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Sustainability for Regions



Volume 6 Number 3 September 2024

CONTENTS

Agnieszka Choczyńska INTERSECTIONAL DIGITAL INEQUALITY IN INDONESIA	11
Shikha Vyas-Doorgapersad FOOD SECURITY STATE AND CHALLENGES IN SOUTH AFRICA	23
Melefetsane Mofolo, Yusuf Lukman ENHANCING QUALITY THROUGH POSTGRADUATE SUPERVISION REMODELING IN HIGHER EDUCATION INSTITUTIONS	27
Assia Redouani, Ghita Ikmel, Kamal Zared, Giedrius Čyras, Najiba El Amrani El Idrissi A COMPREHENSIVE REVIEW OF INTEGRATED ENERGY STORAGE BATTERIES IN RENEWABLE ENERGY STATIONS: TECHNOLOGICAL ADVANCEMENTS, CHALLENGES AND FUTURE TRENDS	40
Matshidiso Caroline Ngwepe, Xolani Thusi, Martinus M. Selepe TOWARDS EFFECTIVE IMPLEMENTATION OF GENDER-BASED VIOLENCE POLICIES IN MANKWENG TOWNSHIP	53
Fidel Isheanesu Mugunzva, Ntise Hendrick Manchidi TITLE: RE-ENVISIONING THE AI-ENTREPRENEURSHIP NEXUS: A PIONEERING SYNTHESIS AND FUTURE PATHWAYS	71
Wafaa Mohamed, Mohamed Ramadan A. Rezk, Amr Soliman, Leonardo Piccinetti, Donatella Santoro, Mahmoud M. Sakr THE ROLE OF TECHNOLOGICAL INCUBATORS IN FOSTERING ENTREPRENEURIAL GROWTH: THE CASE OF EGYPTIAN UNIVERSITIES AND RESEARCH CENTRES	85



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INTERSECTIONAL DIGITAL INEQUALITY IN INDONESIA*

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Abstract. Indonesia is an emerging economy with a fast-growing digital sector. However, the development is not uniform across the country, with wide gaps related to regional differences and personal characteristics. This paper analyses the digital gap in Indonesia in the intersectional framework. I consider several metrics, such as the ratio of the population accessing the Internet, villages receiving mobile internet signal, and telecommunication expenditures. The study spans five years, from 2018 to 2022 (with some years missing for some of the variables). The data comes from BPS-Statistics Indonesia 2022 report "Telecommunication Statistics in Indonesia". I compute the Equality Ratios for one-dimensional and intersectional inequality as the value of the digitalisation metric for the most underprivileged group divided by the value for the most privileged group. Then, I assess the intersectional surplus as the difference between the inequality experienced by the intersectional group and the combination of one-dimensional inequalities. There is a substantial gap in internet usage and mobile internet availability in Indonesia, mostly related to urban/rural division and disparities between provinces. On the contrary, the gender gap is minimal. I also find no inequality in telecommunication expenditures. The gaps in internet usage were converging in recent years, but this was not true for the gaps in internet availability. People in intersectional groups face the combination of one-dimensional inequalities, but in most cases, there are none or minimal surplus effects.

Keywords: digitalisation; digital divide; intersectional inequality; Indonesia

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1. Introduction

In recent years, Indonesia underwent rapid growth in digitalisation and the ICT industry, with a 46.65% increase between 2018 and 2022 (BPS-Statistics Indonesia, 2022). However, the development is not uniform across the country. According to Priharsari et al. (2023), nascent digitalisation still undermines broadband and skills capacity but has high momentum and propensity to change. Any shortcomings in the organisation of digital life will likely be inflated.

First, there are areas of digitalisation that lag behind. According to the ASEAN Digital Development Index, Indonesia scores above the regional average, primarily in the Data Protection & Cybersecurity pillar and in the Digital Payments & Identities pillar (ASEAN, 2021). The report highlights the Digital Skills & Talent pillar as the

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area requiring the most improvement. The reports SMERU Research Institute et al. (2022) and SMERU Research Institute (2023) came to the same conclusion. The latter brings attention to the shortage of ICT specialists for public administration, between the lack of digital skills in society and the growing needs of the private sector.

Another bottleneck identified by researchers is regulatory and infrastructure readiness for the new technologies. Rumata and Sastrosubroto (2020) pointed out that decentralised and insufficient regulations are restraining digital development. According to the ICT Readiness Index by the World Bank, Indonesia ranked in the 105th position in the Infrastructure category, falling by 20 ranks between 2014 and 2016 (Frost & Sullivan, 2018). Indonesia's heterogeneity and geographical properties make it a hard case for infrastructural expansion.

On top of that, the benefits of digitalisation are not distributed evenly (SMERU Research Institute et al., 2022). The report by SMERU Research Institute et al. (2022) identified six facets of digital inequality based on: a) region, b) age, c) disability, d) gender, e) educational attainment, and f) income.

Perhaps most unique to the Indonesian situation is the regional digital gap, as the country is spread across thousands of islands and unequal in the overall level of development. Moreover, the best-performing regions are also the easiest to research, and the data on the underprivileged regions can be scarce (see, e.g., SMERU Research Institute, 2023).

This study aims to analyse the multifaceted problem of internet access in Indonesia. I consider the metrics of internet use, mobile internet availability, and telecommunication expenditures. With regard to them, I identify the extent of the digital gap in three dimensions: gender, region and the urban vs rural division. It expands the current knowledge by analysing the intersectional properties of the digital divide, as the topic has been studied in a one-dimensional way up to date.

There are substantial gaps in internet usage and mobile internet connection availability between provinces and urban and rural areas. The gender gap in internet use is the smallest and already converged in 2022. I also find no substantial inequalities in the telecommunication expenditures. People in intersectional groups face the combination of one-dimensional disparities, but I see none or minimal surplus effects. There is even a significant, negative surplus in mobile internet availability. The disparities between urban and rural areas are even more striking in the most digitalised provinces than in the less developed regions.

My results can be helpful for policymakers by pointing out the aspects of the digital divide that require the most attention. The paper also highlights the need for intersectional research and data collection. The digital divide is a complex problem and cannot be fully measured by the metrics of internet use, availability, and cost alone. The area of ICT education and job opportunities especially needs further exploration and can reveal more sources of inequality.

2. Literature review

The digital divide may be defined as a “division between people who have access to and use of digital media and those who do not” (van Dijk, 2020). Considering the increasing impact of digital solutions on the economy, social and private life, being deprived of opportunities and abilities to use them may seriously harm the quality of life (SMERU Research Institute et al., 2022; Krulický et al., 2024). A comprehensive analysis of the impact of ICT development in Indonesia has been conducted by Rezki (2023). The author linked the mobile phone adoption to several aspects of the socioeconomic development of the villages, including public services, support programs and opportunities for small enterprises.

The issue of the within-country digital divide is well-recognised in literature. However, the existing studies analyse the separation dimensions rather than the intersectional framework. Table 1 presents the summary of the literature survey, depending on the analysed dimension. Value "Pos" means personal characteristics increase digital opportunities, while "Neg" indicates the opposite. Most of the research focuses on gender, age and education.

Long et al. (2023) found a substantial disparity between men's and women's digital development. The gap was primarily due to the endowment effect, e.g., if women had the same opportunities as men, the gap would shrink by half. The gender gap is wider for more advanced aspects of digitalisation, like skills, entrepreneurship and occupational opportunities (Sey, 2021; Gudjonsson et al., 2022). Moreover, the gender gap is also wider for digitalisation metrics related to meaningful internet use than for the metrics of internet device ownership (Sey & Hafkin, 2019).

SMERU Research Institute et al. (2022) performed an extensive analysis of the digital inequalities in Indonesia. They found the gender digital gap as well, though relatively small compared to the inequalities related to age, place of residence, or income level. Probably the most profound digital divide exists between the able-bodied population and the people with disabilities, among whom only 18% access the Internet.

Similarly, Sujarwoto and Tampubolon (2016) found that people who were female, older, unemployed, less educated or living in poverty had lower internet access rates. The study then analysed interaction terms between telecommunications infrastructure and socioeconomic status. It showed that individuals living in infrastructure-deprived regions were less likely to access the Internet, even if they were wealthy or highly educated. Although the study did not use the intersectional framework, its results showcase the need for one. Digital inequality can come from many sources related to the availability of infrastructure, affordability, education, or personal attitudes. People in the intersectional groups – e.g. uneducated individuals from infrastructure-deprived regions – will suffer twofold.

Another aspect of the digital divide is the availability of digital devices. Puspitasari and Ishii (2016) confirmed the findings regarding age and education level in the case of accessing the Internet through mobile phones. Younger and highly educated people from three Indonesian cities were likelier to own smartphones than feature phones with limited internet access options.

Table 1. Literature review of the inequality dimensions in ICT development in Indonesia

Source	Female	Age	Education	Employment	Income	Rural	Region
Internet access (Sujarwoto and Tampubolon, 2016)	Neg	Neg	Pos	Pos	Pos		
Internet access (SMERU Research Institute et al., 2022)	Neg	Neg	Pos	Pos	Pos	Neg	Pos
Mobile access and smartphones (Puspitasari & Ishii, 2016)		Neg	Pos				
ICT opportunities (Sey, 2021; Long et al., 2023)	Neg						
Online shopping (Budiono et al., 2018)						Neg	
Innovation and public spending (Hilmawan et al., 2023)							Pos

Another division line falls between rural and urban areas, with the former being underprivileged. Budiono et al. (2018) listed several problems with e-commerce development in Indonesian villages: lack of infrastructure, skills,

and low incomes. This division often coincides with regional differences, making it an intersectional issue. The country's most urbanised and populous parts, most notably Java and Sumatra Islands, have better infrastructure (SMERU Research Institute et al., 2022) and productivity and innovation levels (Hilmawan et al., 2023). This, in turn, can foster digital development.

3. Methodology

3.1. The intersectional inequality

Current research on inequality recognises its intersectional nature (Bowleg, 2012), first pointed out by Crenshaw (1989). If the inequality is related to more than one aspect (e.g., race, gender and economic status), then the individual characterised by a few of these aspects may be harmed even deeper (Schein & Bauer, 2019). The problem of the intersectional aspect of the digital divide surfaced after the COVID-19 pandemic (Zheng & Walsham, 2021) when more and more aspects of daily life depended on digital solutions.

Intersectionality is a primarily theoretical framework and does not have a clearly defined quantitative methodology (Guan et al., 2021). In a review of 153 quantitative studies incorporating intersectionality, Guan et al. (2021) found that most used regression with intersection terms to explore this issue. The undoubted advantages of this approach are the ease of interpretation and the possibility of assessing the significance of the intersectional terms. However, it requires more granulated data and cannot be used in this analysis.

Schein and Bauer (2019) created the Intersectional Discrimination Index. They compared the means between groups to show that the intersection of race and gender or sexual minority made the subjects more vulnerable to discrimination and adverse health outcomes. Similarly, Meili et al. (2022) compared the schooling ratios in 39 countries and showed that a lot of inequality in education remains hidden if the ethnicity and gender factors are considered separately.

I follow the methodology of the latter, defining Equality Ratio (ER) as:

$$ER(G) = \frac{\min(s_1, s_2, \dots, s_J)}{\max(s_1, s_2, \dots, s_J)} \quad (1)$$

In Meili et al. (2022) paper, this measure was called the Inequality Ratio (IR). However, I changed the name to Equality Ratio because it takes the values between 0 and 1, where 1 means perfect equality. In this way, the results section will be more intuitive for readers.

The groups $s_1, s_2, \dots, s_J$ are designated with regard to dimension G. Gender and Location dimensions divide the data into only two groups (Men and Women, and Rural and Urban locations). The Province (regional) dimension divides the dataset into 10 groups, from the bottom (least developed) 10% to the top 10%.

For the intersectional analysis, the data is divided into $J_1 \times J_2$ groups, and the ER is computed as follows:

$$ER(G) = \frac{\min(s_{11}, s_{12}, \dots, s_{JJ})}{\max(s_{11}, s_{12}, \dots, s_{JJ})} \quad (2)$$

It can be interpreted as the ratio of the variable obtained for the person from the most underprivileged group (in both dimensions) and the person from the most privileged group. Assuming the sources of inequality are independent (e.g., women face the same inequality, regardless of which province they live in), the ER at the intersection should be equal to the multiplication of one-dimensional ERs:

$$ERm(G1 \times G2) = ER(G1) \times ER(G2) \quad (3)$$

Meili et al. (2022) call it mechanical intersectionality and define surplus intersectionality as:

$$\Delta G1G1 = ER(G1) \times ER(G2) - ERm(G1 \times G2) \quad (4)$$

The positive surplus would mean that the people in the intersectional group face even more inequality than the combination of inequalities related to their one-dimensional identities. For example, that would happen if gender digital inequality was stronger in the less developed regions. It would be a concerning result, as solving intersectional problems may require more than solving the one-dimensional inequalities in separation.

On the other hand, the negative surplus may indicate that the one-dimensional sources of inequality partly "cancel each other out". In other words, some barriers to digital development are of the same nature in both dimensions, and a person in the intersectional group will not face double of them.

3.2. Data

The data is sourced from BPS-Statistics Indonesia (2022) report. It includes variables on Internet use and infrastructure from 34 Indonesian provinces between 2018-2022. The report obtained the data mainly from the National Socioeconomic Survey (Susenas) and Village Potential Data Collection (Podes). Some variables were collected by the Ministry of Communication and Information Technology (Kemenkominfo) and telecommunications providers (BPS-Statistics Indonesia, 2022).

The variables are:

- % of the population aged 5 or more who have accessed the Internet in the last 3 months;
- number of villages that receive strong internet signal;
- average household expenditure on telecommunication as a fraction of total expenditure.

I modified the second variable by dividing it by the total number of villages. I also reversed the third variable by extracting it from 100%, which represents the expenditure left on the household after paying for telecommunication services. This way, it will be more intuitive for interpretation, as the higher the value, the better.

I explore the intersections based on three dimensions:

- Gender (male/female)
- Province
- Location type (rural/urban)

The gender dimension only relates to the internet use variable, as the other two are aggregated to villages and households. Gender and Location dimensions divide the data into only two groups (Men and Women, and Rural and Urban locations). The Province dimension divides the dataset into 10 groups, from the bottom (least developed) 10% of provinces to the top 10%. The deciles are computed according to the current population size. The provinces were sorted by the value of the internet access metric so that the top decile contains the most digitalised provinces inhabited by about 10% of the population.

This procedure was applied to reduce the impact of the outliers on the regional gap. As seen in Figure 1, both the bottom and the top of the distribution have outliers. Especially the least digitalised province stagnates while

digitalisation progresses in the rest of the country, meaning that the size of the gap and its changes over time would be distorted.

4. Results

4.1. Internet usage

The internet-using population in Indonesia rose from 39.9% in 2018 to 66.48% in 2022. Figure 1 presents the distributions of the population percentage using the Internet between provinces. Overall, internet usage is on the rise, except for Papua province, where digitalisation lags behind. This is why the gap between internet usage between the most and the least digitalised provinces is growing (see Table 2). However, the ER between the top 10% and the bottom 10% of provinces is less striking.

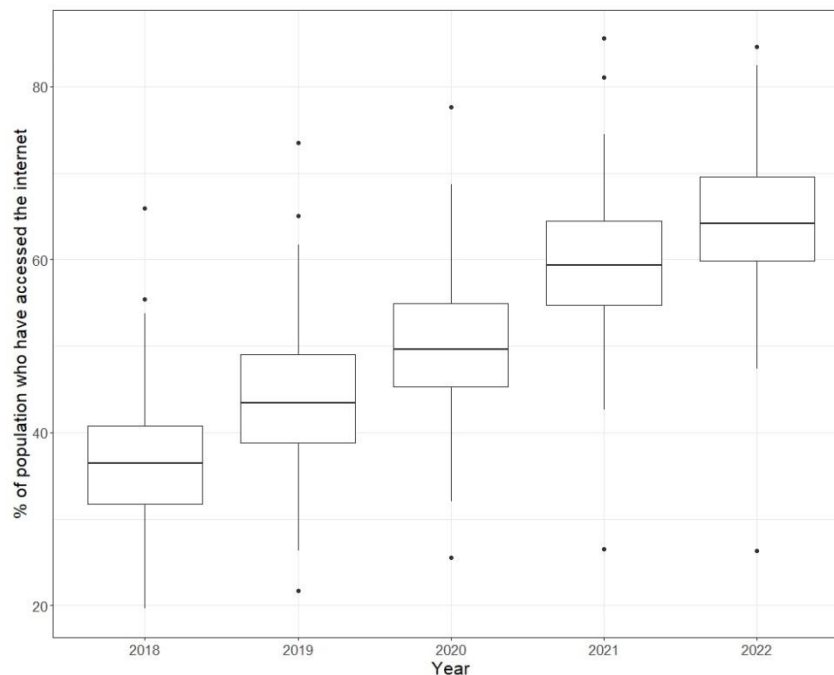


Figure 1. The distribution of the percentage of the population that has accessed the Internet in the last 3 months among provinces

Gender division has the highest ERs, meaning that this dimension exhibits the lowest rate of inequality. In 2022, it reached 99.59%, as men and women accessed the Internet at the same rate. The gaps between rural and urban areas are bigger and the biggest between provinces.

Next, Table 2 provides the intersections between dimensions. The ERs for intersectional groups are typically lower than the ERs in either of the dimensions alone because they suffer from two or more sources of inequality. However, there are some exceptions. In 2022, The ER for the Gender x Province intersection was a bit higher than the ER of just the province intersection (64.07 vs 63.87), and the same is true for the Gender x Location intersection (78.06 vs 75.40). This is because, in 2022, women in urbanised areas in the top provinces had a higher internet usage rate than men.

Surplus inequality is a difference between the multiplication of ERs of two or more groups and the ER of the intersection of these groups. A zero surplus would mean that the dimensions are independent, and a person in the intersectional group suffers the effects of both dimensions.

Table 2. The Equality Ratios and surplus intersectionality of internet access

Dimension	2018	2019	2020	2021	2022
Most digitalised province	65.89	73.46	77.61	85.55	84.65
Least digitalised province	19.59	21.70	25.52	26.49	26.32
ER	29.73	29.54	32.88	30.96	31.09
Top 10% provinces	55.17	63.25	63.51	72.01	74.32
Bottom 10% provinces	26.16	30.29	35.92	43.18	47.47
ER	47.42	47.89	56.56	59.96	63.87
Urban	50.92	58.59	64.25	71.81	74.16
Rural	26.56	33.84	40.32	49.3	55.92
ER	52.16	57.76	62.75	68.65	75.40
Male	-	50.50	51.69	59.75	63.79
Female	-	44.86	46.46	54.46	63.53
ER	-	88.83	89.88	91.15	99.59
Urban x top 10%	60.34	68.08	67.90	75.86	77.39
Rural x bottom 10%	17.95	21.29	25.97	33.37	39.01
ER	29.74	31.28	38.25	43.99	50.41
Surplus	-5.01	-3.62	-2.76	-2.82	-2.25
Male x top 10%	-	60.29	60.82	68.80	70.81
Female x bottom 10%	-	28.39	30.23	37.24	45.37
ER	-	47.09	49.70	54.13	64.07
Surplus	-	-4.55	1.13	0.53	-0.46
Male x Urban	-	61.08	61.01	68.26	67.46
Female x Rural	-	31.13	34.15	42.39	52.66
ER	-	50.97	55.97	62.10	78.06
Surplus	-	0.34	0.43	0.47	-2.96
Male x Urban x top 10%	-	70.79	64.49	71.94	71.38
Female x Rural x bottom 10%	-	19.52	21.49	28.13	35.78
ER	-	27.57	33.32	39.10	50.13
Surplus	-	-3.00	-1.42	-1.58	-2.16

The negative surplus for the Location x Province intersection means the inequality is slightly lower than the combined one-dimensional effects. The inequality between urban and rural areas may be less pronounced in the less digitalised provinces. (Or the differences between provinces may be less pronounced in the rural areas.)

The results for Gender x Province and Gender x Location intersections are mixed, with some of them positive and some negative. Positive values indicate that women in rural and underdeveloped areas face additional hardships in internet access, on top of the one-dimensional effects of gender and location/province. However, the surplus is generally close to zero.

People in the three-dimensional intersection (i.e., women from the rural areas of the least digitalised provinces) face the highest inequality. In 2019, only nearly 20% of them used the Internet, the ratio about 72% lower than for men from urban areas of the top provinces. However, the inequality is diminishing over time at every intersection.

4.2. Infrastructure and affordability

Next, I analyse the inequalities related to infrastructure and affordability of telecommunication services. The former is represented by the percentage of villages receiving a strong mobile internet signal, and the latter by the percentage of the household expenditure after subtracting telecommunication expenditures. Since the data are related to households or villages, I only analysed the regional and urban/rural divisions.

Table 3 presents the results. There is a strong inequality in internet infrastructure related to both dimensions. The penetration is about 40% lower in the less digitalised regions, and the inequality grew slightly in 2019 - 2021. The digital gap between urban and rural areas is almost as high. The intersectional inequality shows that about 48% fewer villages receive a strong signal in the rural areas of less developed provinces. However, the intersectional inequality surplus is negative, meaning that the effect for these groups is lower than the combined effects of one-dimensional inequality.

Table 3. The Equality Ratios and surplus intersectionality of the mobile Internet signal and telecommunication services affordability

Dimension	2019	2020	2021	2022
% of villages with strong signal				
Top 10% provinces	83.41	88.99	89.69	-
Bottom 10% provinces	52.65	54.96	54.38	-
ER	63.12	61.76	60.63	-
Urban	96.96	97.79	97.92	-
Rural	62.50	66.51	66.90	-
ER	64.46	68.01	68.32	-
Urban x top 10%	97.18	97.57	97.98	-
Rural x bottom 10%	49.79	52.36	51.72	-
ER	51.23	53.67	52.78	-
Surplus	-10.54	-26.32	-11.36	-
% of household expenditures without telecommunication				
Top 10% provinces	96.65	96.69	96.31	96.31
Bottom 10% provinces	96.46	96.31	96.00	96.08
ER	99.80	99.60	99.68	99.77
Rural	97.02	96.93	96.51	96.67
Urban	96.57	96.49	96.12	96.17
ER	99.54	99.55	99.60	99.48
Rural x top 10%	97.06	96.69	96.31	96.31
Urban x bottom 10%	95.83	95.69	95.31	95.39
ER	98.73	98.96	98.96	99.05
Surplus	0.61	0.19	0.32	0.20

The telecommunication expenditures (as a % of total household expenditures) are lower in the top 10% provinces. However, they are higher in urban areas, meaning the rural parts are more privileged. Nevertheless, the differences are minimal, and I do not find any substantial inequality in the expenditures. The ER is over 99% for one-dimensional divisions and over 98% for the intersection. The surplus inequality is positive yet barely above zero.

Discussion

Figure 2 compares the Equality Ratios for all considered variables and dimensions. Clearly, the direst are the digital gaps in internet use in intersectional groups, especially in the least developed provinces and rural areas.

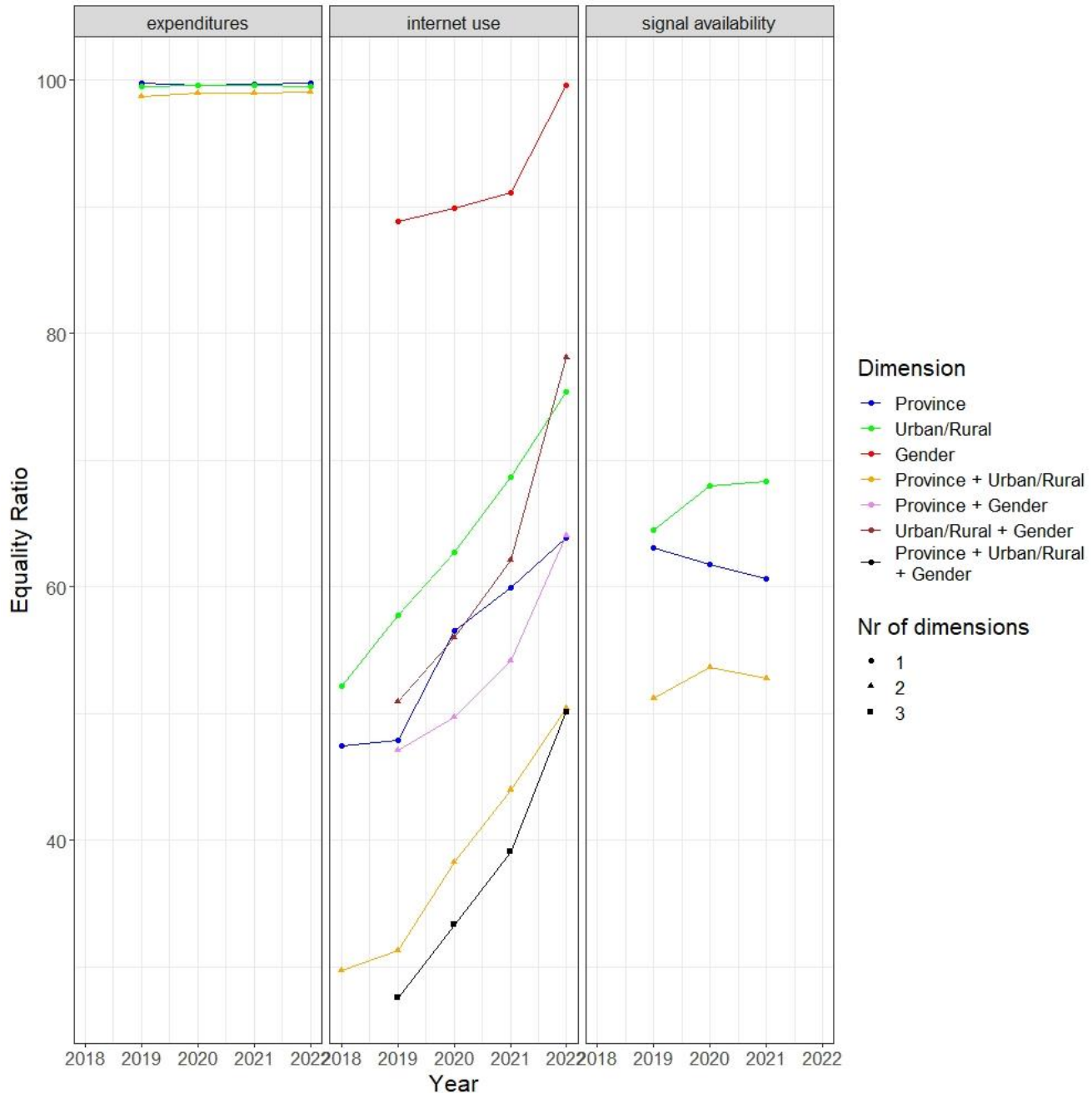


Figure 2. The equality ratios for internet use, availability of mobile internet signal, and telecommunication expenditures.

Comparing my findings with the inequalities in the previous literature (see Table 1), they are compatible regarding regional and urban/rural inequality. I did not find much evidence of strong gender inequality, but this could be for two reasons. First, the gap has diminished recently so that it could be larger in older studies. Second, this type of inequality could be more pronounced in more advanced metrics than just internet use (Sey, 2021). For example, (Kusumawardhani et al., 2023) found that although the adoption of digital technologies allowed more women to enter the workforce, they primarily get low-skilled and informal jobs.

There is not enough evidence to say that gender differences in digital development are over. However, it is a promising sign of the gap convergence.

The gender gap closed between 2021 and 2022, with a sharp rise in the ER related to gender differences in internet use, which also translated to rises in ERs for intersectional groups that include a gender dimension. One potential explanation is that the COVID-19 restrictions encouraged small and medium business owners (the majority of whom are women) to digitalise their businesses (Laksmanawati & Yuniawan, 2021). Nur Asrofi et al. (2023) notes that women who use the Internet have higher chances of starting a business and earning a better income.

On the contrary, the urban/rural gap seems to be closing at a constant rate, and the equality between provinces rose quickly between 2019 and 2020, to slow down with the COVID-19 pandemic.

My study expands the knowledge by applying the intersectional framework. I show that in most cases, the intersectional groups suffer the combination of one-dimensional inequalities. The international surplus is mostly close to zero. The exception is the Province x Location intersection with a large negative surplus, meaning that the two-dimensional inequality is lower than the combination of separate effects.

5. Conclusions

In this paper, I analyse the intersectional digital divide in Indonesia. I examine the differences in internet usage, availability, and telecommunication expenditures. For the latter two, I consider the regional and rural vs urban divisions, and for the former, an additional gender division.

My findings confirm the existence of large digital gaps in internet use. In 2022, the ratio of people accessing the Internet was 36% lower in the 10% least digitalised provinces (than in the top provinces) and 25% lower in rural areas (vs urban areas). These numbers fell from 53% and 48% respectively in 2018.

The gender gap is the least concerning, falling from 11% in 2019 to practically 0 in 2022. In the urban areas in the most developed provinces, the access rates for women were even higher than for men, creating a gender gap in the opposite direction.

I find a positive surplus inequality only in two years for the Gender x Province intersection and in three years for the Gender x Location intersection. However, even there, the effects are minimal. Overall, digital inequality does not have an intersectional property.

Next, I find substantial infrastructural inequality. The less developed provinces and rural areas have 40% and 32% lower ratios of villages receiving strong internet connection. The gap reaches 48% for the intersectional areas, although there is no surplus inequality. Finally, I do not find any inequality regarding expenditures on telecommunication in either dimension or their intersection.

My study explores the gap in research on the Indonesian digital divide by applying an intersectional framework. It points out which dimensions and aspects of digitalisation need further exploration and institutional effort. However, there are several limitations, mainly regarding the data. Other dimensions of the digital gap are not included in this study, such as age or educational attainment (see SMERU Research Institute et al. 2022). Moreover, the metrics used in this study cover the essential aspects of Internet access. Even after reaching convergence in internet access, inequality can still be severe with regard to digital skills or opportunities.

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FOOD SECURITY STATE AND CHALLENGES IN SOUTH AFRICA

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Abstract. The study assesses the status quo of SDG 2 implementation in South Africa. The study further examines the obstacles to achieving SDG 2 within the nation's framework. The study also looks at and assesses several national programmes related to food security. A few interventions are discussed and considered to enhance and augment the extent of food security in South Africa. The study employed a qualitative approach and used the literature review to compile information related to SDG 2 and food security interventions, which was further analyzed through document and conceptual analysis. The findings show that there are issues with the implementation of policies pertaining to food security initiatives. The study aims to answer the following questions: What obstacles need to be overcome for SDG 2 to be implemented effectively, and what measures are necessary to ensure the success of food security interventions in South Africa? Thus, the study aims to evaluate South Africa's progress toward food security (focus). It also seeks to assess the accomplishments and shortcomings of food security initiatives implemented in South Africa (locus). The sustainable livelihoods approach (SLA) is considered a theoretical framework for the study. Suggestions for improving policy are made as a contribution to the public management and governance field.

Keywords: food security; qualitative study; South Africa; sustainable livelihoods approach; sustainable development goals (SDGs), SDG 2.

Reference to this paper should be made as follows: Vyas-Doorgapersad, S. 2024. Food security state and challenges in South Africa. *Insights into Regional Development*, 6(3), 23-26. <http://doi.org/10.70132/q7863983559>

JEL Classifications: O11, O15, Q18

Additional disciplines: Public Management, Development Studies.

1. Introduction

In 2023, it was recorded that nearly 282 million people globally suffered from high levels of acute hunger, spanning 59 countries and territories. This statistic was explored by the Global Report on Food Crises (GRFC). This represents a 24 million increase over 2022, according to the World Bank Report (2024:1). Given that over 36 million children under the age of five suffer from acute malnutrition in 32 different countries, children and women are disproportionately affected by these hunger crises. Particularly among those displaced due to conflict and natural disasters, acute malnutrition became more severe in 2023, as per the report of the World Bank (2024:1). Food security is seemingly the most significant challenge the world is facing in 2024. Therefore, the World Bank has acknowledged that inadequate food and nutrition insecurity is a worldwide challenge that requires strategic interventions. To date, it has contributed an amount of \$45 billion, exceeding its initial projected commitment of \$30 billion that it proclaimed two years ago in May 2022, to addressing issues and protecting

livelihoods worldwide (refer to Andree et al., 2024:1). The study investigates the status of SDG 2, exploring the challenges and interventions related to food security in the context of South Africa.

To bring social-economic development, 17 sustainable development goals (SDGs) were revised as post-millennium development goals (MDGs), with an expected timeline to be realized by 2030. As observed by the United Nations Development Programme (UNDP) (2020), these 17 SDGs are interconnected globally because they share a common focus and complement each other in achieving the goals of sustaining the environment and enhancing social and economic development. Furthermore, to consider, member states of the United Nations (UN) approved the 'Agenda 2030' for sustainable development because they perceived it as a chance to increase global prosperity and peace within a broader scope of liberty, as confirmed by the United Nations Department of Economic and Social Affairs (UNDESA, 2020) and reinforced in the scholarly publications by Vyas-Doorgapersad (2022a: 266-267). To eradicate poverty and realize SDGs by 2030, the 'Agenda' aims to promote development in each member country. The 'Agenda' creates a global vision for sustainable development that benefits all, states the European Foreign Institute (EFI) (2019).

SDG 2 aims to achieve no or zero hunger. Note that hunger is linked to food, meaning zero hunger demands strategic and policy interventions related to food security, hence realizing the aims of SDG 2. The term first originated in the mid-1970s, assuring that essential food items are easily available and financially feasible. It also means that there are no significant fluctuations in the prices of food items causing price instability at both the national and international levels. This was the essence of the definition of food security given by the World Food Conference in 1974 (refer to Food and Agriculture Organisation (FAO), 2006:1). To maintain a constant growth in the consumption of food items and to counteract variations in price and production, the definition emphasizes the necessity of always having sufficient global food supplies of staple foods available (FAO, 2006:1). The definition of food security that resulted from the FAO (1983) analysis was based on the equilibrium between the demand and supply sides of the equation. The study emphasized the need to make sure that everyone always has access to the essential foods they need, both financially and physically, as further recorded in the documents of FAO (2006:1).

Non-numerical textual, visual, or audio data must be gathered and analyzed to address the questions raised and achieve the study's objectives. This is a qualitative study. The social sciences and humanities are the usual fields that employ qualitative research. It is carried out to understand experiences, ideas, or viewpoints, to acquire a thorough grasp of an issue, or to produce fresh concepts for further investigation, as suggested by Bhandari (2020:1) and adapted by Masibigiri (2023:8), and therefore aims to gain a thorough understanding on social issues, as further indicated by various scholars, such as Nyikadzino and Vyas-Doorgapersad (2020:33); Vyas-Doorgapersad (2021:1; and 2023:2061). The data is collected through a literature review. According to May (1997:4), an organized review of the existing literature is essential to research success. The process by which knowledge about what is known and unknown is acquired is through a review of the literature. It is crucial that the researcher plans the literature search around the main ideas that will be examined, and hence also advocated by Jansen (2024:22). The data was analyzed through conceptual analysis. According to Maxwell (2005:66), conceptual analysis is a system of ideas, presumptions, theories, and concepts that guide research. It is typically accepted as a suggested explanation for gaining a clear overview of the socially constructed reality under study, as further validated by Mutandwa (2023:36). On the other hand, a systematic approach called document analysis seeks to obtain a thorough assessment of the material that has been carefully selected to identify any themes, patterns, or biases that may be present within the subject matter under investigation, as opined by Leedy and Ormrod (2001:155) and further augmented in research works by Vyas-Doorgapersad (2022:19).

The study considers the sustainable livelihood approach (SLA) as a theoretical framework for this study. One way to think about developing activities is through the lens of the sustainable livelihoods approach. This covers the goals, priorities, and scope. Formulating development activities is made easier with this method. This

methodology introduces a dynamic perspective on the lives of the impoverished and marginalized, as well as the importance of policies and institutions, as suggested by Morse and McNamara (2013:2) and adapted by Hlongwane (2023:27).

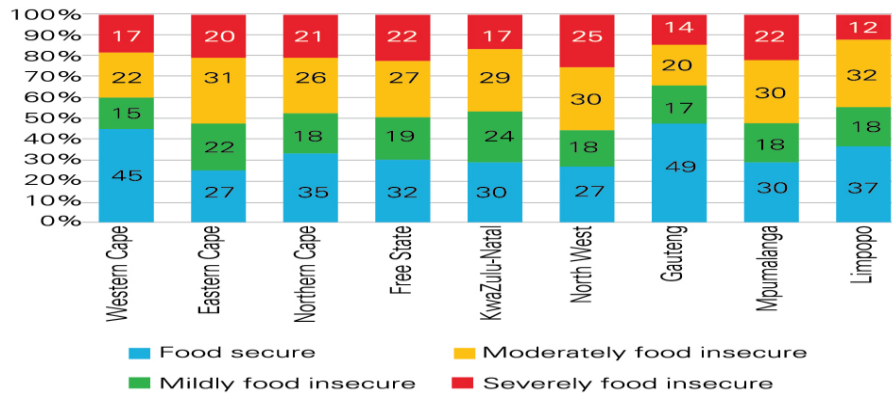
2. SDG 2 in the South African Context

Apartheid South Africa had uneven opportunities related to education and employment that caused segregation of benefits. However, South Africa has faced varied socioeconomic, technological, and political changes since 1994, even after the transition from apartheid to democracy. These inequalities include gender-biasedness in employment, lack of talent management in human resources in organizations, and the digital divide, to state a few. The inequality that forms part of the study is income inequality, which, according to Van Braun (2007:3), is a significant contributing factor to household food insecurity, lack of access to resources, and subsequent difficulty in obtaining enough food. An additional challenge to poverty is linked to the lack of job opportunities, whereby the number of unemployed people and households may increase, hence causing constrained financial resources to access food, as suggested in the works of Adubu-Raheem and Worth (2011:2); and further narrated by Hlongwane (2023:18). According to the statistics published in the official report of the World Bank (2020:1), considering the upper poverty line of ZAR 992 at the national level, it is reported that nearly 55.5% of the populace (that is 30.3 million of South Africans) experienced living as poor, and 13.8 million South Africans (that is 25% of the population) experienced food insecurity. In a similar vein, the international poverty standards estimated that the poverty rate would be 18.9% and 37.6% in 2014–15, respectively, up from 16.6% and 35.9% in 2010–11, based on assessments of \$1.90 and \$3.20 per person per day (2011).

The South African Government has demonstrated commitment towards implementing SDGs. This was done by encouraging organizations, particularly those in the public sector, to align and integrate their strategies, plans, and objectives with SDGs (Statistics South Africa, 2019). Although the general progress towards the achievement of SDGs significantly varies, there is a consensus in the literature that the achievement of SDGs in Africa still needs to be completed. This study seeks to provide an account of the progress towards implementing SDGs in the country, focusing mainly on SDG 2. The goals are to end hunger, reduce food insecurity, enhance nutrition, and advance sustainable agriculture, which are the objectives of SDG 2 (UN, 2024:1).

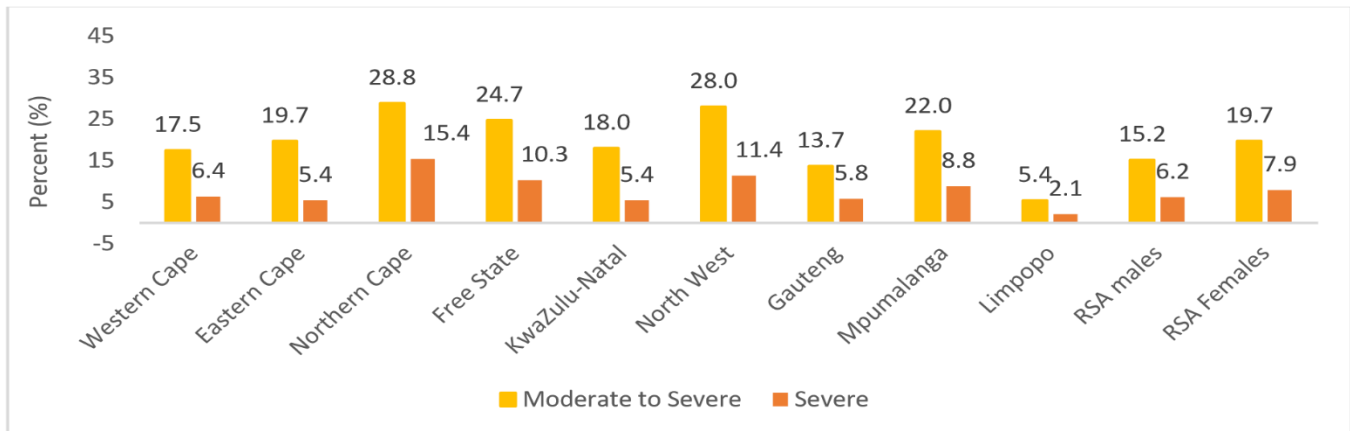
Despite South Africa's concerted efforts to achieve SDG 2 targets, the country still needs to catch up like many other African countries. Literature highlights malnutrition and food insecurity statistics, particularly among rural populations and informal settlements in urban settings (van der Berg, Patel & Bridgman 2022). A survey conducted by the Human Sciences Research Council (HSRC) (2024:1) revealed that although South Africa regards food and nutrition security as a constitutional right, some people still only eat once or twice a day or go to bed hungry in some parts of the nation (HSRC, 2024:1). Using data from South Africa's National Food and Nutrition Security Survey (NFNSS) between the years 2021 and 2023, the survey was conducted to obtain advanced statistical information (HSRC, 2024). The survey measured Household Hunger, Food Consumption, Household Dietary Diversity, and Household Food Insecurity Access Scores (HSRC, 2024). The survey revealed that 17.5% of South African households faced severe food insecurity; 26.7% were moderately, 19.3% were mildly, and 36.5% were food insecure (HSRC, 2024).

Regarding the Household Hunger Score, the survey found that 79.2% of households said they were rarely or never hungry, 15.3% said they were moderately hungry, and 5.6% said they were severely hungry (HSRC, 2024). Although the Household Food Insecurity Access and the Household Hunger scores indicate that South Africa's national food insecurity levels are not severe, there were acute situations in some provinces and districts. Graph 1 below, obtained from the HSRC (2024), reflects the disaggregated food security situation by provinces in the country, with the North West having 25% of the households experiencing severe food insecurity, 30% facing moderate food insecurity, and 10% experiencing severe hunger.



Graph 1. Disaggregated food security situation by provinces in South Africa
 Source: Human Sciences Research Council (HSRC) (2024)

A country report on SDGs released by Statistics South Africa (2023) provides additional information highlighting the percentage of the population facing a lack of food availability. The statistics range from moderate to severe levels of food insecurity, based on the Food Insecurity Experience Scale (FIES) in South Africa (see Graph 2).

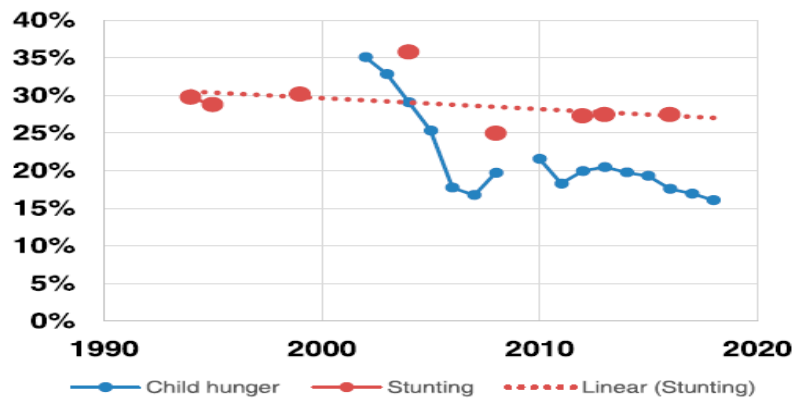


Graph 2. Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES) in 2019, by province and sex
 Source: Statistics South Africa 2023b:33.

Based on Statistics South Africa 2021 data, the provinces (North West and Northern Cape) seemed to have the highest rates of food insecurity, ranging from moderate to severe levels in 2019 (above 28.0%). Particularly the Northern Cape, which experiences drought frequently, hence making it more susceptible to starvation (Statistics South Africa 2023:33). According to van der Berg et al. (2022:722), although there were initiatives regarding investing in social protection programmes; there was still a high level of food insecurity witnessed, along with child hunger. For instance, the Global Nutrition Report (2019) reported that about one-quarter of South African households lacked adequate finances to buy basic food in the past year. Shortages of money to purchase basic food negatively affected nutrition, particularly for children.

Consequently, in 2016, the percentage of children under five that were stunted and wasted was recorded as 27% and 2.5%, respectively (Global Nutrition Report, 2019). Malnutrition among children below five years of age has been identified, albeit directly, as a contributor to child mortality in South Africa. According to Bamford, Mckerrow, Barron and Aung (2018:27), although malnutrition was not the leading cause of death, a third of children who died in South Africa were severely malnourished. These statistics underscore the importance of government nutrition support programmes for children.

A trend analysis of hunger and stunting (van der Berg et al., 2022:724) shows that although South Africa experienced a drastic decline in hunger between 2000 and 2020, it remains high, ranging between 30 and 25% (also referred to as Southern Africa Labour and Development Research Unit, 2021). The reduction in hunger among children was attributed to the Child Support Programme, see Graph 3. The programme, however, failed to reduce stunting.

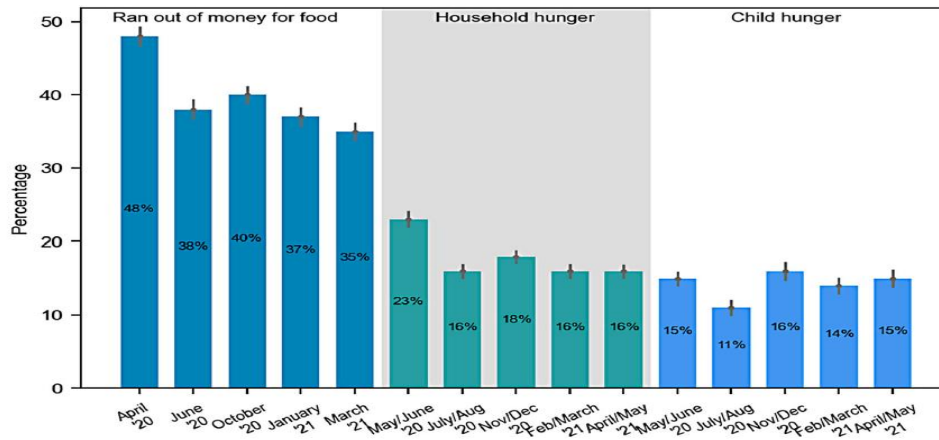


Graph 3. Long-term trends in child hunger and stunting

Source: van der Berg et al. (2022:724)

A recent survey by the HSRC (2024), which measured rates of stunting, underweight, and wasting in children between 0-5 years of age, found that 29% faced stunting, 5.3% faced wasting, and 7.8% faced underweight, respectively. However, results for some provinces showed high levels of stunting. For instance, the Northern Cape recorded an overall rate of stunting (48.3%), of which 16% were severely stunted (HSRC, 2024). The Northern Cape province also experienced severe wasting (21.8%) and severe underweight (22.4%). The status quo of hunger in the country experienced a drastic shift during COVID-19. The level of hunger before and during COVID-19 is also worth mentioning in this study. Before the COVID-19 pandemic in the country, 5.5% of people reported having 'extremely inadequate access' to sufficient food, and about 16% of households reported having 'inadequate access' to food. Roughly 11% of households stated they were at risk of going hungry, as investigated by Kerr, Ardington and Burger (2020) and further explored in the works of Alaba, Hongoro, Thulare and Lukwa (2022:2). The era experienced the existence of COVID-19 had also witnessed a reversal of the national gains towards the achievement of SDG 2 as there was a sharp rise in food insecurity and hunger. The level of hunger during COVID-19 was also studied by another researcher who highlighted that, under strict lockdowns brought on by COVID-19, household hunger skyrocketed, with 47% of households experiencing a shortage of funds for groceries in May/June 2020 (the first wave) (Spaull et al., 2020a) and Alaba et al. (2022:2). The percentage of hungry households fell to 37%. However, there was still a significant increase in hunger and food insecurity compared to before COVID-19, as researched by scholars such as Spaull et al. (2020b) and Alaba et al. (2022:2). Additionally, it had been speculated that by the time the year 2020 ends, the pandemic called COVID-19 may have caused 49 million people to live and experience extreme levels of poverty (Hunger Map, 2020). Hunger is

primarily determined by socioeconomic status, so the likelihood of no hunger by 2030 decreases with increased numbers of hungry people (FAO, 2019) due to poverty and unemployment. Graph 4 below shows a trend analysis of child hunger, hunger and food security in South Africa due to COVID-19 from 2020 to 2021 as per the NIDS-CRMS.



Graph 4. Trend analysis of food security, hunger and child hunger in South Africa

Source: van der Berg et al. (2022:726)

The statistics are supported by the Borgen Project (2021:1) and further affirmed by Hlongwane (2023:3) and Vyas-Doorgapersad (2024:250), stating that South Africa is a home and shelter to 6.5 million. However, 11% of them are considered food insecure and experience hunger. Considering this situation for South African households, approximately 11,6% of families, that is 2.1 million households in the country, experienced hunger in 2021, as explored in the reports of the Statistics SA (2023:1) and further narrated by Vyas-Doorgapersad (2024:250). The latest update is a Household Affordability Index (HAI) that is a report published by the Pietermaritzburg Economic Justice & Dignity Group (PMBEJD) on 24 January 2024 highlighted that a child's primary, nutritious diet would have cost R953,75 on average in January 2024. Providing a child with a diet with primary nutritional value costs R14,02, or 1.5% more on average this month than last. A child's essential nutritious diet costs R100,72 (11.8%) more annually. In January 2024, the Child Support Grant was only R510 (33%), which is less than the R760 Food Poverty Line and 47% less than the average amount of R953,75 that is required to provide a child with an essential nutritious diet (PMBEJD 2024). As highlighted by various scholars, such as Chakona and Shackleton (2019), Mlambo and Khuzwayo (2021:9-10), Vyas-Doorgapersad, Shava and Olowu (2023:65), there are a few significant issues related to food security and nutritional value-driven food items, their availability, and affordability in South African context. Firstly, in some households, a few people earn wages but have many households living as dependents. This situation may cause households to live an impoverished life. Secondly, the country is required to have appropriate disaster risk management strategies and systems to deal with calamities, such as drought and floods. These natural disasters may cause food insecurity for households who live in disaster-prone areas. Thirdly, households require an adequate supply of food items to survive. Lack of such availability may cause hunger and malnutrition among households. Fourthly, households also need more financial support to have purchasing power. Lastly, lack of nutritional value in food items may lead to children facing malnutrition, which in the long run may cause chronic malnutrition that is dangerous to health and may cost the lives of children.

The inseparable relationship and nexus between poverty and food security highlights the need for the Government to focus more on strategies towards reducing poverty and inequalities in the country. Reducing poverty and inequalities may help the country achieve many SDGs. There is a need for a collaborative multistakeholder

approach to control poverty levels in South Africa. With high poverty rates, addressing hunger and malnutrition remains a daunting task.

3. Challenges and Interventions to Achieve SDG 2 in South African Context

The spread of COVID-19 has been highlighted as an unwanted but unavoidable variable hampering government efforts towards achieving SDG 2. The COVID-19 spread in South Africa, and the subsequent lockdown measures resulted in economic disruptions and uncertainties that hounded many South Africans. Therefore, it was unsurprising that poverty and associated hunger and food insecurity worsened. Van der Berg et al. (2022:722) illustrate that the strict lockdown measures introduced by the South African Government to curb the coronavirus spread significantly compromised employment levels and incomes, especially for those in the informal sectors whose income solely depends on daily activities and sales. The negatively recorded financial implications from the COVID-19 pandemic have permanently impacted the nation's efforts and interventions towards SDG2, particularly for a country already struggling with rising unemployment and inequality. The COVID-19 pandemic brought food insecurity, malnutrition and hunger as vital and prominent policy problems between 2019 and 2022 (Southern Africa Labour and Development Research Unit, 2021).

Natural calamities caused by climate change- such as floods and drought- are also significant contributors to food insecurity in Africa, and South Africa is no exception. Ngcamu & Chari (2020:2) hold that drought hampers agricultural productivity and has cost South African farmers vast sums of money. A study by Bahta, Jordaan and Muyambo (2016) and further validated by Bareki and Anitwi (2017:589) found that one of the worst droughts in a century has recently struck South Africa. Agricultural productivity is expected to be compromised in areas that receive summer rainfall. Droughts have severely damaged South Africa's agriculture industry, primarily harming the country's vast farming regions. A report was prepared by Statistics South Africa (2019), based on the percentage of households in each province engaged in agricultural production activities between 2011 and 2016, utilizing information gathered from the Community Survey (CS) 2016 and the Census 2011 (Statistics SA 2019). The report stated that South Africa saw a decrease in the percentage of households engaged in agricultural tasks and undertakings between 2011 and 2016. Approximately 2,9 million households (19,9%) reported engaging in activities related to agriculture in 2011, but by 2016, only 2,3 million households (13,8%) still reported doing so. A decline of 6.1% in the percentage point was noted (Statistics SA 2019:7). Such a trend compromises food security, especially for households in rural areas. The effects and impacts of drought on food security have been worsened by the lack of advanced technologies for providing accurate data to local farmers. Bareki and Anitwi (2017:595) revealed that 98% of the farmers reported needing early warning information to mitigate drought proactively.

The increasing levels of unemployment coupled with high poverty levels among black South Africans are also among the significant variables for lack of food security and inadequate food availability to remain prevalent in the country. Several studies have shown a significant relationship between poverty, food insecurity and hunger (Statistics SA 2019:4; van der Berg et al. 2022:723). As van der Berg et al. (2022:723) put succinctly, hunger and inadequate nutrition, such as an unbalanced carbohydrate diet, are common signs of poverty. Studies have shown high levels of absolute poverty in South Africa (Adetoro, Ngidi & Danso-Abbeam, 2023; Becker & Becker, 2022). Statistics South Africa (2020) revealed that 88.4% of the children living in rural areas experienced multidimensional poverty, with Limpopo Province and Eastern Cape Province being the most poverty-stricken provinces (Adetoro et al. 2023:147). This underscores the need for focused and localized poverty eradication programmes to fight poverty and food insecurity from the grassroots.

Increasing unemployment levels that have characterized South Africa for the past two decades also have a bearing on food security. Unemployment rates in South Africa rose from 38.7% in Q4 of 2019 (Statistics SA 2020) to 41% in Q4 of 2023 (Statistics SA 2024). Unemployment has not only contributed to poverty but also affects food

security. This makes it the linchpin of South Africa's dilemma to achieve SDGs 2030. Although, in some instances, South Africa has managed to produce enough food for the country, due to unemployment and lack of disposable income, [many] South Africans still needed access to food (Statistics SA 2019). Thus, achieving SDG2 in South Africa calls for comprehensive and multifaceted strategies that confront the root causes of poverty, unemployment and inequalities in the country.

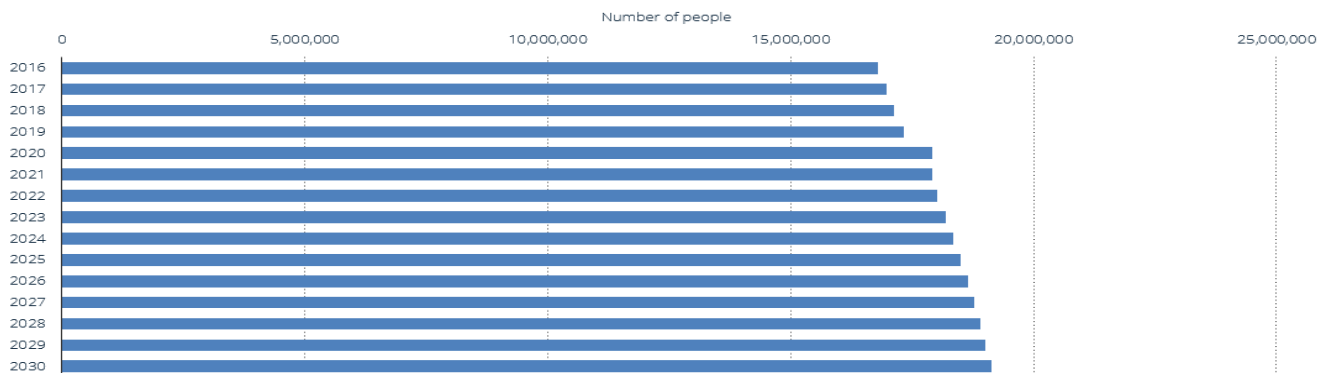
Inflationary pressures have worsened food insecurity. Inflation has also significantly eroded the spending power of many South Africans, particularly low-income people. Since 2009, South Africa has been experiencing rising inflation levels (Statistics SA, 2023a; Staff Writer, 2023). Table 1 below shows ever-rising levels of inflation-adjusted poverty lines.

Table 1. Inflation-adjusted national poverty lines, 2006 to 2023 (per person per month in rands)

Year*	Food Poverty Line	Lower-bound ty Line (LBPL)	Upper-bound Poverty Line (UBPL)
2006	219	370	575
2007	237	396	613
2008	274	447	682
2009	318	456	709
2010	320	466	733
2011	335	501	779
2012	366	541	834
2013	386	572	883
2014	417	613	942
2015 (April)	441	647	992
2016 (April)	498	714	1077
2017 (April)	531	758	1138
2018 (April)	547	785	1183
2019 (April)	561	810	1227
2020 (April)	585	840	1268
2021 (April)	624	890	1335
2022 (April)	663	945	1417
2023 (May)	760	1058	1558

Source: Statistics South Africa 2023:4.

The number of poor people and the extent of poverty is only increasing, as provided by Statista 2024 (see Graph 5).



Graph 5. Number of people living in extreme poverty in South Africa from 2016 to 2030

Source: World Data Lab 2023, provided by Statista 2024.

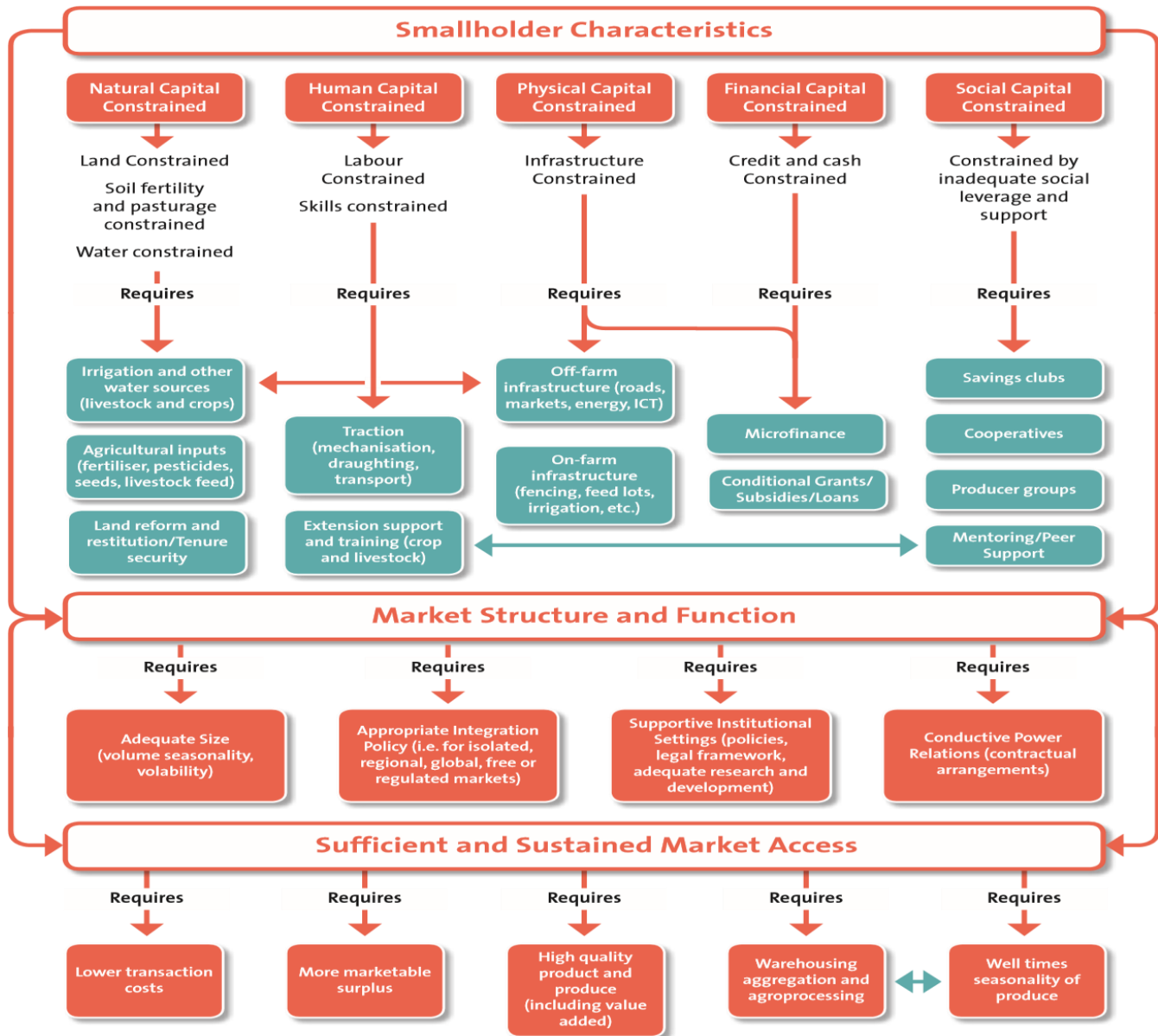
The data shows that 18.2 million people in South Africa are reportedly experiencing extreme levels of poverty as of 2023, with the daily poverty threshold being USD 1.90. A comparison of this data to 2022 indicates that an

additional 162,859 people reported experiencing poverty. Based on this increased number of people, the headcount is expected to rise in the years to come. Survival may be challenging, as by 2023, it is expected that approximately 19.1 million people in South Africa will have to live a life earning at most USD 1.90 a day (Cowling, 2024). This poverty level directly impacts food, as many households cannot buy and consume food.

Additionally, food prices rise yearly in the country due to inflation and other economic factors. According to the Staff Writer (2023), South Africa witnessed a significant shot up in food prices by 13.5% in December 2022 compared to the previous year. It is no surprise that the Staff Writer (2023) reported that a quarter of South Africans (13.8 million) live in extreme poverty that falls below the food poverty line. Consequently, most households in South Africa need help to afford the elevated prices, compromising food security. This statement is justified by the report of the PMBEJD (2024) highlighting the following:

- Month-after-month: The household food basket's zero-rated items went from R2 769,64 in December 2023 to R2 815,93 in January 2024, with an increase of R46,30 (1,7%).
- Year-on-year: The household food basket's zero-rated items went from R2 559,26 in January 2023 to R2 815,93 in January 2024, a rise of R256,67 (10,0%).
- Monthly: The household food basket's items subject to VAT went from R2 468,57 in December 2023 to R2 508,93 in January 2024, an increase of R40,36 (1,6%).
- Annually: The household food basket's items subject to VAT went from R2 358,16 in January 2023 to R2 508,93 in January 2024, a rise of R150,76 (6,4%).

Annually, the household food basket's VAT-exempt items went from R2 358,16 in January 2023 to R2 508,93 in January 2024, a rise of R150,76 (6,4%). The South African Government has introduced and put into implementation a few policies and programmes to enhance the achievement of SDG2. First and foremost, the National Development Plan (NDP) introduced in 2011 is a crucial document seeking to transform South Africa's agriculture. Chapter 6 of the NDP provides a framework for a rural economy that is inclusive and integrated and targets the creation of one million jobs in the farming sector by 2030 (African Centre for Biodiversity 2018:11). The NDP proposes 300,000 opportunities for smallholder and subsistence farmers. It seeks to bring underutilized land and farms into commercial production, thereby creating more jobs (National Planning Commission (NPC) 2011:199). Following the NDP, complementary programmes and policies have been introduced to enhance agricultural productivity and food security and support smallholder farmers across South Africa. Some of the notable programmes include the Agricultural Policy Action Plan (APAP) and the Revitalising Agriculture and the Agro-processing Value Chain (African Centre for Biodiversity 2018:11). The Department of Agriculture, Forestry and Fisheries (DAFF) (2014) report states that priority commodities covered by the APAP 2014–2019 included the integrated value chain of poultry, soybeans, and maize; red meat; wine; vegetables and fruits; biofuels; forestry wheat; and aquaculture and fishing. The South African Government has further introduced comprehensive farmer support programmes to bolster agricultural productivity. The programmes seek to address fundamental factors undermining agricultural productivity, namely, constrained land, labour constraints, infrastructural constraints, financial constraints and poor networks and social support systems (refer to African Centre for Biodiversity 2018:13). Figure 1 below, provided by the Khulisa Management Services (2016:6) summarises the nature and scope of the integrated farmer support programme.

**Figure 1.** Nature and Scope of the Integrated Farmer Support Programme

Source: Khulisa 2016, cited in African Centre for Biodiversity (2018:13)

The programme targets Small, Medium, and Micro Enterprise (SMME) farmers and is informed by the Government's strategy to improve sustainable food security among disadvantaged and vulnerable groups. The Government of South Africa calls on vulnerable and historically underprivileged groups, including youth, women, and individuals with challenges, to apply for the farmer support grant and join our unrelenting campaign against food insecurity through the comprehensive farmer support programme (SA News, 2024).

Social support and food relief programmes were also introduced to enhance food security, particularly among disadvantaged and vulnerable communities. For instance, the Government of South Africa introduced the School Nutritional Programme (SNP), which is part of the school feeding programme aimed at reducing hunger and nutritional deficiencies among children in poor communities (Mafugo, 2021:1). The programme was based on the

government realization that SNPs for low-income households, can help in addressing poverty and historical inter-generational hunger. Mostert (2021:1) found that the School Feeding Programme, in addition to reducing hunger and food insecurity among children, reduced health spending among parents who benefited from the programme compared to those who did not.

The Government introduced a financial support initiative called the Child Support Grant (CSG) to address child hunger and poverty further. According to Oyenubi & Kollamparambil (2022:713), the CSG is one of the largest welfare support schemes in the country. It is reported that the Government has prioritized expenditure on the Child Support Grant that has increased over the years; for example, it has increased from 31.4% in 2007/08 to 37.2% in 2018/19 (Oyenubi & Kollamparambil, 2022:713). South Africa also has other social assistance schemes that significantly impact SDG 2. Some of the notable ones include disability, care dependency, foster care, grant-in-aid, war veterans, and old age grants (cited in Neethling, 2024), who further highlighted that (Neethling, 2024), in 2023/2024, 27.78 people in South Africa received social assistance grants.

4. Conclusions

The findings explore that the Government of South Africa has initiated varied policies and programmes to deal with food insecurity. However, the level of food insecurity is clearly and visibly recorded in official documents. This concern relates to the understanding that although significant policy documents are formulated to deal with the challenges of food insecurity, implementing such policies remains a challenge. This statement is substantiated by the published records, stating that, at present, the child support stipend is approximately R164 below the minimum amount required for survival or about 25% below the poverty line (Yende, 2021:1).

The lack of compliance with legislative frameworks, inadequate monitoring and evaluation practices and control measures may also affect the implementation of programmes. One such cause leading to the lack of implementation is related to corruption, heightened during COVID-19 when people were desperate to have financial support to buy and access food. This statement is supported by the study stating that most of the cases related to misconduct and corruption in government departments were reported on the National Anti-Corruption Hotline (NACH) between April and June 2021. These cases were related to the social relief grant, R350, released from the South African Social Security Agency (SASSA), indicating that the corruption that surfaced during COVID-19 persisted in 2021. During the first quarter, several reported cases of corruption (337) were received on the NACH; 66% of these cases were transferred to the SASSA for investigation purposes. The reason is that these cases were involved in social grant fraud, as highlighted by Bhengu (2021:2) and further affirmed by Vyas-Doorgapersad (2022:16).

The study recommends holding appropriate consultation meetings when developing the agenda for food security-related policies. Extending invitations to academics, practitioners, entrepreneurs, farmers, horticulturists, agriculturists, nutritionists, and any other interested parties who can contribute to the discussion is necessary. It is imperative to incorporate viewpoints and constructive criticism to guarantee that every facet of food and nutrition receives appropriate consideration. When the policies are prepared for execution, careful evaluation of sufficient financial, human, technical, and technological resources is essential to guarantee effective implementation. The implementation of policies must be evaluated to determine their effectiveness. It is necessary to monitor and assess the entire process to ensure that everything runs smoothly and that policies produce the desired positive results.

The Government should also consider holding workshops and inviting professionals to advise farmers on different farming techniques, improving crop production, and the advantages of growing seasonal foods. This knowledge and awareness are essential for advancing more sustainably farmed agriculture.

The Government must also support entrepreneurship initiatives that educate young people about ventures related to agriculture, including, but not limited to, greenhouses, dairy farms, export farming, and plant-based food products. Youth who know their options may be inspired to start their farms and use platforms focused on agriculture to generate a living.

To encourage young people to pursue advanced agricultural studies, tertiary and vocational institutions may provide internships or bursaries. Graduates from this programme may become agricultural economists and analysts who can subsequently impart their knowledge to their families and communities to improve agricultural options, practices, and interventions.

The recommendations above can be implemented on several institutional, educational, and community levels. By taking these steps, individuals, families, and communities can maintain their standard of living, escape poverty, and achieve food security.

The study, therefore, contributes towards public administration, management, governance, and economics and forms part of development studies. However, the study has limitations as well. Interviews with pertinent national authorities could not be conducted due to the topic's comprehensiveness. Future research will also consider the desktop analysis examining country-specific interventions for food security and how they affect the implementation and realization of SDG 2. The disciplines of agriculture and development studies will benefit more from the findings of the comparative and longitudinal studies.

The findings demonstrate how SDG2 (zero hunger) and SDG1 (zero poverty) are related. It implies that there are issues with hunger for those who are poor. The findings additionally validate the relationship between the development goal SDG 3—which pertains to health and well-being—and SDG 2, which mandates food security. This implies that wholesome food is essential for well-being. Future publications may examine connections between SDGs 1, 2, and 3 in a context-specific to a given nation, based on the interconnectedness of these goals, to expand the body of knowledge regarding development objectives.

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ENHANCING QUALITY THROUGH POSTGRADUATE SUPERVISION REMODELING IN HIGHER EDUCATION INSTITUTIONS

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Abstract. The demand for a postgraduate qualification in South Africa has increased due to the Department of Higher Education and training requirement for a Master's degree as the minimum qualification for teaching in universities. However, low completion rates and inferior quality dissertations and theses suggest that these ideals may not be achievable. This study juxtaposed research supervision models and suggested a framework envisaged to promote quality in the exercise. The world's countries, including South Africa, are paying far more attention than ever to supervising postgraduate students. This can be attributed to a variety of factors. For example, diversity and massification issues have put doctoral students' supervision at the centre. In response to these demands, some scholars have emphasised the relevance and suitability of supervision models. As part of the qualitative method, document analysis was used to analyse the supervision models most higher education institutions prescribed in their Policies around the Eastern Cape in South Africa. Among the findings, the policies and their Guide focus on two types of supervision: one-on-one and co-supervision. Regrettably, neither the Policies nor the Guide mention group supervision practices. The finding further revealed that no one ultimate model may guarantee optimal productivity. Hence, more is needed to assist supervisors in delivering excellent supervision. The partnership's efficacy and robustness in supervision rely on trust, commitment, and sound communication. Hence, the researchers developed and recommended the Triple C and Double T framework, a comprehensive and dynamic model, for higher education institutions to be considered for supervision. It is further recommended that the variables in the concept be used to develop the hypothesis and research objectives.

Keywords: One-on-one supervision; Co-supervision; Group supervision; Higher Education Institution; Postgraduate students

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JEL Classifications: I21, I23

1. Introduction

Over the last decade, some higher education institutions have been characterised as dysfunctional in research, which is one of the core businesses of their existence. The supervision of theses and dissertations plays a pivotal role in enhancing research output. This requires quality supervision, among other variables, to be prioritised by the institutions. Completing a dissertation or thesis is the pinnacle of a postgraduate qualification; thus, research supervision is critical. Postgraduate supervision, according to Dautel (2020), is the active participation of a supervisor in supporting students in establishing a path of study, specifying the project scope, and offering guidance for successful completion and dissemination of results. Based on the context and content of the research, this entails continual contact and dialogue between the student and the supervisor. Supervisor feedback significantly assists students' development throughout their academic journey (Hey-Cunningham et al., 2021).

Given the looming challenges in supervision and high rates of attrition among postgraduate students, South Africa, like other countries around the world, is paying much more attention than ever before to the supervision of doctoral students through the custodianship of the Department of Higher Education and Training, with the aim to maximising research output across the higher education spectrum (Masinde & Coetzee, 2023). According to the literature, there were no significant differences in supervisory models between the one-on-one model and team supervision. Even though supervisors and supervisees have different perspectives, conducting in-depth investigations involving both sides is essential to help establish a complete supervision model through which supervisors and students can be directed into established research communities, guided by a framework intended to increase productivity.

Co-supervision is widespread in South African universities but has received little attention in the academic literature. This article examines the experience of co-supervision from the lenses of supervisors and supervisees. Both parties consider co-supervision a learning opportunity, but the time to complete projects with multiple supervisors is a concern. Kerr & Green (2014) addressed aspects such as the diverse supervision of postgraduate students, the time it takes to complete their studies, and the countries' approach to fostering human capital. For instance, increasing the number of PhD students in South Africa is one of the goals of the National Development Plan (NDP): Vision 2030 (Grossman & Crowther, 2015).

The demand for PhD students is more comprehensive than in South Africa. Many African countries also face this demand. African countries are also looking for universities to contribute to the knowledge economy in ways other than producing new academics (Cloete et al., 2015; Wilmot, 2021). A critical factor in this regard is generating innovative ideas, which should be based on intellectual capabilities. To accomplish this, suitable human capital must be produced to meet countries' future developmental requirements. According to Powell and Snellman (2004), innovative ideas lead to improved goods and services and organisational practices. To meet these demands, the literature has been dominated by debates about supervision models in universities that are relevant and suitable to produce suitable candidates at the postgraduate levels.

According to Laetitia (2021), several scholars have explored areas of emphasis related to the relevance and suitability of supervision models in response to such demands. In this regard, Laetitia explains that some authors argue that diversity, empowerment, critical analysis, and independence are essential for students. When it comes to the South African context, this can be so crucial. During colonialism and apartheid, South Africa was racially and tribally divided. Therefore, supervision models that take advantage of the unique characteristics of the South African context and seek social justice are crucial (Knowles, 2015).

After considering all these, Guerin et al. (2014) reveal three (3) supervision models: traditional one-on-one, team, and group. These authors argue that the three models dominate the debates about relevance and suitability, the measures needed to meet the demand for more postgraduates, particularly doctoral students, and how best universities can contribute to the knowledge economy.

Similarly, Bitzer and Albertyn (2011) indicate that traditional one-on-one, team, and group supervision are the prominent models currently in use. Despite these options, some researchers, including Laetitia (2021) and Wilmot (2021), find that the old one-on-one model, sometimes known as the expert-apprentice model, is still prevalent in South African humanities and social sciences. Guerin et al. (2014) contend that no single model is superior to others. Additionally, highlighting this issue, Ngulube (2021) notes that each supervision model has problems. Currently, postgraduate studies attrition and poor completion rates are significant concerns, leading to wasting money, resources and human energy. This evidence warrants a deliberate effort to place a high value on excellence in supervisory methods.

The paper identifies the critical roles of supervisors, one-on-one supervision, and co-supervisors in their responsibilities within postgraduate studies. It provides a model for a diversity of expertise and perspectives to be integrated into the supervision process towards research quality. In this model, tailored aid and guidance are given to supervisors and supervisees so they can excel in their research.

2. The Context of the Study

Although there are similarities, there are different definitions of supervision across the academic spectrum. According to Phillips and Johnson (2022), supervision is a formal process based on the relationship between a supervisor and a supervisee, with the supervisor's job being to assist the supervisee in developing professional behaviour and competence in professional activities. The term supervision also refers to work discipline and oversight. According to Hickey and Forbes (2022), good supervision generates a favourable social learning atmosphere. Nonetheless, Phillips and Johnson (2022) suggest that one of the most critical components of supervision is ensuring the supervisor understands his or her role as the supervisee. As a result, effective supervision strategies will emerge.

2.1 Supervisors roles and responsibilities

According to Van Rooij, Fokkens-Bruinsma, and Jansen (2021), a supervisor's role is to lead, advise, maintain scientific quality, and provide emotional support to supervisees. Different people have different perspectives on the supervisor's responsibilities. Some scholars believe that considering supervisees as autonomous researchers is better, while others argue that supervisees may depend on their supervisors. However, it has been recognised that supervisors must allow their supervisees to be at the centre for them to be both autonomous and reliant. Supervisors must set boundaries and balance things out. According to O'Donoghue and Engelbrecht (2021), spoon-feeding supervisees is incorrect and should not occur during the supervisory process. Supervisors should use their academic expertise to boost the self-esteem and confidence of their supervisees.

To establish the importance of supervision, Phillips and Johnson (2022) stated that supervisors must act as a guide or facilitator for their supervisees, as well as a constructive critic and counsellor. Most students expect competent supervisors to be available whenever they need them. As a result, supervisors should always be available to meet with supervisees and provide feedback on their dissertations and theses. Roach, Christensen, and Rieger (2019) emphasised the importance of supervisors being accessible and available to supervisees when needed. Furthermore, Neupane, Bastola, and Hu (2021) believe that encouragement and accessibility are the essential characteristics of a good supervisor. However, they also contend that effective supervisors are enthusiastic, encouraging, and approachable. Supervisors are expected to provide students with assistance, time, and encouragement, as well as resources, information, comments, and research writing ethics and standards.

Throne and Bourke's work (2022) proposed that supervisors must have a history so students can trust and help them accomplish their theses. Furthermore, personal characteristics and styles of supervisors, as well as a caring attitude, are critical in helping students feel at ease. This also goes along with clear communication, as it is essential to students during supervision. Dimitrov and Hadad (2022) state that flexibility and sensitivity can strengthen the supervisory relationship. Supervisors who can instil positive attitudes in their supervisees may assist them in remaining calm and seeing things. Positive emotions contribute to effective learning. Supervisors who consistently instil negative sentiments in their supervisees may produce uncreative supervisees. Unhelpful behaviour by supervisors toward supervisees may establish a barrier that prevents them from progressing as expected. As a result, supervisors' attitudes toward their supervisees are critical during supervision. Islam, Ahmad, Kaleem, and Mahmood (2021) point out that when supervisees are struggling for assistance, supervisors frequently give direction and provide guidance to ensure that research projects under their supervision are accomplished within schedule.

According to Islam et al. (2021), *supervisors require continuous* supervisory training to bolster their knowledge. Furthermore, supervisors must effectively manage their relationships with their supervisees. Supervisors must be supportive, accessible, and approachable to supervisees for the relationship to thrive smoothly. Dual commitment from the supervisor and the supervisee has a positive impact. Furthermore, supervisors and supervisees must be present and on time during scheduled meetings. To ensure that supervisees take their studies seriously, supervision sessions should be planned and managed, with deadlines assigned (Nash, 2021). Personal characteristics of the supervisor, such as openness, adaptability, permissiveness, and responsiveness, are also crucial for research project success.

2.2 Co-supervision

Co-supervision is defined as the formal agreement of two or more supervisors to supervise a research student, and it has become common in postgraduate settings in the Eastern Cape. Suppose supervision by a single supervisor becomes challenging due to personal issues. In that case, the presence of a co-supervisor will assist in minimising the attrition rate in the project's completion.

Since co-supervision entails collaboration, some universities' supervision policies often impose a strict hierarchy at universities where the researchers for this study work; there is widespread practice for study co-supervision that requires one supervisor to bear the ultimate accountability for the student's research. This supervisor is called the chief supervisor, and the others are called associate supervisors. This hierarchical structure is expected to lessen the supervisors' workload and address the supervisees' significant expectations (Grossman & Crowther, 2015). As stated in the policies examined, this is one of the dominant models of supervision practised at advanced research levels like master's and doctorate degrees. Next is the One-on-one supervision.

2.3 One-on-one Model

One of the perceived gratifying types of supervision is the one-on-one supervision model. According to Wilmot (2021), the one-on-one supervision model is carried out through the interaction between the supervisor (Master) and student (apprentice). However, it can also be accomplished through co-supervision, also known as two-on-one supervision. The supervisor is seen as the “guru” in a one-on-one or dyadic interaction, with the student drawing on the supervisor’s superior knowledge and expertise (Bitzer & Albertyn, 2011).

As demonstrated above, the dyadic paradigm is still widely used in South African and British higher education institutions (Chiang, 2003 in Ngulube, 2021). The One-on-one supervision model is appropriate if the supervisor and student have a good working relationship. Ngulube (2021) offers the following benefits of the one-on-one supervision model:

- it fosters the skills and knowledge required to conduct rigorous research;
- the supervisor is not required to carry the burden of other colleagues;
- no contradictory feedback to students;
- managing a single relationship is simple, and there are no disagreements among supervisors;
- one supervisor has complete control and total commitment to the research project.

Despite the preceding, Ngulube (2021) identifies the following disadvantages of the one-on-one supervision model:

- conforms to conventional ideas while avoiding creativity and risk-taking;
- students may be subjected to insufficient support and resources.
- The supervisor may impose their preferences while disregarding the student's scope and methodology;
- may limit diversity and multiplicity of viewpoints.
- transparency may be lacking;
- without a mediator, tensions between supervisor and student may be challenging to address.

Based on the discussed benefits and disadvantages, a student's success in the one-on-one model depends entirely on the student's capabilities and the supervisor's guidance. In other words, the student has no other options for assistance during their studies. In this regard, Wilmot (2021:3) concurs that “the apprentice is dependent on her innate ability and the master’s influence for her success”. As a result, the one-on-one model fails to consider that students’ supervisory needs vary, as some may be more willing to seek different perspectives and support from others. Thus, this necessitates considering the team supervision model in the following discourse.

2.4 Team Supervision Model

Based on the above discussions, one can deduce that the disadvantages of the one-on-one model have led to the establishment of a team supervision model, which often happens through co-supervisory arrangements. One reason for using teams to supervise postgraduate students is that individual supervisors could only have a partial range of knowledge and skills to support students, particularly at the doctoral level. Therefore, the identified weakness can be avoided by using team supervision (Watts, 2010; Bitzer & Albertyn, 2011).

According to Manathunga (2012), most universities regard team supervision or co-supervision as effective supervision pedagogy, which has also become a policy principle of several universities worldwide. Manathunga (2012:29) further states, “It is believed that the team supervision will provide students with a broader range of intellectual and social support during their candidature.”

As a result, when forming teams or co-supervision arrangements, most universities worldwide consider the ‘coaching’ or ‘mentoring’ model. In this model, an experienced supervisor collaborates with a new or inexperienced supervisor. In this way, the student is supported while a colleague develops the necessary skills for supervision. This model or arrangement has a higher potential for smoother working relationships between supervisors than co-supervising a student by supervisors of equal status. The power dynamics between supervisors can be problematic if unclear (Watts, 2010). According to this author, communication between the supervisors can be difficult, and at times, none of them will take overall responsibility for monitoring the completion of the research project.

Co-supervision necessitates a good relationship and constant communication between supervisors to ensure that individual students are supported for their success. To realise this, South African universities should begin to advocate for the postgraduate students’ voices to be heard. Models of pedagogical supervision that promote students’ voices must be encouraged. This would allow students to question some supervision practices that are not beneficial to them. According to Nkoane (2014:701), who cites Giroux (1994), “this type of supervision practice provides opportunities; encourages collaboration and inclusion; and provides space for a pedagogy of hope and compassion”.

When all the above assertions are considered, there is a need for university policies to provide guidelines on factors that should be considered for the establishment of a co-supervision model and who should take the responsibility in such a relationship to ensure that the student eventually achieves it. Mhlahlo (2020) agrees that university faculties should have protocols to guide supervision relationships to avoid power play and failure to take responsibility for students’ success. Again, supervisors should have a humane relationship with their students. Supervisors should be compassionate when interacting with students and take a patriotic stance to achieve the goal of producing the necessary human capital.

2.5 Group supervision model

According to Guerin et al. (2014), group supervision is based on one supervisor and many students. According to these authors, who cite Samara (2006), group supervision models assist supervisors in working effectively due to the pressure on academics caused by large numbers of students being supervised. However, this does not imply that group supervision is the best or most appropriate model.

According to authors such as McFarlane (2010), group supervision has yet to receive widespread acceptance in universities worldwide. As a result, some supervisors are still determining whether the model has the potential to promote adequate supervision. According to McFarlane (2010), who cites Sales and Navarre's (1970) findings, students in group supervision indicated that time was always wasted by engaging in irrelevant discussions. Furthermore, students claimed their supervisors needed to give them individual attention to their problems. Again, due to the diverse student population in South Africa, most students had varying levels of academic proficiency.

McKenna (2017) advocates for program projects that bring together supervisory teams and provide mentorship and support spaces for the supervisors participating. This paradigm should foster a process recognising the supervisory relationship involving competent personal supervisors and an embracing academic community.

Wilmot (2021), on the other hand, sees the South African diversity context, including culture, language, educational background, age, and social class, as positive attributes that enrich the learning experience. As a result, diversity fosters various perspectives and experiences in the learning environment, which benefits candidates, students, and supervisors.

Given the preceding, the group supervision model has advantages and disadvantages that must be managed. While the advantage of this model is the ability to work effectively with multiple students at the postgraduate level, issues concerning individual problems or the individuality of candidates must still be addressed. On the other hand, diversity within the South African context must be carefully managed.

When considering the three supervision models discussed in this study, one gets the impression that South African universities should have policies and guidelines in place that clearly outline how to manage relationships between supervisors (principal supervisor and co-supervisor) and students, as well as relationships amongst students themselves in case of the group supervision. The following section focuses on the Walter Sisulu Higher Degrees Policy and Postgraduate Research Guide.

3. The Outlook of Higher Degrees Policy a Selected Institution In The Eastern Cape

Providing coverage of higher degree policies used in higher education, among others, this reviewed the postgraduate and higher degree policy of Walter Sisulu University in the Eastern Cape of South Africa. According to Section 1.4 of the Walter Sisulu University (WSU) Higher Degrees Policy, WSU ensures that the research it supports adheres to national and international best practices, among other things. In this regard, this Section also indicates that WSU is following global trends related to research development. Furthermore, Section 1.5 states: *Without being over-prescriptive towards the approaches that researchers and their postgraduate protégés adopt in their search for knowledge about and scientifically derived solutions to societal problems, the University expects its doctoral students and their supervisors to act with the highest standards of ethics, integrity, and professionalism in developing research proposals, seeking research funding, carrying out research, and producing research publications.* (WSU, 2020:1&2)

The policy needs to be more active in discussions on the pronouncements that dictate how supervision models should be established, particularly regarding the challenges raised in this study. Although Section 1.5 states that the University does not want to be overly prescriptive on the approaches that supervisors and students may choose, guidelines must be provided. However, the policy also refers to WSU's Procedures for Postgraduate Programmes, which could refer to the Postgraduate Research Guide (2019) (Guide, 2019, hereafter).

The Guide (2019) states in its preamble that the document is intended to be a resource for postgraduate students and supervisors. Furthermore, the University "acknowledges that postgraduate research implies a relationship and agreement between the candidate, supervisor, ..., each having their respective responsibilities. The Guide will

hopefully assist in ensuring that each of these role players performs optimally and that quality administration and supervision services and postgraduate research outputs will result” (Guide, 2019, p. 4).

Regarding working relationships, the Guide (2019) states that because a good working relationship between the candidate and the proposed supervisor is critical, supervisors and candidates should be kept separate. Both parties must be willing to collaborate. This gives students and supervisors the authority to decide how they should relate and interact throughout the student’s research project. This also implies that assigning students to supervisors requires negotiation with both parties and cannot be done solely by the Head of the Department (HOD) or some other person.

Furthermore, the Guide (2019) specifies the composition of co-supervision arrangements, stating that the principal supervisor should be someone who has previously supervised a student to completion, while a co-supervisor should be someone who has not previously supervised and who is to learn from the mentor (principal supervisor). This co-supervision arrangement is consistent with Mhlahlo’s (2020) proposal. Although this arrangement may be appropriate for addressing the power play between the supervisor and the co-supervisor, it undermines the usefulness or intention of harnessing the required range of skills to expose a student to and achieve success. The Guide also provides guidelines on conditions that require a student to have multiple supervisors (see Ngulube, 2021) and the supervisor’s role and responsibilities.

In the literature reviewed, most higher education institutions, unfortunately, neither the Policy nor the Guide stipulates anything about group supervision practices. This is a cause for concern, especially when one considers what was discussed in the introduction to this study about global trends on issues of diversity and massification, the time it takes students to complete their studies, and the trajectory that the world’s countries have taken toward producing the required human capital. In the case of WSU, one can conclude that the University has not yet effectively positioned itself to provide the necessary guidance on supervision models that should assist in responding to the National Development Plan (NDP): Vision 2030, which seeks to increase the number of doctoral students.

To achieve an exceptional supervision framework that may promote success and quality in postgraduate studies, the entire process must be considered a continuous commitment to knowledge creation and research education pedagogy. According to the findings from the reviewed literature, a sound supervisory model with clearly defined roles for both the supervisor and the supervisee would assist in driving supervision and enhance productivity. The researchers developed the framework shown below.

4. Method

Given the preceding explanations, it is critical that this study provide an analogy of the process followed to develop the framework suggested by the researchers, which is envisaged to strengthen the three established supervisory models. As a result, the researchers will first address the three supervision models, followed by what the researchers refer to as “The Triple C and Double T Models.” Without fieldwork, the study findings were derived from a literature review and policies. In other words, the study used document analysis as an approach or method to arrive at the recommendations. The sources for the study included Google Scholar, Web of Science, books, and book chapters. Figure 1 shows a summary of all the reviewed and sampled studies.



Figure 1. Flow Diagram of the Desktop Review and Studies reviewed

From the literature review, 160 articles were identified as being relevant to this study. Subsequently, a more focused search strategy identified 36 publications of direct relevance to the purpose of this review. The study was confined to publications published between 2010 through 2023.

The time period was selected to keep the research reviews tight with current literature and contemporary perceptions of supervision models adopted in higher education. The researchers limited their focus to publications released in the last 13 years. Such a methodology enabled the researchers to access the wisdom and experience of scholars to develop an advanced supervision model.

5. Conceptual Model

The review of the literature and policies in the previous sections offered an in-depth insight into the research and the advantages and disadvantages of each of the three models. The focal focus of the discussions was the triple supervision models used in higher education and postgraduate policies, as well as the challenges that constrain research production. These formed the basis of the proposed conceptual model, accompanied by principles that will guide the implementation of the three models. Figure 2 depicts the triple supervision models related to the Triple C and Double T principles (see Figure 2).

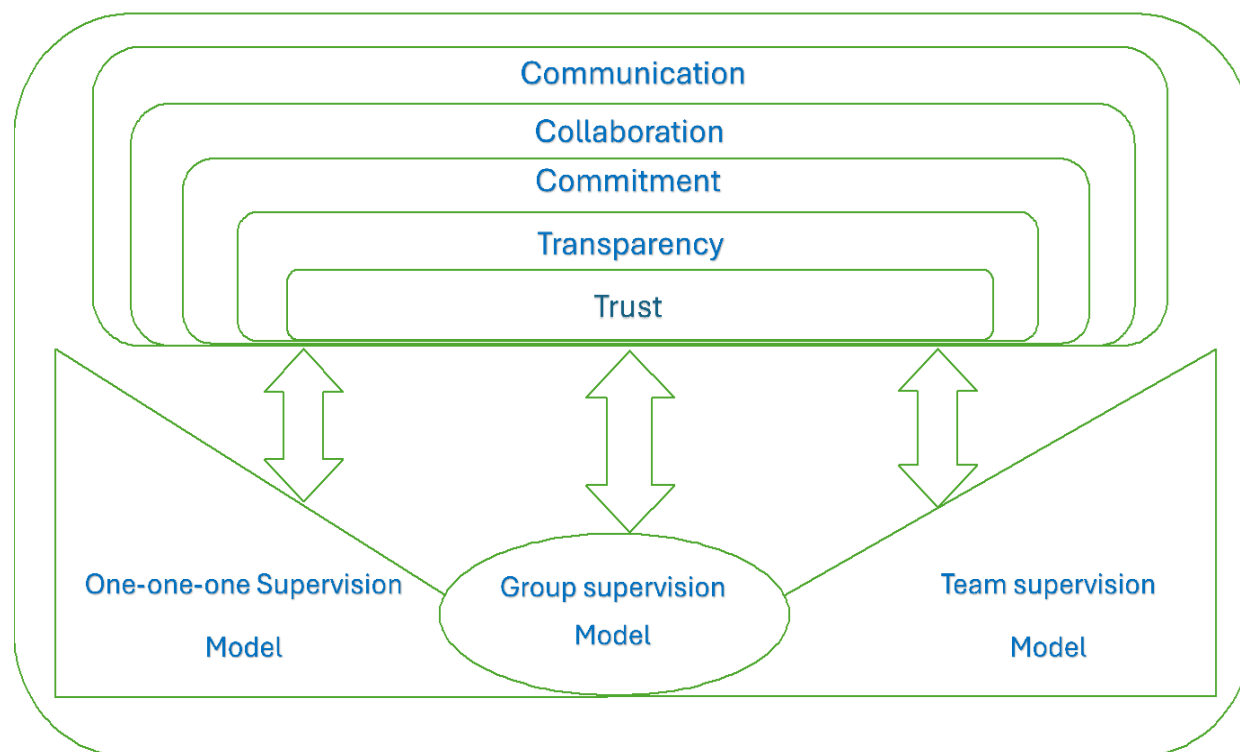


Figure 2. The Triple C and Double T Supervisory Model

Source: Authors own

In conjunction with the policies and the literature reviewed, the researchers developed the model in Figure 2 above, which depicts the triple supervision models connecting all Triple C and double T variables that may enhance the quality and quantity of supervision in postgraduate studies. This would assist in avert looming attrition and ensure the success and timely completion of postgraduate studies among students.

Supervision is a form of interaction between two individuals who may have different viewpoints but share the same goals. Wood and Louw (2018) define supervision as an "intensive, interpersonally focused one-to-one relationship between a supervisor and the student."

Throughout the thesis or research activity, the supervisor-student relationship is critical, and the interaction between the supervisor and the student determines the practical completion of the study (Da Costa, 2016). The traditional supervision model with a single supervisor prepares students for independent research. This model suits intelligent, self-directed students who can become independent researchers with minimum supervision. However, students may miss broader discussions, and isolation may limit the development of researcher capabilities. Students will be exposed to multiple approaches and vast knowledge learned from individual supervisors if they have more than one supervisor.

Group supervision, a unique and uncommon practice in today's university system, allows for supportive cohort interaction. Schefer-Wenzl and Miladinovic (2022) state that group supervision does not necessarily promote scholarly development. However, students must gain in-depth knowledge and overcome the educational gap. Integrating the Triple C and Double T framework with any of the three supervision models foresaw additional value to the process. The model can be adapted to different supervision types and aims to promote efficiency and

effectiveness. A community of students conducting research on one topic concurrently under one seasoned supervisor suggests that knowledge transfer and sharing will improve among them, and scholarly writing groups may influence student attitudes toward writing. This model is envisaged to enhance the supervisory process, especially when there is a shortage of supervisors. This will fit well with undergraduate, diploma, and Honours level supervision. Wilmot (2022) discovered that a peer-based approach may offer advantages such as a higher study completion rate on time, more excellent student involvement throughout the process, and lower failure rates.

Co-supervisors must create trust, respect, and confidence in one another, including relying on one another to react appropriately to unexpected situations (every day when working with students). Hawken and Worral (2002) emphasise the importance of mutuality, equality, and rapport during supervision.

Communication was discovered to be a factor impacting supervision. The co-supervision pyramid depicts several points of contact that co-supervisors, supervisees, and the universities have. These communication paths must be recognised and identified in their diversity and complexity. These channels can function effectively provided transparent, open, and equitable communication is developed. Clear communication was critical for students and the institution in promoting quality research. As co-supervisors, this contact also includes providing and getting regular feedback from one another. Multiple communication channels may increase the likelihood of conflict, yet working as a team will assist in reducing friction in the process.

A substantial body of literature, including Moin, Wei, Khan, Ali, and Chang (2022), showed the importance of commitment to supervision. The authors emphasise the importance of commitment in supervision and maintain that a mutual and shared dedication of both the supervisor and co-supervisor over the student and their study has been recognised as essential to successful co-supervision by all stakeholders. One of the most advantageous aspects of co-supervision was that it did not rely on the availability of a single individual. In the absence of one, the other can work with the student to ensure that the students are not delayed.

Transparency, one of the principles of Triple C in the framework, allows for open communication and decision-making with the student. Openness in supervision allows authority to be acknowledged and negotiated (Nelson, 2019). Transparency is critical for both the institution and the students. It provides students with a proper modelling environment in which to participate successfully.

6. Conclusion and Recommendations

This study focused on discussions about the three supervision models that dominated the debate about their relevance and suitability for postgraduate students. The goal of the model discussions was also to gain knowledge from the literature to eventually analyse supervision models about their directives and the implementation of those models. As a result, the following models were used to guide the discussions:

- one-on-one supervision model,
- Team supervision model, and
- Group supervision model.

The literature revealed that all three models have advantages and disadvantages. However, the literature demonstrated that those models should also be based on current trends and circumstances. In other words, the current global circumstances dictate the model universities should use to respond to the increasing demand for postgraduate degrees. However, while this may be a required practice to keep up with global trends, the needs of individual students, supervisors, and research projects should be considered. The Triple C and Double T framework can be used with the triple models to improve productivity. It is recommended that institutions similar to WSU revise their strategic plans to incorporate the framework to reduce research completion attrition and maximise productivity.

Adopting group supervision at the lower postgraduate level, such as Honours dissertation, can reduce attrition associated with fewer supervisors. Subsequently, it is imperative to allow doctoral students to be exposed to diverse ways or alternatives of learning to generate the necessary knowledge through their research projects. Departmental seminars, for example, could be especially useful in this situation and could be organised for each chapter of postgraduate students' dissertations or theses. The hybrid supervision model should also be considered at institutions of higher learning.

Co-supervision and one-on-one supervision were hazy as a point of departure, yet power dynamics hampered these connections. Supervisory education should be considered a pedagogy and teamwork that needs trust and commitment to achieve sound research output. Detaching the Triple C and Double T principles from the postgraduate supervision policy or the triple supervision model will render efforts by supervisors, supervisees, and institutions futile, whereas integrating the framework will enhance research productivity in the postgraduate studies spectrum.

As a point of departure, the researchers developed the Triple Supervision Model to improve the quality of postgraduate studies and assist in the timely completion of research projects. Using a combination of traditional supervision and peer group/work supervision, this model allows a level of co-supervision that aims to overcome the weaknesses of individual models by recommending a wider variety and levels of expertise, trust, commitment, and collaboration. This flexible model can be used with different types of supervision.

7. Limitations

The main limitation of this study is that it relied solely on secondary data and did not use empirical data. Future research may use the conceptual model developed by the researchers to formulate research questions, testable hypotheses, and research objectives that may assist in addressing supervision-related challenges, reducing attrition in research project completion, and increasing research output in higher education institutions.

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A COMPREHENSIVE REVIEW OF INTEGRATED ENERGY STORAGE BATTERIES IN RENEWABLE ENERGY STATIONS: TECHNOLOGICAL ADVANCEMENTS, CHALLENGES AND FUTURE TRENDS*

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Abstract. The integration of energy storage batteries into renewable energy stations is a crucial development in the quest for sustainable and reliable energy solutions. This review provides a comprehensive analysis of this integration, detailing the types of energy storage batteries, including lithium-ion, lead-acid, and flow batteries, as well as their respective benefits and limitations. The study addresses significant challenges such as the intermittency of renewable energy sources, battery degradation and lifetime, cost and efficiency issues, and technical challenges. It also explores potential solutions to these challenges. Additionally, future directions are discussed, focusing on emerging battery technologies and smart grid system integration. This paper highlights the essential role of energy storage batteries in overcoming the intermittency of renewable sources and ensuring a stable and efficient energy supply.

Keywords: energy storage; renewable energy; technical challenges; smart grid integration; sustainable energy

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1. Introduction

Because of the increasing demand for electricity, pollution, and depletion of nonrenewable energies (Ali et al., 2021), renewable energies are considered a potential solution. The advantages of using renewable energies (REs) can be summarized in their security and environmental impact compared to conventional power generation (Halkos & Gkampoura, 2020). It also serves to reduce the global demand for energy. However, the high level of integration of renewable energies (RE) into an electricity grid presents a number of challenges (Basit et al., 2020), such as voltage or frequency variations, load following, and finally, the energy produced does not always match load demand. As the integration of renewable energy-based power systems becomes a reality, a new field is supporting this group with appropriate tools, including, but not limited to, energy storage systems (ESs).

The quest for an effective energy storage system is as old as mankind itself; starting from the archaic hydrothermal energy storage systems down to the modern electrical storage devices (Siti et al., 2022). Today, the

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efficient and effective integration of energy storage technologies in the global energy infrastructure is an urgent but technologically difficult subject. In light of the growing demand for energy during peak periods, the necessity for a more dependable energy system, the advancement of green culture, grid resilience, and technological innovations in renewable energy sources (RES), the utilisation of energy storage is becoming increasingly crucial. Energy storage is a vital component in the management and balancing of load, the dispatching of energy, the control of transient stability, the assurance of self-sufficiency, the compensation for fluctuations in the grid, the monitoring of load demand and the regulation of frequency (Shazon & Jawad, 2022). Energy storage aims to mitigate irregularities and correct the time lag between electricity demand and supply for both renewable and conventional energy systems (Foley et al., 2020). This is important because in most parts of the world, demand often exceeds available supply capacity, leading to power outages and longer shortage. Figure 1 illustrates the world's planned energy storage facilities, highlighting a dramatic increase in demand driven by the rise in renewable energy sources.

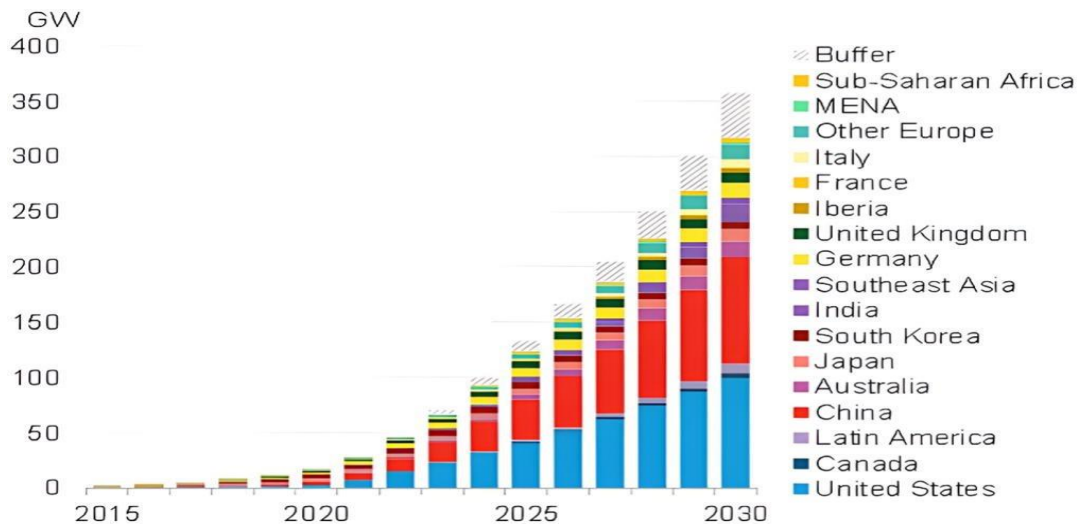


Fig. 1. Cumulative Global Energy Storage Installations Worldwide

Source: (Emrani & Berrada, 2024)

Battery energy storage technology has a wide range of applications, such as integrating renewable energy into the grid, managing microgrids (MGs) (Zhang et al., 2021), providing backup power, load leveling, and peak shaving. Although energy storage technology can also address the issue of grid variability (Tan et al., 2021), energy storage systems will be more competitive, and more practical projects will be developed using advanced energy storage devices. Researchers are actively exploring and making advances in battery manufacturing technologies materials, and are in pursuit of cheaper batteries with longer life cycles and higher energy density (Yang et al., 2022).

1.2. Purpose of the Review

This review provides a holistic comparison of state-of-the-art energy storage battery technologies. The conversion of renewable energy sources raises the challenge of intermittency due to the lack of sufficient storage in low-density grids or transmission lines. Energy storage is essential to minimize the adverse effects of intermittency in renewable energy plants. Various types of storage technologies, including Lead-Acid, Nickel-Cadmium, Nickel-Metal Hydride, Lithium-Ion, Flow Battery, and Ultracapacitor are discussed extensively with their specific advantages and limitations. Some outstanding technical challenges and opportunities of storage batteries are

highlighted in order to promote future research in this area. This review also specifies and classifies the existing challenges and solutions in typical applications of energy storage batteries with renewable energy sources, the grid, or energy management system.

In this review, we will address the integration of energy storage batteries in renewable energy stations, covering various aspects such as technological, economic, and operational factors. First, the introduction outlines the purpose of the study, emphasizing the importance of improving the efficiency and reliability of renewable energy systems through effective storage solutions. Secondly, the Types of Energy Storage Batteries section examines lithium-ion, lead-acid, and flow batteries, highlighting their specific characteristics and applications. The Challenges and Solutions section then addresses issues such as the intermittency of renewable sources, battery degradation and lifetime, cost and efficiency, and technical challenges, discussing strategies for overcoming these obstacles. Future Directions section explores emerging battery technologies and the integration of smart grid systems, which are set to revolutionize energy storage and management. Finally, the Conclusion reaffirms the crucial role of energy storage batteries in mitigating the intermittency of renewable energy sources and ensuring a stable and reliable energy supply for the future.

2. Types of Energy Storage Batteries

Renewable energy sources (Behabtu et al., 2020) such as solar panels and wind turbines are gaining in importance as energy sources and feed-in tariffs because they provide cleaner and more stable power. Also, they are modular, easy to install, and require short implementation times. However, these energy sources are prone to instability, harsh volatility, and uncontrolled production, making integration into the traditional power grid a difficult task (Rahman et al., 2020). Therefore, energy storage systems are becoming more and more necessary installations in renewable energy stations, as they can provide many services needed to integrate these stations into the traditional power grid, such as frequency regulation, peak shaving, spinning reserves, ramp rate control, demand response, islanding mode, among others.

However, energy storage solutions have low round trip efficiency, temperature management issues, present difficult solutions for second life applications, require special care in electrolyte management, and are not well suited to large-scale installations (Tan et al., 2021). Energy storage technologies are typically categorized based on the type of energy they store, which includes electro-chemical, mechanical, chemical, thermal, and electrical energy storage. They can also be classified according to response time, storage duration, and application (Nyamathulla & Dhanamjayulu, 2024). Nevertheless, the available battery solutions have intrinsic properties that can lead to initial investment and subsequent growth by combining larger, more sophisticated storage solutions.

Therefore, largescale batteries have been limited until today. Currently, batteries already in use or maybe appropriate for utility-scale Battery ESS applications include lead acid, lithium, and flow batteries (Emrani & Berrada, 2024). The following table shows the various technical parameters of energy storage systems.

Table 1. A comparative analysis of the technical parameters of different energy storage systems

ESS	Power (MW)	Range	Energy Density (Wh/Kg)	Efficiency (%)	Lifes Years	Cycling Capacity
Lead-Acid	0-21		30-75	70-90	5-15	200-2000
Lithium-ion	0-0.1		100-200	70-85	5-15	1000-10,000
Flow Batterie	<15		15-85	60-75	5-10	>12.10 ³

Source: (Emrani & Berrada, 2024)

2.1. Lithium-ion Batteries

Lithium-ion batteries (Wen et al., 2020) are simply an essential energy storage device when a seamless energy supply is demanded. Their full-packed energy density makes them suitable for small volumes but with large energy storage capacity, making them reasonable options for minor energy resources. However, their high initial cost and short cycle life have held back their widespread use. Despite this, they have become a mainstream energy storage tool in many consumer electronics products, as well as for hybrid electric transport and electric trucks (He et al., 2020), because of the fast development of the EV (electric vehicle) industry. The lithium-ion battery could be arranged in a variety of structures, including tubular, prismatic, and pocket shapes, to suit different equipment.

These different design strategies are generally combined with mesh-like or porous electrodes (Zhao et al., 2021). One best trading characteristic commercial features of this type of battery is that they have a turn rotational design strategy. This flexible packaging pattern helps in contributes to the battery's low cost, so the strategy has indeed been used for large-scale production with high potential in their commercial application. The electronics or the power trapezoids normally must be formed in higher ability, which is often the case for this type of batteries. The medium and longer-term prospects for Li-ion batteries depend on the safety enhancements and growing applications for both automotive and grid technologies.

2.2. lead-acid Batteries

Rechargeable lead-acid accumulator cells (batteries) (Vasant Kumar & Sarakonsri, 2023) are electrochemical devices that use chemical energy to generate electrical potential. Electrochemical reactions convert lead and lead dioxide into lead sulfate and water, storing electrical energy in the form of chemical energy (Guarnieri, 2022). Since their introduction by Camille Alphonse Faure in 1881, lead-acid batteries have been widely used in everyday life to condition electrical energy - from small applications (mobile phones) to large and complex installations (Kay Lup, 2022) (uninterruptible power supplies for computer centers, emergency power supplies for hospitals, power supplies for switching applications in telecommunications, and electric vehicles).

The development of electric vehicles in the 19th century revealed the need to store electrical energy and made it necessary to convert chemical energy into power and vice versa reliably, economically, and considerably (Xu, 2024). Once it was discovered that a basic sheet of lead could generate electricity on contact with an acidic sodium sulfate solution, it did not take long to develop an electric lead-acid storage power pack, which became widely used in early electric vehicles (Rajamand, 2022). In other words, the time lag between electricity consumption and solar flux could also enable the use of solar energy storage systems based on lead-acid batteries. Although the random production of solar loads varies according to time of day and day of year, there is no practical or adequate model to model the random timing of electricity consumption. Fluctuating electricity consumption changes the average waiting time. Fluctuating electricity consumption means that peak loads will be served by the grid at midnight, the opposite of the time when solar battery self-charging is most effective.

2.3. Flow Batteries

Flow batteries are an emerging technology that has gained popularity in recent years (Zhang et al., 2024) due to their scalability as well as their potentially very long cycle lives. These systems are based on liquid electrolytes flowing through permeable electrodes where reversible reactions occur. This continuous flow concept offers a natural solution for power decoupling. Even though flow batteries are known in the industry as technology, applications of this battery chemistry are seen in large-scale energy storage, electric mobility, station power, and shipboard power distribution. In flow batteries, energy storage materials are stored in large external tanks and then flow through the battery's reagent vessels (Zhang et al., 2022). This means they comprise a cell or cells where electricity is directly produced and consumed, converters for interaction with the grid, pumps to circulate

the electrolyte, a heat exchanger to control electrolyte temperature, and a cooling unit. The stack (active component) has many common similarities. Flow battery systems are developed in two basic combinations of electrolytes. This allows a much higher energy storage capacity than in traditional sealed batteries, making flow batteries an attractive option for storing large-scale energy, such as that from solar or wind power. Flow batteries can have different materials than traditional batteries, since the electrode material doesn't need to absorb the charge. Consequently, flow batteries often have much cheaper and longer-lasting materials. Flow batteries can also perform charge/discharge operations, which generally wear out and degrade most batteries without life limitations (Petrov et al., 2021).

3. Challenges and Solutions

Storage systems make it possible to integrate more renewable energies into the power system, facilitating the market penetration of renewable energies. They enable flexible connection, high-quality power supply and smooth intermittent fluctuations. They also provide services such as peak shaving, filling, and monitoring of staggered loads. Renewable energy sources such as solar and wind are important. Energy from these sources is converted into electrical energy by photovoltaic cells and wind turbines, and applied to the grid (Pommeret & Schubert, 2022).

The intermittent nature of renewable resources, such as wind speed and solar radiation, causes large and fast frequency fluctuations during transition events from non-production to production (Sahoo & Sethi, 2021). However, the heavy reliance on renewable sources to electrify the grid is not fully exploited due to their intermittent nature, unpredictability, and source variability. This can lead to significant problems such as the occurrence of a power mismatch between supply and demand, affecting the economy and stability of the power grid and unplanned load sharing of the grid in the event of low production. Therefore, the integration of energy storage in renewable energy sources to store the extra desired energy and then use it when needed has become necessary and thereby imposes the economic and stability solution to grid problems in case of fluctuation, variability, and unpredictability of the renewable energy sources (Tahir et al., 2021). To fully manifest the advantages of ESBs in renewable energy stations, an intelligent energy storage battery system integrated in renewable energy stations is proposed.

3.1. Intermittency of Renewable Sources

Intermittency in renewable energy production is a major challenge in making such energy sources capable of meeting grid demand for continuous, stable power supply. Intermittent behavior of renewable energies is due to their dependence on weather conditions such as solar insolation or wind power (Mlilo et al., 2021). Solar radiation resources contain a high voltage of fluctuations and variabilities in overtime in each region on Earth due to weather conditions and seasons. The changes in these conditions are uncontrollable, making renewable energy production uncertain (Abazari et al., 2020). This has become a serious concern, thus increasing the importance of reliable, consistent, and affordable electrical energy storage technologies. Many methods for controlling electricity intermittency have been discussed and analyzed.

The minimum thermal generation adopted by the electric utilities limits the share of wind and solar power that the grid can accept. Renewable energy storage technologies are essential to meet structural demands and manage the increasing flow of variable renewable energy resources. Furthermore, when feed-in tariffs have changed and better incentives for analysis have been introduced, utilities are reaping great benefits, and large renewable plants, either for utilities or large project developers. Changes in the electricity structure involve, for instance, altering the residence of transmission lines, institutions, grids, and utilities, that may be harmed by decentralized establishment, but regulating this process may restore incentives for network owners to interconnect renewable energy sources (Hu et al., 2023).

Indeed, preventing the power fluctuations that accompany the intermittent mode of renewable energy sources is not limited to improved solar cell design or power control strategies. The firm power capacity of solar energy systems will become very significant for timely market-level control rather than simple end-user price slices or load shifting towards periods of favorable pricing. This brings us to the integration of energy storage batteries. With the help of energy storage batteries, the goal is to transform the distributed and intermittent energy resources into a portfolio of virtual energy sources that provide a more reliable power supply, with reduced power level adjustments, and predictable energy distribution. However, the economic value of increasing battery-pack power through a load leveling algorithm and optimizing the benefit of the peak-shave are currently of lesser importance. Storing excess energy in energy storage batteries and discharging stored energy to the grid according to technical requirements, as well as prevailing price, can facilitate superfluous market participation in the solar generation.

3.2. Cost and Efficiency

Cost is undoubtedly one of the driving factors for energy storage technologies, in addition efficiency. The cost of installing a battery energy storage system has fallen significantly over past 10 years due to advancements in battery technology, making them more viable than before. The reduction in costs opens up potential applications such as grid applications (Mallapragada et al., 2020). Battery costs are typically quoted in \$/kWh capacity, but for grid and ancillary services, the cost of total system in \$/kW responses is more important. The mass manufacturing has also helped to reduce costs, mainly by optimizing manufacturing processes rather than battery architecture (Mongird et al., 2020). The cost of a lithium-ion battery varies according to many factors, such as battery manufacturing, geographical location, and market demands.

As a general rule, the costs of different chemical compositions of lithium-ion batteries with different form factors vary considerably, as each battery has its own properties as well as trade-offs between cathode, anode, and assurance chemistry. For example, lithium cobalt oxide batteries are cheaper than NCA ($\text{LiNi}_{1-x-y}\text{Co}_x\text{Al}_y\text{O}_2$) and lithium cobalt manganese batteries (W. Li et al., 2020). LiCoO_2 batteries have higher energy densities but are less stable than current LFP (Lithium iron phosphate battery) and NMC ($\text{LiNi}_{1-x-y}\text{Mn}_x\text{Co}_y\text{O}_2$) batteries. The materials used in battery production and manufacturing also dominate cost (Shafique et al., 2023). It is difficult to accurately assess and compare costs for emerging technologies such as metal air and solid-state batteries as there are no established and proven manufacturing processes for them.

3.3. Battery Degradation and Lifetime

Lifetime or cycle life of a battery is one of the core attributes that usually determines its ability to successfully support its application. To establish the cycle life of a lithium-ion battery, it must discharge and recharge for a specified set of cycles at a particular C-rate. Battery lifetime and durability can be designed to charge or discharge quickly in half an hour or less for decades, by using ultra-fast ultra-fast charging. Furthermore, battery degradation is caused by irreversible internal and external processes (Zhang et al., 2022). The materials and electrochemical reaction mechanisms used in the battery have direct implications. Over time, battery capacity decreases due to irreversible changes (Li et al., 2021). The battery uses more unstable materials, and as a result, the battery charge-discharge balance increases, accelerating battery ageing (Diaz et al., 2022). These situations pose a security risk.

Besides, other potential aging phenomena arise, such as crystal dissolution, liquid electrolyte interface formation, carbon coatings, solid eutectic interface layers (Collath et al., 2022), particle agglomerations, and solutes that can form stronger, less lithiated interfaces, increase resistance due to these fluctuations and thus contribute to the continued loss of lithium ions (Xiong et al., 2020). In addition to stress, non-uniform plastic compressive stress can amplify the compaction signature and induce stress compatibility within the electrode.

As a solution, cells can be fabricated in a manner that typically improves the probability of a long, reliable, and stable lifespan with both nylon and cloths. This could encourage future expansion by demonstrating relatively low prices and large market populations on which to validate it during the development of an advanced bipolar lithium-sauce, with significant added value.

3.4 Technical Challenges

The process of integrating batteries into renewable energy systems can be a complex task involving technical, regulatory, and administrative challenges (Etukudoh et al., 2024). Various charging and discharging conditions are present at the interface between energy sources and energy storage systems. For example, at the interface between wind turbine systems and energy storage systems, charging conditions vary from full to empty energy storage systems in the presence of low to high wind energy (Datta et al., 2021). Similarly, at the same interface, discharging conditions vary when wind energy is present during low wind speeds and during sudden voltage drops. Each high-power pulse discharge of batteries can have a negative impact on their cyclic ageing. Therefore, dynamic control of discharge power management is very important to protect the ageing of batteries during discharging (Oyekale et al., 2020).

According to the frontiers of PV inverters and PV power electronic conversion in a PV-wind power system, in terms of interface, charge/discharge limitation and control, the battery connection between hybrid PV-wind power in a rural grid-connected energy storage system is a challenge (Emad et al., 2021). To extend the life of energy storage devices, discharging current needs to be scheduled. The development of electronic power interface converters, protection, and lifetime items need better design schemes. To face the future of high-level distributed multi-microgrid installations of residential families, software and control-updating, the smartness and modularity of configurable multiport building power electronic converters are essential (Ravada et al., 2020). Regardless of these considerations, there are several ways to connect energy storage devices with intersection energy systems.

4. Technological Advances and Future Trends

The research conducted on the worldwide status of energy storage, including parameters of the main and well-known energy storage technologies and new promising solutions for large and small-scale applications, indicates the importance of energy storage systems in future smart grids (Calero et al., 2022). With increased levels of renewable energy penetration, the subject of grid-inertial conditions is becoming critical, requiring the use of smart power-electronics interfaces (SPEI) and protective schemes to support grid stabilization (Shi et al., 2020). Energy storage systems can provide a very important contribution to future grid stabilization and flexibility, for which disposal costs should take into account the full life cycle cost of energy storage systems (Foley et al., 2020).

4.1. Innovations in Battery Technologies

Several novel battery technologies have been developed in recent years. These include sodium-sulfur batteries (NSB), zinc-anode batteries (ZAB), Li-air batteries, lithium sulfur batteries, and flow batteries (RFB), all of which are expected to have a significant impact as high-performance, safe, and low environmental-pollution battery systems. Na-S batteries using molten electrolytes were first used in large-scale energy storage and have demonstrated 20-year of operational experience.

Zinc-air batteries (Khezri et al., 2022) are characterized by high-energy capacity, abundance, and low cost associated with zinc, but are limited by cathode instability and porosity, electrolyte loss or reduction inefficiency. As a common industrial and domestic anode material as well as an electrochemically recyclable electrode, zinc (Zn) is considered one of the most attractive electrodes for advanced sodium-ion batteries (SIBs) to satisfy

multiple battery requirements in terms of energy density, power density, cycling stability, and operation safety, ultimately promoting large-scale, low-cost, long-ranging, distributed, and random renewable off-grid power supply (Arafat et al., 2021). Growing concerns about limited fossil fuels, associated environmental problems and energy security led to a fundamental interest in alternative renewable energies such as solar, wind, hydropower, and biomass. Different batteries have different advantages and disadvantages and present various practical barriers and cycle limitations pending large-scale application and, consequently, have different degrees of exposure to today's energy sector (Lu et al., 2020). Extensive theoretical and experimental explorations should catalyze the development of cutting-edge energy storage systems and to lead to discussions on the battery technologies presented in this open access review.

The power and energy demand for various applications in smart grids are quite diverse, and therefore require different forms of ESS. Currently, lithium-ion batteries are established as an ESS for residential applications and are being tested for industrial and utility applications (Alimardani & Narimani, 2021). However, various other emerging forms of battery types are known to be either in the research or development phase for low cost, long-life and high energy storage applications. They are all optimized for their specific design points, such as frequency support requirements of the order of seconds or duration of several hours. A few of the important battery technologies in the research and development stage include zinc-based, flow-based, sodium-based, and advanced lithium-based batteries (Kebede et al., 2021).

4.2. Smart Grid Integration

One of the most crucial demand-side management components, called Vehicle-to-Grid (V2G), aims to modulate the features of the EV battery, taking advantage of its dual role as load or generator (Mojumder et al., 2022). The main challenge of V2G, which involves bidirectional flow, is to avoid damaging the storage unit. Thanks to the Battery Management System (BMS), decision on the correct operation charging or discharging to respect the lifetime of the participating EV batteries are performed. These operations usually occur when the market price of energy or auxiliary services, as well as the user's preferences, are satisfied (Islam et al., 2022). Another positive consequence of V2G participation is their incorporation as network assets. In fact, grid services such as energy arbitrage, Frequency Control Ancillary Services (FRCAS), and Operating Reserve Services are easily realizable. On the other hand, fuel cell EV will also play an important operational role in the field of energy services, which will support the smart grid for the introduction of an increasing amount of renewable sources (Falchetta & Noussan, 2021). The effective participation of mass storage systems, primarily built around batteries, can offer real-time support on the end-user's residential microgrid to ensure the management of in-house electrical needs without overloading the connection to the public distribution grid. Small, modular, compact, and solid-state stationary power systems are able to absorb the power peaks required by ancillary and local services.

Conclusion

In this review, different types of battery storage technologies are investigated and discussed in depth. Lithium-ion batteries are reported to have the highest energy density and Coulombic efficiency. However, they suffer from thermal issues such as overheating and spontaneous combustion. The flow battery type is scalable, which means that any desired capacity can be reached by stacking more units. Battery lifetime is one of the most significant challenges for renewable energy stations or other devices where batteries are used. Taking into account deep discharge and shallow cycling approaches, this review comprehensively investigates flow battery lifetime. As proven by the experimental and theoretical works in the literature, if half the discharge rate of the full rate reaches the predetermined final voltage, the lifetime of the flow battery (or the lifetime of other technologies) can be multiplied by several times.

Grid integration, one of the most crucial and significant aspects of storage, has become increasingly popular due to the growing capacity of renewable energy sources and the subsequent emphasis on providing solutions to control reserve shortages. An energy storage system, interfaced with the renewable energy source, is usually employed to solve a variety of issues, including the provision of frequency control reserve, price arbitrage, power quality enhancement, peak shaving, and demand shifting. High efficiency, fast response, long life, and low purchase price are all necessary for the deployment of battery energy storage among arrays of renewable energy systems. Since renewable energy storage batteries play a different role to energy storage in conventional power systems, their unique characteristics in different scenarios need to be considered. Furthermore, the quantity of renewable energy storage deviates less than the unit cost of storage under specific conditions. Further research into the functionality and advantages of balancing price fluctuations better exploits advantage of the renewable energy over lithium-ion, which has a higher specific energy effect. Such work could support future business activities and policymaking consensus.

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TOWARDS EFFECTIVE IMPLEMENTATION OF GENDER-BASED VIOLENCE POLICIES IN MANKWENG TOWNSHIP

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Abstract. Gender-Based Violence (GBV) remains a pervasive and complex issue in South Africa, particularly affecting women and girls. This study delves into the heart of this problem by focusing on Mankweng Township, an area marked by diverse cultural influences and socioeconomic challenges. Drawing upon a combination of interviews, questionnaires, and focus group discussions, this research comprehensively examines GBV, its root causes, and the experiences of its victims and survivors. The findings illuminate a nuanced picture of GBV, transcending conventional narratives. While the study confirms the predominant role of men as perpetrators, it also recognises that not all men adhere to violent behaviours. Men, women, and members of the LGBTQ+ community in Mankweng Township face varying degrees of violence and discrimination, thus challenging stereotypical perceptions. Traditional customs and cultural norms are revealed as powerful factors perpetuating GBV. The practice of lobola, emphasising ownership of women, and the subjugation of women in relationships are particularly highlighted. However, the study also uncovers potential solutions within cultural and religious frameworks where churches can serve as safe spaces for dialogue and support. Importantly, the research spotlights the often-overlooked experiences of the LGBTQ+ community, who face a disproportionately high risk of GBV. The fear of judgment and discrimination stifles their ability to seek help and report incidents. This underscores the need for a more inclusive approach to GBV prevention and intervention programs. The study's recommendations highlight the importance of awareness programs, better resource distribution, and cultural re-evaluation. It emphasizes the need to involve men and boys actively in GBV prevention efforts, challenging harmful gender norms and behaviours. As explored in this study, the legislative framework provides a robust foundation for addressing GBV. However, the study also highlights the critical importance of effective implementation and enforcement of these laws.

Keywords: Gender-Based Violence; Policy; Policy Framework; Violence; Mankweng Township

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JEL Classifications: R2

1. Introduction

Gender-Based Violence (GBV) encompasses various forms of violence targeting individuals based on their gender, including domestic violence, physical violence, economic violence, sexual violence, emotional violence, femicide, and others. In South Africa, GBV predominantly affects women and children, leading to an urgent call for action from the government and relevant organizations to address the increasing incidences of gender-based violence against women (Enaifoghe et al., 2021). Limpopo Province is one of the regions in South Africa severely impacted by GBV, prompting the implementation of legal and policy intervention strategies such as the Criminal Law (Sexual Offences and Related Matters) and its Amendment Act and the Domestic Violence and its Amendment Act (Managa et al., 2022). However, despite these policy frameworks, GBV persists in the

Mankweng township of Limpopo Province, necessitating a critical investigation into their failure to effectively combat GBV as intended (Phasha, 2021).

The South African constitution, specifically the Bill of Rights, emphasizes the protection of the right to life, which is considered non-derogable and highly valued. However, the cases of GBV in South Africa, as highlighted in Chapter Two of this study, show that many women lose their lives due to the stigma and impact of GBV. The deadly consequences encompass different outcomes, such as homicide, suicide, maternal mortality, and deaths related to AIDS (Sabri and Granger, 2018). The 2012 Criminal Law (Sexual Offences and Related Matters) Amendment Act was implemented as a public policy to improve the prevention of sexual abuse and exploitation. However, studies have indicated that GBV, including sexual, physical, mental, and economic harm, has evolved into various criminal offences such as intimidations of violence, coercion, manipulation, intimate partner violence, child marriage, female genital mutilation, and so-called honour crimes that the Act aimed to prevent (Wanjiru, 2021).

In recent years, there has been an increasing concern about GBV against women and children, which has been exacerbated during the COVID-19 pandemic, leading to a shadow pandemic with deadly consequences for victims (Mongare et al., 2018). The 2011 Protection from Harassment Act aimed to provide effective solutions against harassment but did not significantly impact GBV levels, indicating the need for alternative solutions to address the underlying harassment cases that contribute to the increase in GBV (Dzinavane, 2016). The COVID-19 pandemic further worsened the impact of GBV in South Africa, with restrictions aimed at controlling the virus that created barriers for women and children to seek help and access services. This has also affected the capacity of gender-based violence services to provide support and the effectiveness of policy and practice responses to GBV (John et al., 2020; Mantler et al., 2022; Ndlovu et al., 2022).

Enaifoghe et al. (2021) and Graaff (2021) have extensively discussed the pervasive nature of GBV in South Africa, highlighting the country's exceptionally high rates of violence and gender-based violence compared to other nations. Various interventions, including legislative changes and women-focused reactive initiatives, have been implemented to address the increasing cases of GBV in the country (Dzinavane, 2016). Despite South Africa being a democratic country committed to human rights, GBV continues to persist. GBV is recognized as a human rights abuse, but societies, communities, and individuals often feel helpless in the face of GBV, even if they have experienced it first-hand or witnessed it within their families and localities (Thobejane, 2019). Public policies that forbid violence against women and enhance survivors' ability to access dedicated facilities, such as Women's Police Stations, have the potential to encourage manners among men that condemn violence against women (Cordova & Kras, 2021). However, patriarchal norms and societal expectations often discourage women from reporting assaults or violations involving their spouses or family members, further perpetuating the cycle of violence.

It is crucial to understand the drivers of GBV or intimate partner violence (IPV) as experienced by women and perpetuated by men to develop effective prevention programs (Gibbs et al., 2020). Additionally, it is essential to consider both generic factors, such as quality of life and well-being, and condition-specific aspects related to symptoms resulting from human rights abuses when examining the impact of GBV (Rahman et al., 2021). Overall, this research study provides a comprehensive background to the issue of GBV in Mankweng Township, South Africa, highlighting the shortcomings of existing policy frameworks and the impact of the COVID-19 pandemic.

It also emphasizes the need for alternative solutions and a deeper understanding of the drivers of GBV. Drawing from a qualitative methodology, the aim of this study is to investigate the implementation of a policy framework to tackle gender-based violence in Mankweng Township, South Africa. Therefore, this study seeks to address the following research questions:

- What are the underlying causes of gender-based violence in South Africa?
- Why have the public policy frameworks implemented been ineffective in addressing gender-based violence?
- What are the impacts of gender-based violence on individuals and the community?
- What interventions can be implemented to address gender-based violence in South Africa?

2. Literature Review

The theoretical literature serves as a cornerstone in this study, offering a comprehensive exploration of existing knowledge and research concerning the impact of Gender-Based Violence (GBV) in South Africa. This section delves into relevant academic studies, reports, and publications to gain insights into the underlying factors contributing to GBV and its consequences, particularly for women in the country. The theoretical framework provides a conceptual lens through which to examine the development, implementation, and evaluation of policy frameworks aimed at combating GBV within the unique sociocultural context of Mankweng Township.

The study adopts several theoretical perspectives to elucidate the dynamics of GBV and inform policy interventions. These include:

- **Social Learning Theory:** Social learning theory posits that individuals acquire behaviours through observation and experience. Within the context of GBV, this theory suggests that exposure to violent behaviours during childhood or witnessing violence can shape later violent behaviour. Children learn from their environment and significant individuals in their lives, such as parents, peers, and teachers. Interventions aimed at addressing GBV must consider the influence of social learning and provide alternatives to violence as coping mechanisms (Mongare et al., 2018; Wanjiru, 2021).
- **Learned Helplessness Theory:** Learned helplessness theory suggests that individuals exposed to prolonged aversive stimuli may develop a sense of helplessness, leading to low self-esteem, renunciation, and a perception of loss of control. Within the context of GBV, this theory sheds light on the behaviours and characteristics of battered women, highlighting the complex factors that contribute to their decision-making processes. Understanding learned helplessness is crucial for designing interventions that empower victims and address the underlying causes of their helplessness (Cruz & Klinger, 2016; Wanjiru, 2021).
- **Gender Role Theory:** Gender role theory examines how societal expectations of behaviour for men and women influence judgments and behaviours. Traditional gender roles have historically confined women to domestic duties, reinforcing stereotypes about their capabilities and vulnerabilities. This theory emphasizes the importance of challenging gender norms and recognizing the diverse capabilities of individuals regardless of gender. Addressing gender role expectations is essential for promoting gender equality and preventing GBV (Rua et al., 2020; Dzinavane, 2016).

In South Africa, the legislative and policy landscape regarding Gender-Based Violence (GBV) is anchored in the Constitution of South Africa, Act No. 108 of 1996, which upholds fundamental principles of equality and human dignity. Specific provisions within the Constitution, such as Sections 9, 10, and 12, guarantee equal protection, human dignity, and freedom from violence for all individuals. Furthermore, several legislative acts have been enacted to address GBV comprehensively:

- **The Promotion of Equality and Prevention of Unfair Discrimination Act (Act No. 4 of 2000)** prohibits discrimination based on sex, gender, or sexual orientation, recognizing GBV as a form of prohibited discrimination.
- **The Employment Equity Act (Act No. 55 of 1998)** mandates fair treatment in employment policies and practices, reducing biased prejudice within the workplace.

- **The Code of Good Practice on the Handling of Sexual Harassment in the Workplace (2008)** emphasizes creating a work environment that respects employee dignity and safeguards against sexual harassment.
- **The Amendment of the Criminal Law (Sexual Offences and Related Matters, Act No. 32 of 2007)** addresses sexual violence against adults and children, providing definitions for various sexual offences and establishing structures for effective implementation.
- **The Protection from Harassment Act (Act No. 17 of 2011)** offers civil solutions to shield individuals from harassing conduct, including digital forms of harassment.
- **South Africa's Domestic Violence Act (Act No. 116 of 1998)** comprehensively addresses various forms of family violence, extending protection to individuals in domestic relationships beyond romantic or sexual partners.
- These legislative measures establish a legal foundation for addressing GBV, reflecting South Africa's commitment to equality, dignity, and human rights. However, the effectiveness of implementation and enforcement remains a subject of ongoing research and advocacy.

The GBV policy framework must address socioeconomic, cultural, institutional, and community factors to effectively combat GBV:

- **Socioeconomic Factors:** Prioritizing economic empowerment programs for women, including skills training and access to employment opportunities, can reduce vulnerability to GBV by addressing poverty and inequality.
- **Cultural and Social Norms:** Gender-sensitive education programs should challenge patriarchal beliefs and stereotypes, promoting gender equality and mutual respect. Engaging with traditional and community leaders is essential to change harmful cultural norms.
- **Institutional Factors:** Strengthening the legal framework and ensuring effective enforcement of existing laws against GBV is crucial. Additionally, enhancing support services for GBV survivors, including shelters and trauma-informed counselling, is necessary.
- **Community Factors:** Community engagement and awareness programs can challenge social acceptance and silence surrounding GBV. Partnerships between government institutions, civil society organizations, and local community groups are vital for effective implementation.
- **Intersectionality:** Adopting an intersectional approach that recognizes the unique experiences of marginalized groups is essential. Collaboration with intersectional organizations and activists can inform policy decisions and improve service provision.

By addressing these underlying factors through a comprehensive policy framework, there is potential for significant progress in reducing GBV in Mankweng Township. However, success will depend on sufficient resources, political commitment, and ongoing evaluation and adaptation based on local context and needs.

3. Research and Methodology

This study adopts a qualitative research approach that aligns with the research topic's specific context and limitations. Given the sensitive nature of the subject matter and the aim to delve deeply into individual perspectives, a qualitative approach is most appropriate (Graaff, 2017). The research focuses on conducting a single case study within Mankweng Township in South Africa, warranting an intensive exploration of a smaller sample size to uncover nuanced insights.

The study's focus was on a specific target population within the context of Mankweng Township, directly aligning with the research topic of the implementation of the Gender-Based Violence (GBV) policy framework. The targeted population consisted of women aged between eighteen and thirty-six years old, men aged between

nineteen and forty-three years old, and members of the LGBTQ+ community aged between eighteen and twenty-eight years old. The selection of these age groups was intentional, aiming to capture a broad spectrum of perspectives spanning different life stages. Participants below the age of eighteen were excluded due to the sensitive nature of the topic and the potential impact it could have on their emotional well-being.

The study's location was Mankweng Township itself, which was chosen due to its direct relevance to the research topic. By conducting the research within Mankweng Township, the study sought to gain insights into the experiences, opinions, and perceptions of those who live, work, and study within this specific community context. This study employed a purposive sampling method, specifically drawing from the approach outlined by Kanjiri et al. (2021). The rationale behind choosing this sampling method was its alignment with the research goal, which aimed to comprehensively explore the reasons behind the failure of the implemented gender-based violence policy framework in Mankweng Township. The purposive sampling technique provided the flexibility to select participants based on their capacity to comprehend and address the research questions effectively.

To ensure confidentiality, participants were assigned unique code numbers, such as Participant 001, to safeguard their identities. The selection of these specific participants was driven by the study's geographic focus on Mankweng Township. Given that the research questions centred on this locale, residents, the University of Limpopo students, and local institution staff were deemed particularly relevant as they might have encountered or observed instances of gender-based violence within the township. Their insights and perspectives carried considerable significance in shedding light on the study's concerns.

The sampling process adhered to two distinct criteria:

- All participants aged 18 and above were eligible for inclusion.
- Both undergraduate and postgraduate students were included based on their familiarity with the research topic.
- Staff members from the Mankweng police department and Mankweng hospital and personnel from the University of Limpopo were included.
- A diverse range of educational backgrounds, encompassing both educated and less educated individuals, were considered.
- Participants from various employment statuses, including both employed and unemployed individuals, were included.
- All gender identities, including women, men, and members of the LGBTQ+ community, were represented.
- Individuals below the age of eighteen were excluded from participation.
- Those who expressed discomfort or distress regarding the research topic and its contents were excluded.
- Individuals who declined to participate in the study were excluded.

The application of purposive sampling ensured that the chosen participants offered insightful and contextually relevant perspectives on the failure of implementing the gender-based violence policy framework within Mankweng Township.

The data collection process was an exhaustive endeavour, employing an array of tools to gather substantial insights essential for addressing the intricate challenges posed by the failed policy framework aimed at dealing with GBV. The instruments used to collect data are as follows:

One-on-one interviews emerged as a pivotal data collection instrument. Employing a semi-structured approach, the researcher engaged participants in candid conversations, unearthing their perspectives on the deeply entrenched GBV issue. This approach aimed to strike a balance between uniformity and the freedom to provide expansive insights. The choice of semi-structured interviews, as opposed to unstructured ones, was guided by the

researcher's intention to respect participant comfort levels, steering clear of overwhelming attention that might compromise their openness.

The rationale for this approach aligns with Graaff's observation (2017) that the opinions of participants regarding interventions had often been relegated or underestimated. The study seeks to offer a platform for every voice to be heard, irrespective of societal standing, underlining the collective effort required to combat the perils of GBV. This individualized interaction allowed participants to share experiences, opinions, and concealed sentiments with the researcher, often more comfortably than with their close circles, due to the perceived impartiality and confidentiality of the researcher.

Guiding the interviews was an approach that extended beyond mere questioning, demonstrating empathy and compassion. This approach fostered a responsive dialogue, where participants felt understood and acknowledged rather than interrogated. By embracing semi-structured interviews, participants were empowered to independently articulate their perceptions regarding GBV, unveiling insights not solely reliant on learned opinions.

The questionnaire, a non-intrusive tool, was effectively employed to gather data. Ensuring participant comfort, the researcher distributed questionnaires that were to be completed over seven days. This approach granted participants the flexibility to respond at their convenience, effectively balancing their busy schedules. The method, bolstered by participants' signed consent forms, maintained ethical standards and autonomy.

Crafted for different scenarios, the questionnaire's content varied. One version was intended for one-on-one interviews, guiding participants to address the questions orally. Another was designed for focus group discussions, stimulating open dialogues by presenting the questions for communal deliberation. Lastly, a questionnaire was provided for independent completion, facilitating private responses in line with participants' preferences.

The essence of data preservation and security led to the inclusion of documentation as a robust tool. Information gathered from the case study, interviews, and questionnaires were meticulously converted into soft copy documents and stored in a secure, researcher-accessible location. This practice safeguards against data loss and assures the information's safety for future inquiries.

Acknowledging the diversity of participants and their constraints, virtual interviews emerged as a viable solution. Leveraging platforms like Google Meet and Zoom, or even telephonic communication, these virtual engagements enabled the researcher to engage with participants who couldn't attend face-to-face interviews. This approach reflects the researcher's commitment to inclusivity and flexibility, ensuring diverse perspectives were captured.

4. Results' Interpretation and Discussion of Findings

This chapter delves into the qualitative data, its presentation, analysis, interpretation, and discussion. Robust empirical research hinges upon the meticulous examination and profound comprehension of data, which ultimately culminate in the study's findings and implications (Graaff, 2021). Therefore, this chapter offers an in-depth exploration of the data gleaned from semi-structured interviews. These interviews were conducted in Mankweng Township, with the choice of environment being guided by the participants themselves. The researcher employed semi-structured interviews as the primary means to collect information from the participants in alignment with the research's aims and objectives (Mkhonto, 2022). This chapter not only draws conclusions from the data but also connects these findings to the broader issues of gender-based violence expounded upon in chapters two, three, and four (Dzinavane, 2016).

Please refer to Table A below for a breakdown of demographic details for each participant, including their assigned code, age group, education level, spoken language, marital status, gender (if provided), and employment status.

Table A. Breakdown of demographic details for each participant

Participant Code	Age Group	Education Level	Language Spoken	Marital Status	Gender (Optional)	Employment Status
Participant 001	23	Honours	Sepedi	Single	LGBTQ+	Unemployed
Participant 002	32	Diploma	Venda	Single	Male	Security Personnel
Participant 003	29	Bachelor	Sepedi	Single	Female	Administrative Assistant
Participant 004	25	Masters	Sepedi	Single	Male	Assistant Lecturer
Participant 005	38	Higher Certificate	Tsonga	Divorced	Male	Shop Retailer
Participant 006	20	Undergraduate	Venda	Single	Female	Unemployed
Participant 007	43	Diploma	Sepedi	Married	Male	Police Officer
Participant 008	35	Bachelor	Sepedi	Divorced	Female	Receptionist
Participant 009	27	Honours	Venda	Single	Female	Security Personnel
Participant 0010	23	Bachelor	Sepedi	Single	LGBTQ+	Entrepreneur
Participant 0011	30	Grade 10	Sepedi	Single	Female	Unemployed
Participant 0012	33	Doctorate	Tsonga	Married	Male	Lecturer
Participant 0013	24	Honours	Swati	Single	Male	Lab Assistant
Participant 0014	21	Undergraduate	Venda	Single	Female	Unemployed
Participant 0015	22	Undergraduate	Swati	Single	Female	Unemployed
Participant 0016	34	Doctorate	Sepedi	Single	Male	Lecturer
Participant 0017	29	Diploma	Sepedi	Single	Female	Store manager
Participant 0018	26	Masters	Tsonga	Single	Male	Assistant Lecturer
Participant 0019	27	Diploma	Sepedi	Single	Female	Unemployed
Participant 0020	36	Bachelor	Sepedi	Married	Female	Nurse
Participant 0021	24	Undergraduate	Swati	Single	Male	Entrepreneur
Participant 0022	35	Bachelor	Venda	Divorced	Female	Cashier
Participant 0023	33	Bachelor	Venda	Married	Female	Cashier
Participant 0024	19	Undergraduate	Sepedi	Single	Male	Unemployed
Participant 0025	28	Diploma	Swati	Single	Female	Secretary
Participant 0026	29	Bachelor	Venda	Single	Female	Finance Manager
Participant 0027	20	Undergraduate	Swati	Single	Female	Unemployed
Participant 0028	18	Undergraduate	Sepedi	Single	Female	Unemployed
Participant 0029	24	Honours	Sepedi	Single	Female	Peer Counsellor
Participant 0030	26	PGCE	Swati	Single	Male	Language Consultant
Participant 0031	23	Undergraduate	Tsonga	Single	Female	Unemployed
Participant 0032	27	Honours	Venda	Single	Male	Lab Assistant
Participant 0033	18	Undergraduate	Sepedi	Single	LGBTQ+	Unemployed
Participant 0034	28	Masters	Sepedi	Single	LGBTQ+	Accountant

This participant information sets the stage for the subsequent analysis and discussion of the research findings, all of which directly align with the research topic's aim, objectives, and research questions (Graaff, 2021).

Before venturing into data collection, a series of essential procedures were meticulously followed to uphold the research's integrity and ethical standards. The study commenced by seeking approval from the Turfloop Research Ethics Committee (TREC), ensuring that the research posed no harm or risk to its participants. The University of Limpopo granted an ethics clearance certificate, authorizing the data collection process. Data collection unfolded between the first week of October 2023, spanning day and night dedication by the researcher to deliver a comprehensive data analysis after data gathering.

During the data collection phase, participants were segregated into three categories: one-on-one interviews, focus group discussions, and virtual (online) interviews. Twelve participants participated in one-on-one interviews, typically lasting 15-30 minutes, while thirteen opted for virtual interviews, averaging 30-45 minutes each. Nine participants engaged in a focus group discussion, which extended for approximately 60-90 minutes. Questionnaires distributed to participants in those three categories took four days to a week to be returned. Audio

recording was employed in some interviews with the consent of the participants. Every participant was presented with a confidentiality and consent form before participating in interviews, focus group discussions or filling out the questionnaires. It's crucial to emphasize that all participants willingly chose to participate, and no form of coercion or inducement was employed.

In this qualitative study, thematic analysis was employed to analyse the semi-structured interview data collected from participants. The thematic analysis allowed for a systematic exploration of the key themes and patterns emerging from the data.

The initial coding process involved assigning labels or codes to relevant portions of the data. These codes served as concise summaries of the participants' responses regarding the implementation of the gender-based violence (GBV) policy framework in Mankweng Township. Codes were then scrutinized and grouped to develop overarching themes and sub-themes.

The iterative process of thematic analysis resulted in the identification of several key themes:

Staying in Abusive Relationships: Participants discussed enduring abusive relationships for extended periods, highlighting coping mechanisms and challenges faced.

- *Coping Mechanisms:* Participants employed various coping strategies, including seeking support from family and faith-based practices.

Some participants found strength through supportive relationships. One participant shared her experience, stating, *"To be honest, I was never going to make it without my brother-in-law, who was a very stubborn person. He would tell me that I was giving power to my abuser by not fighting to be better. So, one day, I think I shocked him when I asked him and my sister to accompany me to file a case of domestic violence. Since then, he has been the person I have spoken to more than my sister because he was my best friend before my brother-in-law. He became my unofficial therapist."* - Participant 0023

- *Challenges Faced:* Financial dependency, traditional customs, and victim-blaming culture emerged as significant challenges within abusive relationships.

Financial dependency emerged as a significant challenge. Participant 0022 emphasized this aspect, stating, *"Religion teaches women to obey their husbands if they provide for you, and it does not account for when that same husband treats you like a doormat...Sigh... We are expected to endure any kind of torture they throw our way."* This participant took back her freedom into her own hands as her coping strategy by starting yoga to feel calm and collected when previously she was not allowed to.

Failure of GBV Policy Framework: Participants expressed dissatisfaction with the effectiveness of the GBV policy framework in addressing gender-based violence in Mankweng Township.

- *Legislative Frameworks:* Participants cited specific legislative acts such as the Domestic Violence Act and the Protection from Harassment Act, questioning their efficacy.

As one participant astutely pointed out, *"I can guarantee that many residents in Mankweng have never even heard of these policies. I only know about them because I'm pursuing a degree in public administration. Otherwise, I'd be fighting this battle blind."* - Participant 004

Participant 008 echoed these sentiments: *"If you ask me about this act, I will tell you that it is used by the government to make money instead of protecting the victims. I mean, why fine the offender instead of putting his ass in jail for a few years to learn not to disrespect or harass others?"* - Participant 008, suggesting that the act is used by the government to generate revenue rather than genuinely protecting victims.

Prevalent Types of GBV: Participants identified sexual assault, brutal murders, and physical abuse as the most prevalent types of GBV in Mankweng Township.

- *Impact on Victims:* The devastating effects of GBV on victims were highlighted, including psychological trauma and loss of life.

The effects of such violence ranged from emotional trauma to physical injuries. Participant 0014 shared a particularly poignant story of her friend's ordeal: *"I was just there at her house but afraid to defend my friend because I was a coward, and our friendship ended there because I never wanted to be seen with her in public because I thought he would do to me what he did to her...she looked at the floor."* Participant 0014, emphasizing the consequences of domestic violence. Her account serves as a stark reminder of the profound impact such violence can have on individuals.

Participants recounted grappling with self-blame and shame following their ordeals. Participant 009 poignantly expressed, *"You know I started to blame myself after what happened. I can't believe I listened to the mentality that said if I did not wear my mini-skirt, I would not have been raped. To this day, I am the one dealing with the effects that rape left behind."* These emotions often led to diminished self-esteem and a sense of unworthiness.

Prevention Strategies: Participants discussed potential strategies for preventing GBV, including education and media campaigns.

- **Educational Initiatives:** Lack of education and victim-blaming culture were identified as barriers to prevention efforts.

Participant 0018 summed it up, saying, *"Education is the key to many of South Africa's challenges. It equips individuals with the knowledge and awareness needed to tackle issues like GBV. While success can be achieved without formal education, an educated populace is better equipped to understand and address real issues like GBV."*

Participant 0032 emphasized the transformative power of support: *"Supporting those who have experienced GBV can make all the difference. When I encouraged my friend to reclaim her power, I was initially furious at her for contemplating giving up. However, I assured her of my unwavering support. This gave her the courage to seek counselling and support, knowing that there was hope for her future. It even fuelled her determination to see her perpetrator brought to justice."*

Table B. Summary of Themes and Sub-themes

Theme	Sub-theme
Staying in Abusive Relationships	Coping Mechanisms, Challenges Faced
Failure of GBV Policy Framework	Legislative Frameworks
Prevalent Types of GBV	Impact on Victims
Prevention Strategies	Educational Initiatives

The thematic analysis revealed the multifaceted nature of GBV in Mankweng Township, highlighting the complex interplay of social, cultural, and economic factors. Addressing GBV requires a holistic approach that encompasses legislative reform, community education, and support for survivors. By understanding the nuanced experiences and perspectives of individuals affected by GBV, policymakers and practitioners can develop more effective interventions to combat this pervasive issue.

5. Findings

The novelty of this study lies in its comprehensive approach to understanding Gender-Based Violence (GBV) within the unique sociocultural context of Mankweng Township. Unlike previous studies that often generalise GBV issues across broader regions, this research provides localised insights, highlighting the specific cultural norms, socioeconomic challenges, and community dynamics perpetuating GBV in Mankweng. Additionally, the study's focus on the LGBTQ+ community and the role of traditional customs and religious institutions in either perpetuating or combating GBV presents new dimensions for understanding and addressing this issue. The

recommendations provided are tailored to the local context, offering practical solutions that leverage existing cultural and religious frameworks to foster dialogue, support, and prevention efforts.

Male participants in the study disclosed their experiences with various forms of gender-based violence. However, it was noted that most men refrained from reporting such incidents to the police or discussing them with friends. One participant explained this reluctance, stating, *"In our culture, a man is considered weak if he goes to the police to report an abuse by a woman; they would laugh at you, and no one wants to be called weak"* (Participant 0016).

This study recognizes that men can also be victims of gender-based violence, underscoring the importance of involving them in initiatives to combat GBV. It aligns with Shaw's (2017) perspective that feminist theories should not exclude men but should provide a more comprehensive understanding of violence experienced by all genders. Shaw suggests that feminist theories can be applied to various gender identities, including men, women, transgender individuals, and genderqueer groups, ensuring inclusivity.

Male participants highlighted the continued influence of traditional customs in contemporary society. They acknowledged that these customs placed expectations on women to be submissive in households. One participant emphasized, *"Even today, if a woman is to be married, she is being prepared on how to take care of and obey her husband, but men are not taught how to take care of and respect women"* (Participant 004). This acknowledgement illustrates that men recognize the challenges women face and the importance of including them in initiatives to address GBV. This aligns with the study's agenda of fostering unity and breaking down traditional gender norms. Male participants conceded that culture often reinforced negative norms, such as the practice of lobola, which implied ownership of women, leading to the normalization of gender-based violence. They acknowledged that this cultural framework instilled submissive roles in women, often resulting in punishment, including physical and emotional abuse, for non-compliance. These cultural factors make addressing gender-based violence more complex, but some participants believed that religion and culture could be harnessed positively to reshape societal perceptions. They suggested that churches could serve as safe spaces for discussions about GBV and provide counselling for survivors. Additionally, participants advocated for an end to judgment against LGBTQ+ members within religious institutions, emphasizing the importance of respecting diverse identities and experiences.

The female participants in the study voiced their concerns about the persisting gender-based violence in the 21st century, reflecting a mix of disappointment and sadness. They raised issues such as the objectification of women in the film industry, particularly in superhero movies that often depict female characters in skimpy outfits, emphasizing the sexualization of women. This concern aligns with findings by Aley and Hahn (2020), who conducted a study on gender roles in film content, revealing that male heroes are often portrayed as more powerful compared to their female counterparts. Nonetheless, some participants noted a positive shift in the industry, citing examples like the series 'WandaVision' and the male-led movie 'Doctor Strange,' where women were portrayed as powerful characters. One participant expressed pride in these portrayals, stating, *"Women are now getting more powerful roles, and I am feeling so proud right now"* (Participant 0027). This shift signifies a growing recognition of women's strength and potential, challenging traditional stereotypes that have long confined them to passive roles.

Women were asked to identify the triggers of gender-based violence, shedding light on the societal factors that contribute to this issue. Many participants attributed GBV to deeply ingrained beliefs in male dominance and female subservience, often cultivated within families that adhere to patriarchal norms. A participant shared her experience of divorcing her husband due to a polygamous marriage, highlighting a lack of attention and feelings of neglect. She emphasized the role of traditional customs in perpetuating gender-based violence, especially in polygamous unions.

The participants identified several triggers:

- **Shame Culture:** Many participants observed that one of the triggers of GBV was the culture of shame imposed on women who fell victim to violence. This culture often overshadowed government legislative efforts like the Domestic Violence Act and the Protection from Harassment Act, pointing to the need for a societal shift in mentality.
- **Blame Game:** Another trigger identified was the tendency to blame victims based on their clothing choices, state of intoxication, or perceived recklessness rather than holding perpetrators accountable. This victim-blaming often led to social ostracization and further perpetuated the culture of silence.
- **Societal Treatment:** The participants highlighted society's harsh treatment of women who sought to break free from traditional gender roles by becoming independent. Women who aspired to lead and make political or domestic decisions were often criticized and discouraged.
- **Religious Influence:** The role of the church in reinforcing the docile role of women was also recognized. Participants explained how religious institutions discouraged women from seeking help and made them feel embarrassed about airing their grievances, further trapping them in toxic relationships.
- **Abusive Households:** Growing up in abusive households was identified as a potential precursor to becoming either an abuser or a victim, perpetuating the cycle of violence.

These triggers underscore how deeply entrenched gender-based violence is within Mankweng Township, driven by cultural norms and societal attitudes. The participants also alluded to the Social Exchange Theory and its application in abusive relationships, emphasizing the role of self-interest and individual social rationality (Yin, 2018) in such dynamics.

The female participants shared the profound effects of gender-based violence on their lives. These effects often persisted long after the traumatic experiences, reshaping their identities and well-being. These consequences illuminated the partially similar diverse facets of gender-based violence, as reported by the participants of the (Dzinavane, 2016) study, the consequences highlighted include:

- **Low Self-esteem and Confidence:** Women who had experienced GBV commonly reported a loss of self-esteem and confidence. They often felt diminished and less attractive due to the emotional scars left by the abuse.
- **Sexual and Reproductive Issues:** Participants noted that GBV disproportionately affected women, resulting in unwanted pregnancies, sexually transmitted infections, and difficult decisions regarding termination. The psychological trauma from such experiences was immense, sometimes leading to suicidal thoughts.
- **Impact on Productivity:** Women who survived GBV faced challenges in their daily lives, including missing school or work due to injuries, legal proceedings, and emotional stress. These disruptions often hindered their personal and professional growth.

Members of the LGBTQ+ community, both men and women, face a disproportionately high risk of gender-based violence. Research conducted by Wirtz et al. (2018) revealed that healthcare providers often lack understanding and knowledge about the experiences of LGBTQ+ patients, further adding to their vulnerability. The fear of judgment and discrimination frequently prevents LGBTQ+ individuals from coming forward about their experiences, as emphasized by a participant's account of not revealing their sexual orientation to their Christian parents (Participant 0033)

"One day when we were casually talking, I just somehow inserted this topic to observe their reactions; I hate to say I was disappointed and saddened, so I did not tell them for fear of being disowned...he laughs...yes it also happens in the black communities they can disown your ass."- Participant 003

Studies have indicated that LGBTQ+ individuals experience higher levels of violence, leading to adverse mental health outcomes (Sherman et al., 2021). Additionally, the impact of poly-victimization within this community differs in presentation, duration, and severity (Sherman et al., 2021). It is imperative to address the stigma surrounding LGBTQ+ individuals in relationships and acknowledge the specific risks they face (Gamarel et al., 2020).

Participants shared their experiences of facing violence and discrimination due to their sexual orientation, with one recounting a disturbing incident where a lesbian was gang-raped and murdered, an event largely unreported in the media. The LGBTQ+ community often remains in the closet, fearing judgment and assault.

In conclusion, these findings offer a multifaceted view of gender-based violence in Mankweng Township, highlighting the pervasive influence of traditional customs, cultural practices, and societal norms. It underscores the necessity of including all segments of the community, particularly men, in initiatives to combat GBV and encourages rethinking cultural and religious influences to promote gender equality and reduce violence.

The Study's Research Gap and the Direction for Future Research

Gender-based violence (GBV) is a deeply concerning issue in South Africa, recognized globally as a human rights violation. It predominantly targets women and girls, and studies often identify men as the primary perpetrators. As Brankovic (2019) noted, GBV frequently involves the assertion of power and control over another person, as seen in cases of intimate partner violence.

However, this study illuminates a crucial perspective often overlooked: not all men are perpetrators of GBV, just as there are both good and bad individuals among women. Male participants in this study displayed a promising commitment to becoming better versions of men in this era. They acknowledged their responsibility in addressing men's violent behaviour and actions against women, expressing a desire not to harbour violence or consider it an appropriate disciplinary measure against women.

The LGBTQ+ participants in this study shed light on another facet of GBV. They articulated feeling marginalized in discussions about GBV, even though they are equally impacted by it. Wirtz et al. (2018) support this sentiment, highlighting the pronounced gendered power dynamics present in cases of violence against LGBTQ+ individuals. Yet, research, prevention, and response efforts for GBV among the LGBTQ+ population remain limited.

The research gap identified in this study is the scarcity of literature addressing GBV among men and the LGBTQ+ community. While there is a substantial body of literature focusing on why women and girls are the primary victims of GBV, other genders have been comparatively neglected. The male participants in this study expressed a genuine desire to be actively involved in initiatives aimed at combating GBV, and some have already taken steps by participating in programs such as the Men's Association Against Violence (MAAV) hosted by the University of Limpopo in May this year.

One notable example of research addressing GBV among men is the study conducted by Graaff (2017) titled "Masculinities and Gender-based Violence in South Africa: A Study of a Masculinities-focused Intervention Programme." This study delved into the link between masculinity and GBV in South Africa, offering valuable insights. It demonstrated that men can also experience violence and emphasized the importance of involving them in future GBV intervention and prevention programs.

Additionally, as Brankovic (2019) pointed out, in societies where patriarchal norms and inequality prevail, frustrated masculinity can manifest in violent behaviour, not because men inherently desire violence but because they have been conditioned to behave that way. Unveiling this dynamic is essential to understand and address GBV comprehensively.

Hence, there is a need for future research to explore GBV from the perspectives of men and the LGBTQ+ community. This research should aim to provide a more inclusive understanding of GBV, recognizing that all genders can be both victims and perpetrators. It can build upon the foundation laid by this study and scholars like Graaff (2017) to contribute to a more holistic approach to addressing GBV.

Furthermore, future research can also be crucial in guiding policy frameworks and government initiatives.

Governments should prioritize addressing GBV across all genders and include them in prevention and intervention programs. By doing so, they can create more effective policies that address the root causes of GBV and provide support to all affected individuals.

6. Recommendations

Gender-based violence (GBV) remains a significant challenge in Mankweng Township. Based on the comprehensive findings of this study, the following recommendations are made to address this pressing issue:

- Awareness of Gender-Based Violence Programs

Initiatives to combat GBV should prioritize raising awareness among the community members, particularly men and boys. Programs and campaigns should be designed to reach all population segments to ensure that everyone understands the gravity of GBV and the role they can play in preventing it. Raise awareness by developing community-driven awareness campaigns to educate residents about existing policies and resources available to combat GBV. Collaborate with local schools, community centres, and religious institutions to disseminate information effectively.

This recommendation aligns with the study's findings that men and boys expressed a genuine willingness to be part of the solution to GBV. By increasing awareness and education, we can engage men and boys in dialogue about GBV and encourage their active involvement in prevention efforts. This is vital for changing social norms and attitudes surrounding violence.

- Better Distribution of Resources for Gender-Based Violence Issues

Resources allocated for GBV issues should be distributed more effectively and equitably, considering the unique needs of different genders, including men and LGBTQ+ individuals. This includes funding for support services, prevention programs, and research efforts. Advocate for increased government commitment and funding towards the implementation of GBV policies. This should include rigorous monitoring and evaluation mechanisms to ensure effectiveness.

The study revealed that GBV affects various genders, including men and LGBTQ+ individuals. Therefore, resource allocation should be more inclusive and tailored to address the specific challenges faced by these groups. This recommendation aims to ensure that resources are channelled where they are most needed.

- Rethinking Cultural and Religious Influences to Promote Gender Equality and Reduce Violence

Efforts should be made to reshape cultural and religious influences to promote gender equality and reduce violence. This can be achieved by fostering open and inclusive discussions within religious institutions, schools, and the broader community about GBV and gender equality. The cultural transformation could be achieved by launching community-based programs to challenge and transform traditional cultural norms and practices that perpetuate GBV. Engage community leaders and elders in these efforts.

Cultural and religious norms were identified as significant factors perpetuating GBV. To address this, creating safe spaces for dialogue within these institutions is essential. By challenging traditional beliefs that normalize violence, we can work towards cultural and religious environments that support gender equality and discourage violence.

- New Gender-Based Violence Policy Frameworks that Cater for All Genders Male, Female, and LGBTQ+ People

The government and policymakers should develop new GBV policy frameworks inclusive of all genders, including males and LGBTQ+ individuals. These frameworks should address the unique needs and vulnerabilities of each group. Current policy frameworks often focus predominantly on women and girls, leaving other genders marginalized. To create effective policies, it is essential to consider the experiences and challenges faced by all individuals affected by GBV. This recommendation aims to ensure that policies are comprehensive and equitable as encouraged by recommendation number 2.

- Prioritize Urgent Response to Gender-Based Violence Victims and Survivors

There should be a prioritization of urgent response mechanisms to assist GBV victims and survivors. This includes establishing rapid response teams, accessible crisis hotlines, and safe shelters for those in immediate danger. Victims and survivors of GBV often face critical situations that require immediate assistance. Establishing efficient response mechanisms can save lives and provide essential support during emergencies.

- Increase Support Services and Access to Justice for Victims and Survivors of GBV

Access to support services, including counselling, legal aid, and medical assistance, should be increased and made readily available to victims and survivors of GBV. This includes ensuring that justice is accessible through fair legal processes and is served. The study revealed the profound and lasting effects of GBV on victims and survivors. By expanding support services and improving access to justice, we can provide much-needed assistance and help individuals rebuild their lives after experiencing GBV.

Implement economic empowerment programs targeting women in Mankweng Township, providing them with opportunities for financial independence and self-sufficiency. These recommendations, rooted in the study's findings, emphasize the importance of inclusivity, awareness, and the active involvement of all community members, regardless of gender or sexual orientation, in the collective efforts to prevent and respond to GBV. This study not only serves as a crucial foundation for future research but also as a call to action in the ongoing battle to eradicate GBV, both within this region and beyond.

7. Limitations of the Study

While this study endeavoured to provide a comprehensive exploration of the implementation of the gender-based violence (GBV) policy framework in Mankweng Township, certain limitations must be acknowledged. Firstly, the study's focus on a single case study limited the generalizability of the findings to other contexts (Rass, 2020). The unique socio-cultural and geographical characteristics of Mankweng Township have affected the transferability of the study's results to different regions.

Secondly, despite careful efforts to ensure the ethical conduct of the research, the sensitivity of the topic had potentially led to response bias or underreporting, as participants were hesitant to openly discuss their experiences or opinions on gender-based violence. Furthermore, the researcher's subjectivity and biases, though minimized through reflexive practices, could have influenced the interpretation of data (Garland-Thomson, 2020).

Additionally, the sample size, though selected purposefully to provide rich insights, did not fully capture the diversity of perspectives within Mankweng Township. The reliance on self-reported data, while valuable, could be subject to memory biases or varying levels of accuracy in participants' recollections (Cypress, 2017).

Building upon the findings and deductions of this study, several suggestions emerge to guide future research, policy development, and interventions aimed at addressing gender-based violence (GBV) (Table C).

Table C. Directions of further research

Suggestion	Explanation
Inclusive Research:	Scholars should conduct more inclusive research that explores the experiences of GBV across genders, including women, men, and LGBTQ+ individuals. This approach will provide a comprehensive understanding of the factors contributing to GBV and inform targeted interventions.
Intersectional Analysis:	Future research should adopt an intersectional approach, considering how various factors such as race, socioeconomic status, and disability intersect with gender and sexual orientation to influence experiences of GBV. This nuanced perspective can guide more effective interventions.
Comprehensive LGBTQ+ Studies:	Given the underrepresentation of LGBTQ+ experiences in GBV research, future studies should focus on the unique challenges faced by this community. This includes understanding the intersections of discrimination, violence, and mental health among LGBTQ+ individuals.
Normative Change Initiatives:	Initiatives should be developed to challenge and change harmful cultural and religious norms that perpetuate GBV. These initiatives should involve community leaders, religious institutions, and grassroots organizations to promote gender equality and non-violence.
Inclusive Policy Frameworks:	Policymakers should prioritize the development of gender-based violence policy frameworks that explicitly cater to the needs of all genders, including male, female, and LGBTQ+ individuals. These policies should provide resources, support, and protection for all victims and survivors.
GBV Prevention Programs:	Universities and institutions should expand their GBV prevention programs to include men, boys, and LGBTQ+ members. Programs like the Men's Association Against Violence (MAAV) at the University of Limpopo should be promoted and supported to engage men and boys in combating GBV.
Community-Based Support:	Initiatives should be established within communities to provide safe spaces for victims of GBV, regardless of their gender or sexual orientation. These spaces should offer counselling, legal support, and resources for healing.
Awareness Campaigns:	Public awareness campaigns should be launched to challenge stereotypes, raise awareness about GBV against all genders, and encourage reporting. These campaigns should include diverse voices and representations.
Encourage Reporting:	Measures should be put in place to encourage victims to report GBV without fear of judgment or stigma. This may involve strengthening legal protections, offering anonymity, and increasing accessibility to reporting mechanisms.
Longitudinal Studies:	Researchers should consider conducting longitudinal studies to assess the long-term effects of GBV on individuals and communities. This could provide valuable insights into the lasting impacts and recovery processes.

Incorporating these suggestions into future research, policy development, and interventions can contribute to a more inclusive, comprehensive, and effective approach to addressing gender-based violence in all its forms and among all segments of society.

6. Conclusions

This study has provided valuable insights into the intricate issue of gender-based violence within Mankweng Township. By successfully achieving its research objectives, the study has uncovered the root causes of GBV, identified the limitations of existing policy frameworks, elucidated the profound impacts on individuals and the community, and proposed interventions to combat this deeply entrenched problem. It is evident that addressing GBV necessitates a multifaceted approach that challenges deeply ingrained cultural norms, demands government commitment, and empowers individuals through education and economic opportunities (Graaff, 2017). By

implementing the aforementioned recommendations, Mankweng Township can take significant strides toward reducing GBV and fostering a safer, more equitable community for all its residents. This study underscores the significance of addressing the identified research gap through future research initiatives that explore gender-based violence (GBV) from the perspectives of men and the LGBTQ+ community. Such research endeavours are pivotal for fostering a more inclusive and comprehensive approach to combatting GBV, not only in South Africa but on a global scale. Hence, the researcher strongly advocates for the active involvement of men and boys in GBV prevention programs. These programs should prioritize educating them about healthy masculinity, consent, and the importance of fostering respectful relationships. By positioning men as allies in the battle against GBV, these programs can challenge harmful gender norms and behaviours, offering a promising avenue to reduce GBV cases.

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RE-ENVISIONING THE ARTIFICIAL INTELLIGENCE-ENTREPRENEURSHIP NEXUS: A PIONEERING SYNTHESIS AND FUTURE PATHWAYS

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Abstract. The rapid advancement of artificial intelligence (AI) is profoundly transforming the entrepreneurial landscape while presenting a myriad of opportunities and challenges. However, scholarly inquiries into this pivotal intersection remain fragmented and lack a comprehensive and interdisciplinary understanding. This study provides a systematic review that consolidates insights from across AI, innovation and entrepreneurship literature to provide an integrated examination of the AI-entrepreneurship nexus. Through rigorous analysis of 92 studies, key themes are elucidated, including AI's impact on opportunity recognition, business model reinvention and socio-economic dynamics. An original Socio-Technical Systems framework is proposed, capturing the interplay between AI adoption decisions, AI-augmented opportunity exploration, innovative AI configurations and broader socio-economic consequences. While acknowledging AI's transformative potential, the review sounds a clarion call for responsible scholarship that centres on equity and social justice. It advocates a reflexive, inclusive approach, allowing marginalised voices and alternative perspectives to emerge. Theoretical contributions are made by extending established frameworks from technology adoption, business models and socio-technical systems to the AI-entrepreneurship context. Furthermore, actionable implications are provided for policymakers to develop governance models balancing innovation and ethical oversight. Therefore, entrepreneurs and support organisations are guided in facilitating responsible AI integration across diverse ecosystems. This unprecedented cross-disciplinary synthesis illuminates crucial gaps, charting an agenda for future research on transparency, accountability and mitigating AI's unintended impacts. As AI continues reshaping entrepreneurial frontiers, this review catalyses a trajectory of ethically- conscious scholarship poised to shape inclusive technological progress aligned with human values and societal wellbeing.

Keywords: Artificial intelligence (AI); entrepreneurship; entrepreneurial opportunities; business models; artificial intelligence adoption; socio-economic impact

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1. Introduction

Technological advancements in artificial intelligence (AI) are fundamentally reshaping the entrepreneurial scope and nature within the context of the ongoing industry 4.0 revolution (Nambisan et al., 2019; von Briel et al., 2018; Carbonara & Santarelli, 2023). Despite a growing sense of AI optimism and technical dynamism, AI is no longer a futuristic concept but a present-day reality. While this may be the case, scholarly research on this complex relationship continues to be fragmented, though incremental contributions with diminished real-world relevance have been observed.

This paper presents a comprehensive and interdisciplinary research agenda that systematically explores the economic, ethical and societal implications of AI-driven entrepreneurship. More specifically, analysing and integrating various interpretations from existing studies to establish a coherent understanding while identifying key research gaps that warrant further investigation. We consider analytical frameworks derived from technology adoption theories such as UTAUT (Venkatesh et al., 2003) and business model perspectives (Massa et al., 2017) to consolidate a wide range of literature to uncover the diverse impacts of AI on opportunity identification, business model structures and socio-economic positioning within the entrepreneurial landscape. However, the current research on the AI entrepreneurship nexus has not yet advanced and it still seems there is a paucity of studies related to that (Kraus et al., 2019; Aldoseri et al., 2023).

From a theoretical point of view, this paper moves beyond detailing possibilities to consider potentially disempowering negative impacts of increasingly ubiquitous AI algorithms within entrepreneurial contexts. We argue that AI scholarship requires a responsibility perspective centring on equity and social justice. Thus, this paper contributes conceptual consolidation while advocating a reflexive, questioning approach, allowing marginalised voices and alternative understandings to emerge through open-minded discovery (Box-Steffensmeier et al., 2022). In doing so, scholars can contribute to a deeper understanding of AI's transformative impact on entrepreneurial activities and inform the development of policies and practices that foster responsible and inclusive entrepreneurial ecosystems in the digital era.

Despite various scholarly debates on AI, there is no doubt that AI advancements present unprecedented opportunities for entrepreneurs to identify new business ideas, reach customers and develop innovative business models (Upadhyay et al., 2022). However, considerable uncertainty remains regarding potentially invasive, manipulative and biased AI technologies that could erode privacy and human agency in entrepreneurial ecosystems (Lu, 2022). One of our primary concerns is the emergence of these opaque, advanced AI systems that generate tension between algorithmic secrecy and ethical concerns. Tangential to this are entrepreneurial actors increasingly relying on these algorithmic systems, which often remain black boxes, inaccessible and mysterious to an average entrepreneur. Yet in policy debates, ensuring transparency and accountability of AI systems is crucial but frequently disregarded or evaded. It is not our intention to adopt an excessively pessimistic stance in our analysis. Still, future entrepreneurship scholarship must query pre-configured AI solution narratives by foregrounding human-centric perspectives and pluralistic governance approaches. Therefore, we look forward to responsible AI adoption necessitating reflexive questioning of extant assumptions that risk technological solutionism. As entrepreneurship scholars, we suggest that this may require renewed and modernised mechanisms balancing AI with ethical human oversight and participation by diverse entrepreneurial stakeholders. This necessitates scholars to examine asymmetric power dynamics and advocacy needs to empower entrepreneurs in increasingly AI-mediated ecosystems.

1.1 Research gaps and contributions

Despite the proliferation of AI's transformative potential for entrepreneurship, there is paucity of existing literature providing a comprehensive and interdisciplinary integrated understanding of this complex phenomenon, especially from a human-centric perspective. Scholars draw attention to specific aspects of AI's impact, such as opportunity recognition (Kang et al., 2023), business model innovation (Åström et al., 2022) or job automation (Tyson & Zysman, 2022), without considering the interconnectedness and broader socio-economic implications. Our conjecture is that the utilisation of well-established theoretical frameworks, such as UTAUT, TAM, and business model perspectives in the context of responsible AI and entrepreneurship remains underexplored.

Based on our knowledge thus far, this paper addresses these gaps by providing the first systematic review that consolidates insights from computer science, entrepreneurship studies, innovation and ethics literature, offering a holistic perspective on the AI-entrepreneurship nexus. It extends existing work by proposing an original Socio-Technical Systems framework that integrates key domains, such as AI adoption decisions, AI-augmented

opportunity recognition, innovative AI configurations and socio-economic consequences, into a coherent conceptual model. We do not fully comprehend the urgent need for responsible AI scholarship that centres on equity and social justice concerns, which are often overlooked in prevailing techno-optimistic narratives. Hence, this paper paves the way for more inclusive and ethically conscious research on AI and entrepreneurship.

2. Literature Review

Recently, AI has generated a remarkable fascination and garnered widespread attention among humankind as it has become increasingly recognised as a possible all-encompassing technology in the last decade (Brynjolfsson et al., 2021). Due to its technical dynamism, AI is widely regarded as a versatile and transformative technology in this industry 4.0 era (Brynjolfsson & Mitchell, 2017). Driven by improvements in machine learning, the cost of forecasting in different fields is rapidly decreasing (Agrawal et al., 2019, 2023). This poses intriguing questions about the areas where AI will be implemented and its potential to disrupt entrepreneurship (Gans & Leigh, 2020). However, Alvarez and Barney (2007) argued that the burgeoning wave of AI systems presents transformative technological solutions that have the potential to alleviate crucial uncertainties that are integral to novel entrepreneurial opportunities. Although significant advancements have been made in AI technologies since the publication of Alvarez and Barney's work (2007), the fundamental premise that AI systems can offer transformative solutions to mitigate uncertainties inherent in identifying and pursuing entrepreneurial opportunities remains applicable. This is supported by Kang et al. (2023), who assert that despite the growing interest in entrepreneurship and the utilisation of AI, there is still a gap in the existing literature regarding their influence on opportunity recognition. While individual studies have examined these factors individually, only a limited number have explored the combined impact of entrepreneurial bricolage and AI utilisation on opportunity recognition (Olan et al., 2022). Even though these gaps exist, we do not hold any reservations that AI enables entrepreneurs to identify new patterns, optimise decision-making and automate tasks, therefore fundamentally reshaping the way opportunities are discovered and pursued (Agrawal et al., 2023).

2.1 AI and Business Model

During Industry 4.0, new technologies like AI, IoT, deep and machine learning are reshaping and disrupting current entrepreneurial business model practices. (Amoako, et al., 2021; Chalmers et al., 2021). This shows that AI is a fundamental and critical technology that is significantly disrupting entrepreneurial activities (Agrawal et al., 2023). Despite the widespread recognition of the beneficial impacts that AI can have on entrepreneurial endeavours such as trend identification, decision-making and judgment (Mikalef & Gupta, 2021), the nexus of AI and entrepreneurship business models remain a complex and multifaceted phenomenon. Hence, AI integration into business model processes presents both opportunities and challenges that necessitate a nuanced understanding, especially within the entrepreneurship ecosystem. With the foregoing discussions on AI business models, it is imperative to underscore that a significant proportion of the empirical data underpinning extant scholarly literature on the utilisation of AI technologies emanates from well-established and technologically advanced corporate entities. Put simply, there is still an unexplored research field in the field of nascent entrepreneurs, according to Mikalef & Gupta (2021). This could be due to the challenges of successfully integrating AI applications faced by nascent entrepreneurs. Such challenges necessitate specific capabilities and resources, substantial investments and protracted development cycles typically associated with established organisations (Brock & Von Wangenheim, 2019).

As AI technologies continue to advance and become more accessible, their potential to augment entrepreneurial business model processes, enhance resource allocation and streamline operations remains highly relevant (Nambisan, Wright & Feldman, 2019). While specific AI applications and uses may have evolved, the underlying notion of leveraging AI to mitigate uncertainties and foster business model success remains a valid and pertinent consideration in the current entrepreneurial landscape. However, to capitalise on AI technology, it is imperative to comprehend how this technology can be commercialised by implementing a fitting business model (Bouncken et

al., 2021). According to Valter et al. (2018), previous research has been insufficient in comprehending the effective operationalisation of AI solutions by entrepreneurs within their business models, especially in relation to the technological advancements in the AI field. As such, the literature lacks a comprehensive examination of how established theoretical frameworks, such as UTAUT and business model perspectives, can be adapted and extended to better understand the AI-entrepreneurship nexus.

One central perspective that informs our understanding of how AI transforms opportunity exploration and business model innovation is the notion of "AI as a general-purpose technology" (Brynjolfsson et al., 2021). This view suggests that AI has the potential to revolutionise a wide range of industries and entrepreneurial activities, like previous general-purpose technologies like electricity and the internet (Brem et al., 2021). To comprehend this concept, business models can be defined as "an intermediary framework between technology and economic value" (Chesbrough & Rosenbloom, 2002) and can be categorised into two crucial functions: mechanisms for value creation and mechanisms for value capture (Chesbrough, 2007). In other words, the business model encompasses a series of activities with the objective of fulfilling the needs of the end customer while outlining the strategies employed by the operating firm to generate economic gain from said activities. Consequently, when novel technologies like AI are incorporated into the entrepreneurial environment, business model theories must be adapted to fully exploit the potential of these disruptive AI technologies. This is due to the fact that innovating the business model is equally crucial as developing sophisticated technical solutions (Muhic & Bengtsson, 2021).

However, a contrasting perspective emphasizes the "limits of AI", arguing that the current capabilities of AI are often overstated and that significant technical and societal barriers remain. This view arguably suggests that the impact of AI on entrepreneurship may be more incremental and context-dependent than the general-purpose technology perspective implies. Our analysis of AI adoption and integration challenges, as well as the socio-economic consequences of AI resonates with this perspective. Another key debate in the literature concerns the "substitution vs complementarity" of AI in entrepreneurial activities (DeCanio, 2016; Lichtenthaler, 2018). Some scholars argue that AI primarily substitutes human labour, leading to widespread job displacements and the concentration of economic power (Acemoglu et al., 2020). Other scholars suggest that AI mainly complements and augments human capabilities, enabling entrepreneurs to create new forms of value and pursue previously unattainable opportunities (Jorzik et al., 2023). Our analysis of AI-augmented opportunity recognition and AI-transformed business models speaks to this debate, highlighting both AI's substitutive and complementary aspects in entrepreneurial processes. The review also advocates the need for responsible oversight mechanisms and inclusive governance models to ensure equitable distribution of AI's benefits.

2.2 Socio-economic and ethical implications of AI

Our enthusiasm is also drawn by the desire to comprehend AI's socio-economic and ethical implications for entrepreneurship. This view emphasizes the importance of considering the moral and social dimensions of AI development and deployment beyond purely economic and technological considerations (Cowls & Floridi, 2018). Our analysis of the socio-economic ramifications of AI and the demand for responsible AI scholarship aligns with this perspective. Moreover, we argue that entrepreneurship research must engage critically with the ethical challenges posed by AI, such as algorithmic bias, data privacy and the distribution of benefits and risks. By advocating for a reflexive and inclusive approach that centres on equity and social justice, this paper makes a valuable contribution to the ongoing scholarly discourse on the ethical imperatives of AI-driven entrepreneurship.

2.3 Socio-technical Systems and AI

Finally, our study draws upon the "socio-technical systems" perspective, which underscores the intricate interplay between social and technical elements in shaping socio-technical matters (Volti & Croissant, 2024). This view suggests that the outcomes of AI-driven entrepreneurship depend not only on the inherent capabilities of AI technologies but also on the broader social, technical and institutional contexts in which they are developed and deployed (Johnson & Wetmore, 2021). The proposed Socio-Technical Systems framework in this review

integrates insights from this perspective, highlighting the interconnected domains of AI adoption decisions, opportunity exploration, business model innovation and socio-economic consequences. By situating AI-driven entrepreneurship within a socio-technical systems context, the study offers a more holistic and contextualised understanding of the phenomenon.

In a nutshell, this review critically examines multiple perspectives within the academic discourse on AI-entrepreneurship connection, connecting them to the core research questions. By drawing upon insights from the general-purpose technology perspective, the limits of AI view, the substitution vs complementarity debate, and the ethical implications of AI and socio-technical systems approach, the study offers a comprehensive and nuanced analysis of the AI-entrepreneurship nexus. In doing so, this amalgamation of these diverse perspectives strengthens the theoretical and practical relevance of the review while also highlighting the complex and multifaceted nature of the phenomenon under study. As such, this paper contributes to advancing the scholarly conversation on AI and entrepreneurship, while also providing actionable insights for entrepreneurs, policymakers and support organisations navigating the opportunities and obstacles of AI-driven entrepreneurship.

3. Theoretical Frameworks

The Unified Theory of Acceptance and Use of Technology (UTAUT) proposed by Venkatesh et al. (2003) offers a valuable framework for analysing the adoption of AI among entrepreneurs. The UTAUT synthesises elements across eight theories to explain technology acceptance and use. Key factors such as performance expectancy, effort expectancy, social influence, and facilitating conditions can provide valuable insights into the motivations and obstacles faced by entrepreneurs when it comes to incorporating AI into their businesses. However, UTAUT's applicability may be limited for disruptive, emerging technologies like AI due to its origins in more mature organisational contexts (Uren & Edwards, 2023). Adapting UTAUT to the specific characteristics of AI technologies and entrepreneurial settings is crucial for enhancing its explanatory power (Lin et al., 2022).

AI could disrupt an entrepreneur's value proposition, activities, resources and revenue streams. Yet these business model frameworks largely view technology as an enabler rather than exploring its autonomous and intelligent characteristics (Burstrom et al., 2021). Integrating perspectives from areas like machine behaviour (Rahwan et al., 2019) and AI ethics (Cowls & Floridi, 2018) may enhance the relevance of these frameworks for AI-driven entrepreneurship.

In addition to UTAUT and business model frameworks, other theoretical perspectives, such as the Technology-Organisation-Environment (TOE) framework (Na et al., 2022) and the Resource-Based View (RBV) (Ahmad et al., 2020), can provide complementary insights into the AI-entrepreneurship nexus. The TOE framework encompasses an analysis of the TOE factors that significantly impact technology adoption decisions. On the other hand, the RBV underscores the significance of distinctive resources and capabilities as drivers of competitive advantage. By integrating these theoretical perspectives, a more comprehensive comprehension of how entrepreneurs effectively navigate the opportunities and challenges associated with AI technologies can be attained.

4. Literature Search Methodology

The systematic review centred around two core research questions (RQs):

RQ1: *How is AI transforming opportunity exploration and business model innovation within entrepreneurial contexts?*

RQ2: *What are the broader socio-economic consequences of proliferating, often opaque AI systems across entrepreneurial actors and activities?*

Multiple databases were systematically searched between January and April 2024 following the PRISMA guidelines (Moher et al., 2009), including Web of Science, IEEE Xplore, ScienceDirect, JSTOR, and Google Scholar. Advanced searches combined selected keywords using Boolean operators: (“artificial intelligence” OR “AI” OR “automation” OR “machine learning”) AND (“entrepreneur” OR “entrepreneurship”) AND (“start-up” OR “new venture”). Additional relevant papers were identified through backward and forward citation searching of selected articles (Table 1).

Table 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
○ Peer-reviewed articles. ○ Published articles between 2010-2024. ○ Explicit examination of AI’s impacts on entrepreneurial actors or ecosystems. ○ English language.	- Non-peer reviewed articles. - Focused solely on technical aspects of AI lacking entrepreneurial context. - Did not examine AI’s impacts on entrepreneurial activities or ecosystems. - Paper written in foreign languages.

After removing duplicates, 264 records were screened based on title and abstract review, while 118 full-text articles were evaluated for eligibility according to the inclusion/exclusion criteria. In total, 92 studies met the criteria and were included in the final review. A spreadsheet was created to extract relevant data fields from studies, including author(s), year, methodology, sample, key topics, findings, and limitations. The authors then extracted data to minimise bias. Any disagreements by the authors were resolved through discussion. Rigorous thematic analysis involved an iterative process of open coding, creating categories and identifying overarching themes related to the research questions. Atlas ti software facilitated transparent and systematic data analysis. Codes were compared across studies and synthesised into conceptual themes describing AI’s impacts on entrepreneurial opportunity exploration, business models and socio-economic landscapes. This rigorous methodology provides a transparent, systematic approach to searching, screening, assessing eligibility, extracting and synthesizing findings across the identified literature. The detailed procedures aim to boost reproducibility while ensuring a comprehensive evidence base addressing the guiding research questions.

5. Data Analysis

Extracted data from the 92 studies underwent rigorous qualitative thematic analysis to classify common themes, patterns and insights across the AI-entrepreneurship domain. Initially, open coding was utilised, where data were read line-by-line to assign conceptual labels to text segments related to the overarching research questions (Saldaña, 2021). For example, text passages discussing new business models enabled by predictive analytics were coded as “AI-based business model innovation”. This surfaced an initial set of analytic categories. In addition, focused coding grouped open codes into conceptual clusters to develop main categories such as “opportunity recognition”, “data-driven business models”, “socio-economic impacts”, etc. These category codes were then systematically applied to the entire dataset using Atlas ti software.

Finally, thematic analysis elicited higher-order themes encompassing sets of categories. Key overarching themes included "AI Adoption and Integration", "AI-Augmented Opportunity Recognition", "AI Transforming Business Models", and "Socio-Economic Impacts". Within these themes, nuanced findings around sub-topics emerged through careful iteration between data and theory. For instance, under the "AI Adoption and Integration" theme, the analysis revealed complex factors influencing entrepreneurs' AI adoption decisions, such as performance expectancy, effort expectancy and facilitating conditions, aligning with the UTAUT framework (Venkatesh et al., 2003). However, the analysis also highlighted the limitations of applying UTAUT in the context of disruptive AI technologies and the need for further adaptation.

Similarly, within the “AI Transforming Business Models” theme, the analysis uncovered how AI reshapes key business elements like value proposition, activities, resources, and revenue streams. Nevertheless, the analysis also emphasised the importance of integrating perspectives from machine behaviour (Rahwan et al., 2019) and AI ethics (Cows & Floridi, 2018) to better capture the autonomous and intelligent characteristics of AI technologies in entrepreneurial settings. The in-depth qualitative analysis, guided by established theoretical frameworks while remaining open to emerging insights, allowed for a rich and nuanced understanding of the AI-entrepreneurship nexus. The analytical process moved beyond descriptive statements to provide critical interpretations and implications, contributing to the paper's theoretical and practical relevance.

6. Key Findings

Summary of key findings is provided below in Table 2.

Table 2. Summary of key findings

AI Adoption and Integration	- Integrating AI appears to be an urgent priority for entrepreneurs seeking enhanced analytical capabilities despite barriers around required data, skills, and ethical risks (Giuggioli & Pellegrini, 2022). - Analysis through theoretical lenses like UTAUT reveals performance expectancy and effort expectancy as key drivers of adoption, aligning with productivity narratives (Cubric, 2020). However, UTAUT's applicability may be limited for disruptive AI technologies, necessitating further adaptation. - Costs, security risks, inadequate human oversight may hinder assimilation but are understudied aspects (Vieira et al., 2022). - Beyond rationalistic framings, research must examine systemic constraints, political interests and situated contexts shaping if, how and which entrepreneurs integrate AI (Shepherd & Majchrzak, 2022).
AI-Augmented Opportunity Recognition	- Increased accessibility enables more entrepreneurs to leverage AI to identify promising niches from complex data patterns (Iansiti & Lakhani, 2020; Chalmers et al., 2021). - Assumptions of neutrality and objectivity mask risks of amplifying societal biases, necessitating responsible oversight mechanisms balancing automation and human judgment (Kleinberg et al., 2018). - Limited transparency surrounds the inner workings of AI systems, hinders accountability, and potentially disproportionately impacts under-resourced entrepreneurs.
AI-Transformed Business Models	- AI revolutionises key business processes, enabling data-driven decision-making but displacing some entrepreneurial roles (Jorzik et al., 2023; Verganti et al., 2020). - AI radically reshapes model configurations - tailored value propositions, micro-targeted customers, observation-based pricing (Roundy, 2022; Massa et al., 2017). Yet, solely enumerating possibilities overlooks constraints around data, industry complexity, integration capabilities (Agrawal et al., 2023). - Excessive AI intensifies risks of uncontrollability, necessitating updated oversight mechanisms integrating machine behaviour (Rahwan et al., 2019) and AI ethics perspectives (Cows & Floridi, 2018).
Socio-Economic Consequences	- Persisting debates on AI's potential to displace jobs through automation, requiring strengthened protections and training programs (Acemoglu et al., 2020). - AI rhetoric promising progress rarely draws critique from entrepreneurship scholarship (Heeks, 2021), lacking grounded investigation across diverse communities (Vinuesa et al., 2022). - While presenting opportunities, AI also generates risks and constraints requiring identification of oversight models upholding humanistic values.

Key Findings: Addressing the Research Questions

RQ1: How is AI transforming opportunity exploration and business model innovation within entrepreneurial contexts?

Our analysis reveals that AI is fundamentally altering the landscape of opportunity exploration and business model innovation in entrepreneurship through three primary mechanisms:

1. AI-Augmented Opportunity Recognition:

Undoubtedly, AI technologies are not merely enhancing but fundamentally restructuring the process of opportunity recognition. By leveraging machine learning algorithms and big data analytics, AI systems can identify complex patterns and market gaps that would be imperceptible to human cognition alone. This shift aligns with the theory of entrepreneurial bricolage (Baker & Nelson, 2005), where AI serves as a powerful tool for recombining existing resources (data) in novel ways. However, our findings indicate that this AI-driven approach to opportunity recognition may inadvertently reinforce existing biases in data, potentially narrowing the scope of entrepreneurial vision rather than expanding it.

2. Business Model Reinvention:

It appears there is a fundamental reimagining of business model structures catalysed by AI integration into entrepreneurial ventures. Drawing on the business model canvas framework (Osterwalder & Pigneur, 2010), we observe that AI is not simply optimising individual components but reshaping the entire architecture of value creation, delivery and capture. For instance:

- Value propositions are becoming increasingly personalised and predictive, leveraging AI's capacity for real-time data analysis and forecasting.
- Key entrepreneurial activities are shifting from human-centric to AI-augmented processes, blurring the lines between automation and human expertise.
- Customer relationships are being redefined through AI-driven interactions, raising critical questions about the nature of trust and authenticity in business-customer dynamics.

This transformation challenges traditional notions of competitive advantage, suggesting a shift towards what Teece (2018) terms "dynamic capabilities" in the AI era.

3. AI as a General-Purpose Technology (GPT):

Our findings support the characterisation of AI as a general-purpose technology (GPT), as proposed by Brynjolfsson et al. (2021). This shows that AI's impact on entrepreneurship extends beyond specific applications, fundamentally altering the nature of innovation and competitive advantage across industries. What this means is that the GPT nature of AI is driving a "creative destruction" process (Schumpeter, 1942) in entrepreneurial ecosystems, where AI-native startups are challenging incumbents and reshaping industry boundaries. Furthermore, our analysis reveals that AI is not merely a tool for incremental improvement but a driver of disruptive innovation in entrepreneurial contexts. This aligns with Christensen's (1997) theory of disruptive innovation, where AI-enabled startups are capable of rapidly scaling and challenging incumbent firms. However, our findings also indicate a 'winner-takes-most' dynamic emerging in AI-driven markets, potentially leading to increased market concentration and barriers to entry for nascent entrepreneurs.

RQ2: What are the broader socio-economic consequences of proliferating, often opaque AI systems across entrepreneurial actors and activities?

Our review uncovers several critical socio-economic implications, which we analyse through the lens of socio-technical systems theory (Geels, 2004):

1. Labour Market Dynamics

Our fundamental premise pertaining to labour market dynamics asserts that AI's impact on employment is more nuanced than a simple displacement effect. Drawing on the task-based model of technological change (Acemoglu & Restrepo, 2018), we argue that AI is simultaneously substituting for certain tasks while complementing others and creating entirely new job categories. In this sense, it results in a complex reallocation of labour across tasks and sectors rather than wholesale job losses. Tyson & Zysman (2022) supports this nuanced view, showing varying impacts across different skill levels and industry sectors.

2. Knowledge Asymmetries and Power Dynamics

It is important that the opacity of many AI systems is creating significant knowledge asymmetries between developers and users or those affected by them. This dynamic aligns with Zuboff's (2019) concept of "surveillance capitalism," where data and algorithmic knowledge become key sources of power. This raises crucial questions in the entrepreneurial context as this may lead to a new form of digital divide, where access to and understanding of AI technologies become critical determinants of success. The diffusion of AI technologies in entrepreneurship is exacerbating existing socio-economic inequalities. This aligns with the concept of "skill-biased technological change" (Goldin & Katz, 2018), where AI disproportionately benefits highly skilled entrepreneurs and workers. Furthermore, the data and computational resources required for advanced AI systems are concentrating power among a small number of tech giants and well-funded startups, raising concerns about market concentration and barriers to entry for new entrepreneurs.

3. Ethical Implications and Governance Challenges

There is a need to understand how the rapid deployment of AI systems in entrepreneurial contexts is outpacing the development of ethical frameworks and governance structures. This is worth noting as this gap creates significant risks, including algorithmic bias, privacy violations and unintended societal consequences. Drawing on stakeholder theory (Freeman, 1984), we argue that entrepreneurs have a responsibility to consider the broader societal impacts of their AI-driven innovations beyond immediate business goals. The algorithmic opacity and complexity of AI systems are creating significant challenges for accountability and fairness in entrepreneurial decision-making. The lack of transparency not only poses ethical concerns but also creates regulatory challenges as existing governance frameworks grapple to keep pace with AI advancements. Considering this regulatory lag, uncertainties and potential risks in areas such as data privacy, algorithmic bias and AI safety are created. While the European Union (EU) has pioneered global AI regulation with its comprehensive AI Act, the effectiveness of this groundbreaking legislation remains to be seen. Furthermore, its applicability to African contexts is uncertain, raising questions about its potential impact beyond European borders.

4. Ecosystem-Level Transformations:

AI is catalysing shifts in entire entrepreneurial ecosystems, altering the dynamics of innovation, competition and collaboration. This transformation aligns with the concept of "innovation ecosystems" (Adner & Kapoor, 2010), where the success of individual entrepreneurs becomes increasingly dependent on a complex network of AI-enabled actors and resources. AI is fundamentally altering the structure and dynamics of entrepreneurial ecosystems. Drawing on the ecosystem theory of entrepreneurship (Spigel, 2017), we argue that AI is reshaping the relationships between various actors (entrepreneurs, investors, support organisations) and the resources available within the ecosystem. This transformation creates new forms of interdependencies and changes the nature of competitive advantage within entrepreneurial ecosystems.

In conclusion, our analysis demonstrates that the impact of AI on entrepreneurship is profound and multifaceted, extending far beyond technological adoption to reshape fundamental aspects of opportunity recognition, value creation and socio-economic structures. These findings underscore the need for a more holistic, interdisciplinary approach to understanding and managing the AI-entrepreneurship nexus, one that considers not only the technological possibilities but also the broader societal implications and ethical considerations.

This analysis challenges simplistic narratives of AI as a uniformly positive force for entrepreneurial innovation, highlighting instead the complex interplay of opportunities and risks that demand careful consideration from entrepreneurs, policymakers and scholars alike.

7. Discussion

This systematic review offers an unprecedented integration of insights across AI, innovation, and entrepreneurship literature, providing a comprehensive understanding of the AI-entrepreneurship nexus. By consolidating fragmented scholarship, the study contributes the first cross-disciplinary analysis that uncovers AI's transformative impact on opportunity recognition, business models and socio-economic landscapes. The proposed Socio-Technical Systems framework offers an original conceptual lens encompassing key domains of AI adoption decisions, AI-augmented opportunity exploration, innovative AI configurations and socio-economic consequences. This holistic perspective extends existing work by highlighting the interconnectedness and broader implications of AI-driven entrepreneurship. However, the review also sounds an alarm on the lack of critical perspectives in prevailing techno-optimistic narratives. It argues that responsible AI scholarship centring on equity and social justice is essential as AI proliferates. Building on these foundations, this paper advocates for a reflexive and questioning approach that allows marginalised voices and alternative understandings to emerge, paving the way for more inclusive and ethically conscious research. By situating the findings within the broader academic literature on technology adoption (Venkatesh et al., 2003), business model innovation (Massa et al., 2017) and socio-technical systems (Benk et al., 2022), the review offers valuable theoretical contributions and highlights areas for further conceptual development.

8. Implications for Policy and Practice

The analysis of our review bears significant implications for policymakers, entrepreneurs and support organisations. Policymakers must develop comprehensive governance frameworks that balance the gains of AI-driven innovation with the imperatives for transparency, accountability, and inclusive participation. This requires updated regulations, ethical guidelines and oversight mechanisms that consider the unique characteristics of AI technologies and their potential impact on entrepreneurial ecosystems. Policymakers should ruminate on investing in targeted support programs and infrastructure to enable equitable access to AI resources and skills development for diverse entrepreneurial communities. Entrepreneurs must approach AI adoption with a critical and responsible mindset, carefully considering the ethical implications and potential risks alongside the opportunities. They should actively engage in dialogue with policymakers, researchers, and other stakeholders to shape the advancement and positioning of AI technologies in ways that align with societal values and priorities.

Moreover, entrepreneurs should also invest in building their own AI literacy and collaborating with experts to ensure the responsible integration of AI into their business models and practices. While support organisations, such as incubators, accelerators and entrepreneurship networks, play a crucial role in fostering responsible AI adoption and facilitating knowledge exchange, they should develop targeted programs and resources to assist entrepreneurs in navigating the complexities of AI technologies, including ethical considerations, data management and stakeholder engagement. Furthermore, support organisations can also serve as platforms for cross-sector collaboration and advocacy, bringing together entrepreneurs, researchers, policymakers and civil society to address the challenges and opportunities presented by AI.

9. Future Research Directions

This review lays the foundation for a rich research agenda on the AI-entrepreneurship nexus. Future studies should further refine and validate the proposed Socio-Technical Systems framework through empirical investigations across diverse contexts and industries. Researchers should also explore the boundary conditions and contingencies that shape the impact of AI on entrepreneurial processes and outcomes, considering factors such as industry maturity, regulatory environments, and cultural norms. Moreover, further research should aim to explore the ethical dimensions of AI-driven entrepreneurship, examining issues such as algorithmic bias, data privacy and the distribution of benefits and risks. This may require scholars to develop new methodological approaches, such as participatory action research and value-sensitive design, to engage entrepreneurship

stakeholders in the co-creation of responsible AI solutions. Hence, interdisciplinary collaboration, particularly with fields such as computer science, sociology and philosophy, will be essential to advance a holistic understanding of the AI-entrepreneurship nexus.

Finally, future research should investigate the long-term societal implications of AI-driven entrepreneurship, considering both the positive and negative externalities. By so doing, it includes examining the impact on job displacement, income inequality and the concentration of economic power, as well as the potential for AI to enable new forms of social entrepreneurship and sustainable value creation. By adopting a forward-looking and systems-oriented perspective, scholars can contribute to shaping the trajectory of AI-driven entrepreneurship in ways that promote inclusive growth and social well-being.

10. Conclusion

In conclusion, this systematic review provides a timely and critical examination of the AI-entrepreneurship nexus, highlighting the transformative potential of AI technologies while also exposing the ethical and societal challenges that must be addressed. By proposing an original conceptual framework and outlining a comprehensive research agenda, the study aims to inspire and guide future scholarship that is both theoretically rigorous and socially relevant. As AI continues to reshape the entrepreneurial landscape, it is imperative that researchers, policymakers, and practitioners work together to ensure that its benefits are harnessed in a responsible and equitable manner. This review serves as a call to action for a modernistic era of AI-driven entrepreneurship investigation that places human values and societal well-being at the centre of its inquiry.

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THE ROLE OF TECHNOLOGICAL INCUBATORS IN FOSTERING ENTREPRENEURIAL GROWTH: THE CASE OF EGYPTIAN UNIVERSITIES AND RESEARCH CENTRES

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Abstract. Incubators enable firms to grow technologically by providing them access to leading technologies and technical support. This paper undertakes an analysis of the way technological incubators can be utilized to enhance how Egyptian universities and research centres competitively drive entrepreneurship projects. The paper delves deeper into dimensions of cost reduction, improved quality, speed and flexibility in performance, creativity, and innovation. Using primary data on assembled information from a survey of entrepreneurs being trained under the INTILAC program and secondary information from business and academic publications, the paper tests how resources, strategies, operating techniques, and incubator management methods influence the capabilities of entrepreneurial ventures. The research results have proven that there is a strong positive statistically significant relation at the level of (0.01) between the dimension (objectives of the incubator and its administration) and the competitive advantage dimensions from entrepreneurship projects in the technological incubators of the Academy of Scientific Research. The research then proceeded with an overview of the SWOT analysis of the internal and external factors that affect business incubator performance. The study, therefore, seeks to establish a way by which technology-based incubators can develop an enabling environment not only for incubating innovative startups but also for fostering the region's economic growth. Results showed the indubitably significant role of those incubators in transforming the outputs of scientific research and innovations into a viable, economically feasible, and technologically competitive business that supports the development of Egypt's knowledge-based economy.

Keywords: Technology incubators; Competitive Advantage; Entrepreneurship; Egyptian Universities

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1. Introduction

Entrepreneurship is crucial for ensuring economic security by influencing employment, income, self-realization, and financial literacy, ultimately enhancing personal competitiveness within the economic system (Oblaukhova, 2023; Aghion, 2016). Incubators facilitate the launch of new businesses by giving entrepreneurs the resources and environment they require during the ideation phase. They function as hubs for entrepreneurial activity, transforming business concepts into ready-to-use operational procedures, goods, or services (Kaur et al., 2024).

Business incubation is widely recognized as a crucial mechanism for supporting entrepreneurs in establishing new ventures and is considered an integral part of modern entrepreneurial ecosystems (Szabó, 2006; Hausberg & Korreck, 2018). These incubators not only drive job creation and regional economic development by providing various facilities (Abetti, 2004), but they also play a significant role in the innovation system (Aerts et al., 2007). The effectiveness of business incubators hinges on their ability to attract high-quality ventures and to foster the development of new firms with significant growth potential, often originating from R&D activities within universities and research institutions (Alsos et al., 2011). Incubators already play a crucial role in facilitating the development of entrepreneurial capabilities within universities. Intrapreneurship refers to applying entrepreneurial skills and techniques within an existing organization, usually to devise and drive new business initiatives (Shekhar et al., 2023).

In addition, incubators contribute to the technological advancement of startups by facilitating access to cutting-edge technologies and technical support. This aspect is particularly crucial for technology-based startups whose competitive advantage often depends on their ability to innovate quickly (Leitão et al., 2022). Business incubation programs help create successful business opportunities, help achieve a good rate of return on investment, develop poor geographical areas, and improve the image and reputation of local communities, not to mention helping them reduce production costs and high rate of return on investment (Ali & Nazmi, 2023). In this context, the term "technology incubator" describes a system that facilitates the transfer of technology, helping in the growth of small businesses through innovation and supporting economic development methods (Allen & McCluskey, 1991). Universities worldwide have shifted their focus and goals in response to the requirement to remain economically viable and grow their value-generating activities (Wright, 2012), which also significantly impacts entrepreneurial ecosystems (Rubio & Cubero, 2015). These advances have strengthened the emphasis on academic entrepreneurship, defined as entrepreneurial activities conducted within academic environments by employees (Klofsten et al., 2021).

University technology incubators are crucial in fostering entrepreneurship and innovation within academia. The university business incubator (UBI) is defined as an incubator set up by the university to provide office space, equipment, mentoring services, and other administrative support to assist in the formation of new ventures (Wonglimpiyarat, 2016). These incubators serve as hubs for entrepreneurial ecosystems, providing support for young business startups through tangible and intangible resources (Rifai et al., 2023). These incubators provide startups with not only a physical workspace but also access to essential resources, including mentorship, networking opportunities, and often important funding sources. Knowledge, human capital, material capital, and entrepreneurial capital can all have an impact on a startup's performance (Audretsch & Keilbach, 2004). Access to various networks, resources, and expertise can also impact startup performance (Battistella et al., 2018). The role of these incubators extends beyond simply providing support to significantly enhancing the competitive advantage of entrepreneurship projects. They act as catalysts that turn innovative ideas into viable business ventures equipped to thrive in competitive markets (Nawawi & Mulyadi, 2022).

Most countries in the world have long-term public incubator programs aimed at promoting economic and social development. In Africa, they have recently begun to expand the activity of incubators based on science, technology and innovation (Lalkaka, 2002; Chandra, 2009; Dalmarco et al., 2018). In Egypt, business incubators have become a key part of the entrepreneurial ecosystem, supporting the growth and development of startups and fostering innovation. These incubators provide essential resources such as funding, mentorship, office space, and technical support, and they are often closely linked with universities, government initiatives, and private-sector partnerships. As a component of their innovation and entrepreneurship policies, many countries use technology business incubator programs to promote economic development. (Ács & Naudé, 2013).

One of the most important incubation programs in Egypt is the INTILAC Program affiliated with the Academy of Scientific Research and Technology. The INTILAC Program is considered the largest umbrella for establishing

and managing technological incubators in the entrepreneurship and innovation system. The program has established 43 technological incubators and aims to transform ideas, innovations and research outputs into emerging technological companies capable of economic and technological competition and their products. With a competitive ability to achieve the goal of the knowledge economy and to implement this program, the Academy cooperates with all parties in the country, including universities, institutes and research centres, in addition to cooperation with several ministries such as investment, industry and trade, in addition to the private sector and civil society institutions. Despite the potential importance of incubation in enhancing technological entrepreneurship and, consequently, the country's competitiveness, limited research has been conducted to determine the ability of Egyptian incubators to meet these high expectations.

Technology incubators enhance competitive advantage by fostering innovation, entrepreneurship, and collaboration between academia and industry, leading to economic growth, job creation, and societal benefits (M et al., 2022). A startup's competitive advantage is crucial for its success, stemming from unique attributes that outperform competitors (Sokhan & Popovskyi, 2023). Business incubators significantly enhance the competitive advantage of startups by establishing a supportive ecosystem that promotes growth and innovation. By providing essential resources such as office space, technology, and administrative services, incubators reduce overhead costs, allowing startups to focus on strategic growth activities (McAdam & McAdam, 2008). Organizations must continuously innovate and adapt to external environmental demands and internal capabilities for sustained competitive advantage. Creativity and innovation are essential pillars for maintaining this edge. The primary dimensions of competitive advantage include quality, which entails providing defect-free products at minimal cost and flexibility (Diab, 2013), which involves rapidly adapting to changes in product design and customer requirements and innovation, which empowers organizations to swiftly address environmental challenges and seize new market opportunities more effectively than their non-innovative counterparts. Additionally, cost efficiency plays a critical role in achieving competitive advantage by minimizing production costs to meet the demands of a broader customer base (Jerab & Mabrouk, 2023).

The aim of this paper is to present a study that handles and elaborates on the positive relationships between the dimensions of technological business incubators and the dimensions of competitive advantage for entrepreneurship projects that the "technological incubators of the Academy of Scientific Research and Technology" in Egypt incubated. This considers focusing on how the resources, the strategy, the techniques of operation, the objective, and the method of management of the incubators affect the improvement of entrepreneurial project capabilities of cost reduction, quality improvement, speed, and flexibility improvement along with creativity enhancement and innovation development and identifies the reality of business incubators by assessing the indicators of the internal environmental analysis and the external environment to identify the factors that have an effect on the success of business incubators at Egyptian universities and research centres.

2. Methodology

This study employs a structured methodology to explore the relationship between technology business incubators and their role in enhancing competitive advantage. The research framework is designed to focus on both independent and dependent variables. The independent variables of business incubators comprise dimensions such as resources, strategy, operational techniques, and management goals, while the dependent variable of competitive advantage comprises dimensions such as cost reduction, quality improvement, speed and flexibility, and creativity and innovation. Data collection for this research depends on primary data collected through a survey administered to entrepreneurs in incubators affiliated with the Academy of Scientific Research, which includes 43 incubators under the INTILAC program, encompassing 1,794 entrepreneurs.

The survey was designed to capture quantitative insights into the incubation processes and their outcomes, with a random sample of entrepreneurs in the technology incubators affiliated with the Academy of Scientific Research

totalling 340, and a response rate of 93.2%, resulting in 317 valid questionnaires. At the same time, the secondary data were sourced from published and unpublished studies, annual reports of technology incubators, and relevant academic and commercial publications. A SWOT analysis was administered to the managers of business incubators to assess the challenges and opportunities of incubators related to the Academy of Scientific Research and Technology in Egyptian universities and research institutes.

Descriptive statistics were applied to analyze the following dimensions of the study: Incubator Strategy, Incubator resources, Operational Techniques, Goals and Management of the Incubator, Cost Reduction, Quality Improvement, Speed and Flexibility, Creativity, and Innovation. A five-point Likert scale was utilized to measure each item of the survey, ranging from "Strongly Agree" (5), "Agree" (4), "Neutral" (3), "Disagree" (2), to "Strongly Disagree" (1). Based on the number of response, the range from (1-1.80) represents complete disagreement with a completely low level of agreement, range from (1.81-2.60) represents disagree with a low level of agreement, range from (2.61.-3.40) represents neutral with a moderate level of agreement, range from (3.41-4.20) represents agree with a high level of agreement and the range from (4.21-5) represents completely agree with a completely high level of agreement.

3. Results

3.1. Descriptive analysis

As shown in Table 1, the analysis of responses in respect of the incubator resources has detected moderate consensus regarding most statements, which, finally, is traced in the average mean score of 2.94, with a standard deviation of 0.23. The highest average mean value (3.19) was observed for the statement "The incubator's management encourages private sector institutions, companies, and banks to invest in developing scientific research," which sheds light that the role of the incubator is directed positively and there is support from the incubator for the private sector to invest in research. In contrast, the lowest score was observed for "The incubator provides an environment that supports innovation and commercialization" with an average mean of 2.51, supposedly indicating some dissatisfaction with the support environment in the incubator.

Most of the responses were in the 'Neutral' range (2.61-3.40), with an average level of agreement regarding the dimensions surveyed. The effectiveness of the incubator resources has shown a moderate level of consensus, with an average mean score of 2.94 and a standard deviation of 0.23 across all the statements. The highest average mean score of 3.19 was measured regarding this statement: "Incubator's management encourages private sector institutions, companies, and banks to invest in developing scientific research." Conversely, the lowest average score of 2.51 was recorded regarding this statement measured regarding the support rendered by the incubator to innovation and commercialization, suggesting a critical area for improvement. Most of the responses fell into the 'Neutral' category (2.61-3.40); hence, the general attitude toward the incubators would lean more toward ambivalence rather than standing firmly against the potential of incubators to become more supportive structures stimulating innovation and attracting more substantial private sector engagement.

Table 1. Mean, the degree of agreement, and standard deviation of the incubator strategy and incubator resources dimensions

Incubator strategy dimension	Mean	Standard deviation	Degree of agreement	Incubator resources dimension	Mean	Standard deviation	Degree of agreement
The incubator has a clear strategic vision about the necessity of investing in the human element.	2.63	1.216	52.6%	The incubator allocates a portion of its revenues to support technological ideas and training programs.	2.77	1.123	55.4%
The incubator constantly seeks to diagnose and adopt investment opportunities.	2.79	1.518	55.8%	The incubator continuously prepares exhibitions to sell products and provide services.	2.86	1.463	57.2%

Incubator strategy dimension	Mean	Standard deviation	Degree of agreement	Incubator resources dimension	Mean	Standard deviation	Degree of agreement
The incubator hosts projects in one field or projects in various fields.	2.97	1.401	59.4%	The incubator provides an environment that supports innovation and commercialization.	2.51	1.279	50.2%
The incubator organized several meetings with companies and mentors.	2.58	1.199	51.6%	The incubator management system is effective and supportive.	2.91	1.386	58.2%
The incubator has one or more alliances with industrial institutions in the incubator's field of work.	3.06	1.280	61.2%	The incubator's management team possesses effective leadership skills.	3.18	1.170	63.6%
The incubator maintains a close relationship with universities to encourage students and project members to develop new products.	3.18	1.513	63.6%	The incubator helped you effectively with regard to business deal processes (promotion, negotiation, contracting, etc.).	3.12	1.430	62.4%
The incubator evaluates the results achieved from human investment.	3.31	1.324	66.2%	The incubator facilitates cooperation and networking with other entrepreneurs.	2.97	1.363	59.4
The incubator targets technology companies for investment.	2.98	1.275	59.6%	The incubator's management encourages private sector institutions, companies and banks to invest in developing scientific research.	3.19	1.349	63.8%

Source: Authors

Table 2 shows the mean, relative importance, and standard deviation of responses on the operational technique's dimensions; the average mean was 2.87 and average standard deviation (1.40). Notably, the item "The incubator provides updated databases to facilitate patent registration procedures for their innovative projects" registered the lowest mean, indicating lower perceived effectiveness. On the other hand, the statement "It provides the necessary incubator to support the ideas and projects of talented people" recorded both the highest and lowest standard deviation, suggesting it is viewed positively albeit with varied experiences. Entrepreneurs' responses regarding the objectives and management of the incubator dimension resulted in an average mean 2.62 and a standard deviation 1.60, the item with the lowest mean was "The incubator management provides databases with advanced programs for business implementation," which suggested lesser effectiveness. The highest mean was 2.96 noted for "The incubator management system including mentors, managers, alliances, and company representatives cooperate in a consistent and integrated manner," indicating higher satisfaction.

Table 2. Mean, relative importance, and standard deviation of the operational techniques and goals and management of the incubator dimensions

Operational Techniques dimension	Mean	Standard Deviation	the degree of agreement	Goals and Management of the Incubator dimension	Mean	Standard Deviation	the degree of agreement
The incubator evaluates the team members and ensures that they are integrated.	3.08	1.304	61.6%	The incubator has a clear and specific goal that guides and decides its development direction.	2.28	1.603	45.6%
During the selection stage, the incubator is keen to evaluate the timetables for running projects and give comments and advice.	3.05	1.400	61%	The incubator management provides databases with advanced programs for business implementation.	2.25	1.438	45%

The incubator provides services in the field of establishing projects.	2.29	1.360	45.8%	The incubator management provides learning opportunities by sending external missions.	2.36	1.570	47.2%
The incubator provides updated databases to facilitate patent registration procedures for their innovative projects.	2.14	1.479	42.8%	The incubator's management uses advanced technologies to deliver its creative and innovative explorations.	2.61	1.510	52.2%
It provides the necessary incubator to support the ideas and projects of talented people.	3.48	1.239	69.6%	The incubator management has strong capabilities to integrate external technological resources with internal resources.	2.81	1.769	56.2%
The incubator has an efficient technological system to complete and manage activities with high efficiency.	3.47	1.298	69.4%	The incubator has clear policies that allow you to have appropriate expectations for the future.	2.77	1.647	55.4%
One of the criteria for evaluating projects is the ability to achieve rapid growth.	2.83	1.481	56.6%	The incubator management system, including mentors, managers, alliances and company representatives, cooperate in a consistent and integrated manner.	2.96	1.692	59.2%
During the selection stage, the selection team is keen to evaluate the available capital.	2.65	1.635	53%	The incubator creates job opportunities and commercializes new technology.	2.90	1.608	58%

Source: Authors

Table 3 indicates that responses to queries regarding the cost reduction dimension in technological incubators averaged a mean of 2.67. The statement, "There is a commitment from the incubator to reduce the costs of providing services by providing benefits to customers," received the most positive response from entrepreneurs; it has a mean of 2.79 and a standard deviation of 1.572. The statement, "The cost in entrepreneurs' projects is low compared to competing projects," received the least positive response, with a mean of 2.43 and a standard deviation of 1.285. Simultaneously, the average mean of the responses related to the quality improvement dimension was 2.98. This statement, "The incubator provides feedback from the client about quality," received the strongest endorsement (mean of 3.35, standard deviation 1.155). On the other hand, with a mean of 2.75 and a standard deviation of 0.987, the statement that got the lowest rating was, "The incubator seeks to improve and develop the quality of services to suit the desires and needs of customers." These results show that entrepreneurs are only somewhat satisfied with the incubators' attempts to reduce costs and increase quality.

Table 3. Mean, relative importance, and standard deviation of the Cost Reduction and Quality Improvement dimensions

Cost Reduction dimension	Mean	Standard Deviation	Degree of agreement	Quality Improvement dimension	Mean	Standard Deviation	Degree of agreement
The cost of entrepreneurs' projects is low compared to competing projects.	2.43	1.285	48.6%	The incubator seeks to improve and develop the quality of services to suit the desires and needs of customers.	2.75	0.987	55%
The incubator seeks to perform all functions and activities at a lower cost and with high efficiency.	2.74	1.434	54.8%	The incubator constantly evaluates the quality of its services and develops them compared to competing services.	2.76	1.223	55.2%
The incubator seeks to reduce fixed and variable operating costs.	2.45	1.463	49%	The incubator is interested in distinguishing its services from those of its competitors on an ongoing basis.	3.03	1.088	60.6%
The incubator is interested in making better use of the available capabilities in order to reduce costs.	2.67	1.194	53.4%	The services provided by the incubator are subject to continuous improvement.	3.02	0.887	60.4%
The incubator is committed to reducing the costs of providing services by providing benefits to customers.	2.79	1.572	55.8%	The incubator provides feedback about quality from the client.	3.35	1.155	60.4%

Source: Authors

Table 4 showed that the responses regarding the dimension of speed and flexibility were moderate, with an overall average mean of 2.96. The most agreeing response within this dimension came from entrepreneurs regarding the statement, "The incubator adheres to the specified deadlines to provide services to customers as quickly as required," which scored the highest mean of 3.21 and a standard deviation of 1.195. Conversely, the least positive feedback was for the statement, "The speed of service delivery is appropriate for customers," which recorded a mean of 2.72 and a standard deviation of 1.168. Similarly, responses related to the dimension of creativity and innovation averaged a mean of 2.98. The peak response in this category was for "The incubator works to develop and provide new and innovative services," with a mean of 3.31 and a standard deviation of 1.275. The lowest scored statement was, "The incubator is interested in constantly developing creative individuals in their field of work," with a mean of 2.82 and a standard deviation of 1.140. These results underscore a moderate level of entrepreneur satisfaction with both dimensions, highlighting areas where further enhancements could bolster incubator effectiveness.

Table 4. Mean, Degree of Agreement, and Standard Deviation of The Speed and Flexibility, Creativity, and Innovation Dimensions

Speed and Flexibility dimension	Mean	Standard Deviation	Degree of agreement	Creativity and Innovation dimension	Mean	Standard Deviation	Degree of agreement
The incubator can meet ever-increasing demands.	3.08	1.027	61.6%	The incubator is interested in new ideas and works to develop them.	2.97	1.124	59.4%
The incubator develops service delivery systems in order to respond to customer requests quickly.	3.05	1.092	61%	The incubator encourages research and development efforts.	2.88	0.808	57.6%
The incubator has the ability to reschedule internal operations to improve the speed of providing services to clients.	2.76	1.017	55.2%	The incubator is interested in constantly developing creative individuals in their field of work.	2.82	1.140	56.4%

The speed of service delivery is appropriate for customers.	2.72	1.168	54.4%	The incubator has financial and human capabilities and capabilities that distinguish it from competitors.	2.93	1.157	58.6%
The incubator adheres to the specified deadlines to provide services to customers as quickly as required.	3.21	1.195	64.2%	The incubator works to develop and provide new and innovative services.	3.31	1.275	66.2%

Source: Authors

The Pearson correlation coefficient test was used to determine the correlation coefficients between the dimensions of technological business incubators and the dimensions of competitive advantage for entrepreneurial projects. The analysis showed that there is a positive, statistically significant relationship at the level (0.01) between the dimension (incubator resources) and the dimensions of competitive advantage (cost reduction, quality improvement, Speed and flexibility, creativity and innovation) with correlation coefficient values (0.543, 0.571, 0.548, 0.529), respectively. There is a statistically significant positive relationship at the level of (0.01) between the dimension (incubator strategy) and the dimensions of competitive advantage (cost reduction, quality improvement, speed and flexibility, creativity and innovation) with correlation coefficient values (0.589, 0.526, 0.524, 0.517), respectively.

There is also a statistically significant positive relationship at the level of (0.01) between the dimension (operating techniques) and the dimensions of competitive advantage (cost reduction, quality improvement, speed and flexibility, creativity and innovation) with correlation coefficient values (0.735, 0.738, 0.669, 0.674), respectively, and there is a relationship Positive, statistically significant at the level (0.01) between the dimension (objectives of the incubator and management) and the dimensions of competitive advantage (cost reduction, quality improvement, speed and flexibility, creativity and innovation) with correlation coefficient values (0.792, 0.741, 0.630, 0.647), respectively.

The results indicate that technological incubators associated with the Academy of Scientific Research actively support investment by private sector entities, companies, and banks in scientific research. Entrepreneurs confirm that these incubators facilitate the evaluation of outcomes derived from human investment and ensure the availability of essential facilities like halls, labs, and equipment. They also collaborate with production lines of various companies and factories to assist the projects and ideas of entrepreneurs. Furthermore, from the perspective of the entrepreneurs, the incubators' goals and management aim to establish a cohesive and comprehensive network among mentors, managers, strategic alliances, and company representatives. These incubators affiliated with the Academy of Scientific Research prioritize cost reduction in service provision by offering benefits to clients and gathering customer feedback on quality. They also maintain loyalty to timelines for delivering services rapidly. Additionally, the incubators attempt to innovate and supply new services.

3.2. SWOT analysis

The SWOT analysis of incubators in universities and research centres highlights a strong structure that supports innovation transformation, technical needs, and risk reduction, coupled with effective utilization of resources and transparent policies. Despite these strengths, the incubators face significant challenges, including insufficient government funding, limited marketing reach, and bureaucracy that hinder operational effectiveness and strategic planning. Opportunities arise from Egypt's rich resources and the presence of global companies, enhanced by donor support and technological advances. However, threats such as budget deficits, inadequate intellectual property protections, cultural barriers, and the potential brain drain to more favourable economic environments pose substantial risks to the sustainability and effectiveness of these incubators.

Strengths:

- **Organizational Structure:** Incubators have a defined structure aligned with university and research centre goals, fostering community service and environmental development.
- **Support for Innovation:** Provides crucial assistance in transforming innovative ideas into marketable products.
- **Technical Support Facilities:** Offers workshops and labs to support the technical needs of incubated projects.
- **Transparent Policies:** Implements innovative and transparent policies for project acceptance.
- **Risk Reduction:** Minimizes obstacles and risks associated with starting businesses.
- **Resource Utilization:** Capitalizes on the university's capabilities and its creative and innovative talents.
- **Project Evaluation:** Conducts comprehensive evaluations of incubated and graduated projects.
- **Reporting and Feedback:** Provides periodic reports to help diagnose strengths and weaknesses.
- **Entrepreneurial Training:** Trains entrepreneurs to link their projects with various financing and investment programs.

Weaknesses:

- **Insufficient Funding:** Lack of adequate government funding to enhance product development and marketing.
- **Limited Marketing Reach:** Marketing strategies of incubators are confined to local levels, not extending to national or international scopes.
- **Cultural Dissemination Gaps:** In some universities, there is an absence of mechanisms to spread the culture of business incubation.
- **Bureaucracy:** Prevailing bureaucratic and non-dynamic approaches within incubator management.
- **Strategic Planning Deficiencies:** Shortcomings in strategic plans aimed at achieving financial sustainability.
- **Hiring Standards:** Limited adherence to clear global standards in recruiting talent.
- **Operational Weaknesses:** Weak operational procedures related to the stages of incubation.
- **Continuity and Awareness Issues:** Lack of continuous updates and awareness of the specialized courses offered by the incubator.

Opportunities:

- **Natural and Human Resources:** Egypt's rich and diverse resources provide a solid foundation for potential growth.
- **Presence of Global Companies:** The existence of leading global companies offers partnership and learning opportunities.
- **Donor Support:** Significant backing from donor agencies and international cooperation programs that support innovation.
- **Technological and Digital Advances:** Initiatives like the establishment of technological cities and a digital city enhance infrastructure for business incubation.
- **Government and International Partnerships:** Increasing trends towards creating collaborative ventures among government, universities, and industry.

Threats:

- **Budget Deficits:** Increasing deficits that impact funding availability for innovative projects.
- **Intellectual Property Rights:** A lack of procedures and awareness for protecting intellectual property.
- **Unemployment:** High unemployment rates could dampen the entrepreneurial spirit.
- **Government Bureaucracy:** Bureaucratic hurdles that complicate business processes and project registration.
- **Lack of Competitive Analysis:** Insufficient market analysis and business strategy development tailored to evolving markets.

- Cultural Barriers: Low societal acceptance of entrepreneurship and self-employment.
- Taxation and Economic Challenges: High taxation and economic hurdles that discourage startup culture.
- Brain Drain: Flight of startups and entrepreneurs to more favourable economic environments, particularly the Gulf countries.

4. Discussion

The study showed the presence of positive, statistically significant relationships at the level of (0.01) between the dimensions of technological business incubators in Egyptian universities, which include the incubator's resources, strategy, operating techniques, goals, and management, and the dimensions of the competitive advantage of the incubated entrepreneurial projects. These dimensions include cost reduction, quality improvement, speed and flexibility in performance, and creativity and innovation. These results were reached through analysis of data collected from business incubators affiliated with the Academy of Scientific Research, which indicates that these incubators play an important role in enhancing the competitive advantage of the entrepreneurial projects they incubate.

Based on insights from a recent questionnaire and SWOT analysis, a series of strategies have been recommended to enhance the efficacy of Egyptian business incubators. These include increasing government support for universities and research centres in transforming scientific research into practical applications. There is also a call for developing distinct national policies that foster creativity and innovation. Establishing a committee of experts to refine project selection criteria is suggested to improve the quality and effectiveness of these incubators. Raising awareness about the importance of intellectual property rights is crucial for nurturing an economy based on knowledge and innovation. Additionally, there is a push for academics to translate their research into viable investment projects and for their active participation on the editorial boards of journals, focusing on research with tangible economic benefits. It's advised that research agendas should align more closely with labour market demands and promote the application of findings in practical settings.

Other recommendations also include using performance appraisals and constructing sound information systems that can monitor the project. It signals the creation of expanded units in universities to support specialized units to foster rare but innovative projects, programs for media activation that can demonstrate the benefits of partnerships, and policies that can facilitate the export capacity of pioneering projects. More crucial are propelling closer cooperation between the Academy and industry as well as stirring support by business leaders for innovative projects, not to mention revisiting the legislation framework that can support the creation of startups, said to be a necessary adjunct to bring the ecosystem closer to Egypt. Finally, linking relationships between the incubators and the business through the sector in terms of scientific organizations.

Conclusion

"Exploring the Role of Technology Incubators within Egyptian Universities and Research Centers Confirms Their Pivotal Impacts in Promoting the Growth of Entrepreneurship and Innovation." The incubators are the main catalyst for transforming creative ideas into competitive, feasible business projects. They can thus integrate pooled resources that would include mentorship, office space, and technology tools to strategic support from the Academy of Scientific Research and Technology, universities, and the government. Incubators significantly decrease startup costs and barriers so that entrepreneurs can instead focus on strategic growth and innovation. The results from the survey and SWOT analysis in the document, therefore, expose that the incubators do not only support startups by offering necessary resources but also through their integration into an ecosystem that supports sustainable economic development. Such an environment is valuable in enhancing innovation and offering the competitive edge that the startups urge in the global market. In conclusion, this study of Egyptian business incubation provides evidence that these have been, and continue to be, an integral source of support for the

country's broader economic development strategy via technological innovation. Incubators facilitate the commercialization of new technologies and contribute significantly to the economic and social landscape as they support the growth of knowledge-based enterprises.

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