shcd/psychology/

Decision	Tick	Reader signature
(i)Accepted.		
ii) Accepted, but candidate should take note of warnings/ recommendations.	X	
iii) Concerns to be addressed - to the satisfaction of the supervisor		

SECTION B: ETHICS

Comments for the applicant to address on the Ethics Application Form:

See some small omissions and inconsistencies

Comments for the applicant to address on the Participant Information Sheet:

none

Comments for the applicant to address on the Consent Form:

none

Methodological comments for the applicant to consider:

Think about using REDCap rather than google forms. It is a more secure platform. I have left a note on this in the appropriate place on the proposal.

Reviewer's overall comments:

Looks like a solid study, and should be fine to pass through ethical review.

SECTION C

Summary of overall risk category of this study. Refer to risk category definitions for what these risks specifically refer to. Please TICK the appropriate boxes.

Risk category	Category identified by applicant	Category identified by reviewer
No risk		
Minimal risk	X	X
Low risk		
Medium risk		
High risk		

Does the reviewer believe that the applicant has adequately dealt with all the potential risks of this project? (YES / NO)

Yes

SECTION D

Recommendation (please indicate):

Accept as is	
Minor revisions	X
Moderate revisions	

Major revisions	
Resubmit	

NOTE: If revisions to the content of the application are required, reviewers must see the revised version and approve the changes before an application can be approved.

I have seen and approved the changes that have been made. Prof. Andrew Thatcher

Appendix D- Ethical Clearance

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

SCHOOL OF HUMAN AND COMMUNITY DEVELOPMENT ETHICS COMMITTEE
CONSTITUTED UNDER THE UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)

CLEARANCE CERTIFICATE **PROTOCOL NUMBER: MAORG-24-02**

PROJECT TITLE: Measuring sustainable ergonomics: A hybrid multi-criteria perspective on Occupational Health and Safety Indicators.

INVESTIGATOR Cohen Dena

SCHOOL/DEPARTMENT OF INVESTIGATOR SHCD/Psychology

DATE CONSIDERED 08 July 2024

DECISION OF THE COMMITTEE Approved unconditionally

RISK LEVEL Minimal Risk

EXPIRY DATE 31 December 2026

ISSUE DATE OF CERTIFICATE 23 July 2024 **CHAIRPERSON** Aline Ferreira Correia
(Prof. Aline Ferreira Correia)

cc: Prof. Andrew Thatcher (Supervisor)

DECLARATION OF INVESTIGATOR

To be completed in duplicate and **ONE COPY** returned to the Chairperson of the School/Department ethics committee.

I/we fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure be contemplated from the research procedure as approved, I/we undertake to submit an amendment of the protocol to the Committee.

Signature **Date** ______/______/______

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

Appendix E- Approval from SAIOSH

From: **Saiosh CEO** Neels@saiosh.co.za
Subject: FW: Possible research project through SAIOSH
Date: 15 April 2024 at 17:27
To: Andrew Thatcher andrew.thatcher@wits.ac.za
Cc: Saiosh Marketing marketing@saiosh.co.za, 1864842@students.wits.ac.za, Harold Gaze harold.gaze@occutech.co.za

SC

Dear Professor Thatcher,

I refer to the e-mail below received from Harold Gaze, our Saiosh Vice President.

We will gladly assist with this Health and Safety research project. I believe that the result of this research will be greatly beneficial to our professionally registered members.

Our Membership and Communications Manager, Gareth marketing@saiosh.co.za (copied), will be the contact person to set up a newsletter for the survey / research questions to be distributed to our members.

Regards

NEELS NORTJÉ
Chief Executive Officer
South African Institute of Occupational Safety and Health
010 001 7455
082 464 6754
neels@saiosh.co.za
www.saiosh.co.za

Apply For **Saiosh** Membership Today
Saiosh

From: Harold Gaze <harold.gaze@occutech.co.za>
Sent: Monday, April 15, 2024 9:16 AM
To: Saiosh CEO <Neels@saiosh.co.za>
Subject: FW: Possible research project through SAIOSH

Good Day Neels

Prof Andrew Thatcher from Wits University is hoping that we can help in an Ergonomic Research Project .

Harold Gaze

OCCUTECH

Tel: 031 2061244
Fax: 031 2052561
Cel: 083 625 2914

Appendix F- Details and Results of the statistical analysis performed

<u>Mann–Whitney U Test:</u>

This nonparametric test was used to compare differences between two independent groups (such as education levels) on the ratings of EIs, addressing differences without assuming a normal distribution.

Brief Explanation

This test was performed for each data gathered from five questions of each EI. This means that 115 results (i.e., 23 EIs, comprising 5 questions for each) for the Mann–Whitney U test were reported.

Data

The data, divided into two groups by considering the respondents' education levels (Table 3), was used: Associate degree (n= 54) and Bachelor's Degree (n=36)

Null Hypotheses (As examples):

- There is no statistically significant difference between education levels on the measurability of EI1.
- There is no statistically significant difference between education levels on the reliability of EI1.
- There is no statistically significant difference between education levels on the resilience of EI1.
- There is no statistically significant difference between education levels on the proactiveness of EI1.
- There is no statistically significant difference between education levels on the policy relevance of EI1.

Results

Nearly all hypotheses (n = 114) were failed to reject, representing no statistically significant difference between education levels on the evaluation criteria of EIs. Exceptionally, as remarked in Table G1, only one hypotheses was rejected, which is listed below, since the p-value was lower than 0.05:

- There is statistically significant difference between education levels on the policy relevance of E4 ($U = 707.000$, $p = 0.025$).

The Mann–Whitney U Test results indicate that, except for one specific aspect of policy relevance in EIs, education level does not significantly influence the ratings of EIs among respondents, suggesting that factors other than education may play a more role in these evaluations.

Table G1

The results of the Mann Whitney U tests for all ergonomics indicators (n=23)

Ergonomics indicator (Sarbat & Ozmehmet Tasan, 2022)	Consolidated evaluation criteria									
	Measurability		**Reliability**		**Resilience**		**Proactiveness**		**Policy Relevance**	
	U	**p**	**U**	**p**	**U**	**p**	**U**	**p**	**U**	**p**
E_1	943.000	.799	872.000	.391	934.000	.748	919.500	.656	862.000	.350
E_2	963.500	.940	869.500	.377	920.500	.663	768.500	.083	814.500	.177
E_3	948.500	.842	852.500	.310	862.500	.352	947.000	.833	924.500	.689
E_4	885.000	.438	942.500	.797	863.500	.353	807.000	.160	707.000	**.025**
E_5	944.000	.809	878.500	.416	964.500	.949	935.000	.747	914.000	.625
E_6	930.000	.714	955.000	.884	850.500	.301	814.500	.185	874.500	.412
E_7	957.500	.900	919.500	.652	930.000	.723	955.000	.885	964.000	.946
E_8	887.500	.462	878.000	.428	860.000	.346	810.000	.172	939.000	.781
E_9	921.000	.661	905.000	.574	912.000	.614	902.000	.558	899.000	.541
E_{10}	953.000	.868	903.500	.561	829.000	.225	780.000	.105	928.000	.708
E_{11}	850.000	.275	839.500	.248	850.500	.294	939.000	.775	848.000	.284
E_{12}	884.000	.451	956.000	.893	806.000	.163	845.000	.287	939.000	.780
E_{13}	846.500	.291	888.000	.481	901.000	.551	918.500	.654	934.000	.751
E_{14}	919.500	.657	961.500	.930	949.000	.847	912.500	.618	881.000	.446
E_{15}	927.500	.708	922.500	.676	912.000	.614	970.000	.987	943.500	.811
E_{16}	966.500	.963	921.000	.669	925.500	.696	882.000	.451	971.500	.997
E_{17}	868.500	.381	946.500	.830	940.500	.791	932.000	.737	921.000	.667
E_{18}	931.000	.724	906.500	.578	918.000	.647	887.500	.477	916.000	.635
E_{19}	842.500	.274	962.500	.936	965.500	.957	929.500	.721	885.500	.468
E_{20}	899.000	.536	919.000	.656	927.000	.705	960.000	.919	954.000	.880
E_{21}	926.500	.691	927.500	.707	939.000	.781	794.000	.136	962.000	.933
E_{22}	803.000	.150	895.000	.517	922.500	.677	949.000	.847	874.500	.413
E_{23}	919.500	.651	938.500	.776	861.000	.348	923.000	.679	934.500	.752

Note: one of the p-values was remarked to indicate the statistically significant results (n=1)

<u>Kruskal-Wallis Test:</u>

This test compared more than two independent groups (like departments) to assess variations in the importance and relevance of the indicators.

Brief Explanation

This test was performed for each data gathered from five questions of each EI This means that 115 results (i.e., 23 indicators, comprising 5 questions for each) for the Kruskal-Wallis test were reported.

Data

The data, divided into 4 groups by considering the respondents' Industry (Chapter 2, section 2.5.1, Table 2), was used: Resource-intensive and Infrastructure Sectors (n= 69), Knowledge and Service Sectors (n= 30), Public and Connectivity-orientated sectors (n=17), and Other (n=9).

Null Hypotheses (As examples):

- There is no statistically significant difference between industries on the measurability of EI1.
- There is no statistically significant difference between industries on the reliability of EI1.
- There is no statistically significant difference between industries on the resilience of EI1.
- There is no statistically significant difference between industries on the proactiveness of EI1.
- There is no statistically significant difference between industries on the policy relevance of EI1.

Results

Nearly all hypotheses (n = 114) were failed to reject, representing no statistically significant difference between Industries on the evaluation criteria of EIs. Exceptionally, as remarked in Table G2, only one hypothesis was rejected, which is listed below, since the p-value is lower than 0.05:

- There is statistically significant difference between industries on the measurability of E5 ($U = 8.839$, $p = 0.032$).

Table G2

The results of the Kruskal-Wallis tests for all ergonomics indicators (n=23)

Ergonomics indicator (Sarbat & Ozmehmet Tasan, 2022)	Consolidated evaluation criteria									
	Measurability		**Reliability**		**Resilience**		**Proactiveness**		**Policy Relevance**	
	U	**p**	**U**	**p**	**U**	**p**	**U**	**p**	**U**	**p**
E_1	5.300	.151	3.112	.375	6.986	.072	0.194	.979	0.479	.923
E_2	5.060	.167	1.547	.671	1.049	.789	2.311	.510	3.797	.286
E_3	2.104	.551	.768	.857	.489	.921	.886	.829	.671	.880
E_4	6.078	.108	5.038	.169	2.604	.457	2.826	.419	2.835	.418
E_5	8.830	**.032**	5.095	.165	3.966	.265	1.785	.618	1.332	.721
E_6	1.628	.653	6.304	.098	.307	.959	1.368	.713	3.924	.270
E_7	7.317	.062	2.695	.441	1.702	.637	.574	.902	1.214	.750
E_8	2.337	.506	2.785	.426	1.658	.646	.917	.821	.902	.825
E_9	.957	.812	2.139	.544	3.433	.330	2.460	.482	1.779	.619
E_{10}	1.078	.782	1.912	.591	3.725	.293	1.137	.768	.676	.879
E_{11}	4.344	.227	2.562	.464	.661	.882	2.562	.464	.323	.956
E_{12}	1.385	.709	4.864	.182	2.904	.407	4.243	.236	1.786	.618
E_{13}	2.431	.488	1.248	.742	.302	.960	.930	.818	2.519	.472
E_{14}	3.561	.313	3.809	.283	.815	.846	.125	.989	1.218	.749
E_{15}	3.364	.339	3.674	.299	1.011	.799	.823	.844	1.581	.664
E_{16}	2.960	.398	2.347	.504	4.082	.253	4.476	.214	.864	.834
E_{17}	1.073	.784	2.538	.468	2.272	.518	2.730	.435	2.551	.466
E_{18}	2.544	.467	4.561	.207	6.064	.109	1.891	.595	2.395	.494
E_{19}	.244	.970	1.668	.644	1.631	.652	3.425	.331	1.358	.715
E_{20}	.123	.989	1.082	.782	1.178	.758	1.433	.698	.873	.832
E_{21}	.429	.934	3.277	.351	.597	.897	3.030	.387	1.491	.684
E_{22}	4.253	.235	1.268	.737	1.233	.745	.561	.905	.499	.919
E_{23}	2.061	.560	7.430	.059	5.608	.132	6.970	.073	2.621	.454

Note: one of the p-values was remarked to indicate the statistically significant results (n=1)

Chi-Square Test of Independence

This examines relationships between categorical variables, specifically education level and industry, with the most and least important EIs to see if preferences or rankings differed significantly by these demographic factors.

Brief Explanation

This test was performed for the data gathered from the respondents' selections on the most and least important evaluation criterion. This analysis was made in two parts by considering respondents' education levels and industries. This means that 4 results (i.e., 2 results, comprising respondents' education levels, and 2 results, comprising respondents' departments) for the Chi-Square test of Independence were reported.

Part 1

Data

The data, divided into two groups by considering the respondents' education levels (Table 3), was used: Associate degree (n= 54) and Bachelor's Degree (n=36)

Null Hypotheses:

- There is no statistically significant relationship between education levels on the most important evaluation criterion selected.
- There is no statistically significant relationship between education levels on the least important evaluation criterion selected.

Results

All hypotheses (n = 2) were failed to reject, representing no statistically significant difference between education levels, since their p-values were higher than 0.05:

- There is no statistically significant relationship between education levels on the most important evaluation criterion selected: $\chi 2_{(4,\ n=103)} = 2.632$, $p = 0.621$

- There is no statistically significant relationship between education levels on the least important evaluation criterion selected $\chi 2_{(4,\ n=103)} = 2.889$, $p = 0.577$

Part 2:

Data

The data, divided into 4 groups by considering the respondents' industry (Table 3), was used: Resource-intensive and Infrastructure Sectors (n= 69), Knowledge and Service Sectors (n= 30), Public and Connectivity-orientated sectors (n=17), and Other (n=9).

Null Hypotheses:

- There is no statistically significant relationship between industries on the most important evaluation criterion selected.
- There is no statistically significant relationship between industries on the least important evaluation criterion selected.

Results:

All hypotheses (n = 2) were failed to reject, representing no statistically significant difference between industries, since their p-values were higher than 0.05:

- There is no statistically significant relationship between industries on the most important evaluation criterion selected: $\chi^2_{(12,\ n=125)} = 14.494$, $p = 0.270$
- There is no statistically significant relationship between industries on the least important evaluation criterion selected: $\chi^2_{(12,\ n=125)} = 10.212$, $p = 0.597$