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Assessing Strategies to Mitigate Cable Theft in the South African Railway Sector

Muhle Mthombeni, Bheki Makhanya, and Jan Harm C Pretorius
Postgraduate School of Engineering Management
University of Johannesburg
Johannesburg, South Africa
mhlanzimuhle77@gmail.com, Bsm374@yahoo.com,
jhcpretorius@uj.ac.za

Abstract

South Africa has witnessed a remarkable increase in copper cable theft over the past five years, which has had a severe impact on the critical infrastructure in telecommunications, electric power supplies, municipalities, and railways. The railway sector has been the most affected industry, accounting for 75% of all cable-theft-related economic losses in state-owned companies. Constant threats to railway infrastructure security have led to unreliable rail networks, train delays, and operational and safety risks, which threaten the sustainability of the railway sector in South Africa. This study aims to investigate the strategies used to combat cable theft and the reasons for their failure to implement them effectively. To achieve this objective, an online survey questionnaire was used to collect quantitative and qualitative information on current cable theft prevention strategies and challenges from experienced railway professionals. The survey received thirty-one responses from participants sampled using the snowball method. Statistical analysis of the survey results indicated that the most common strategies for preventing cable theft include the use of patrolling officers, access control, scrap regulation, and robotic surveillance. The challenges experienced in preventing cable theft are linked to failures of security personnel, security systems, scrap sale regulations, and law enforcement. The study recommended that railway companies diversify their strategies by including more of the less commonly used tactics, such as micro-dot marking, CCTV surveillance, wireless network systems, alarm systems, and community awareness campaigns.

Keywords
Cable Theft, Railway Sector, South Africa, Strategies, and Combat.

1. Introduction
As the global demand for scrap copper increases (Guo 2022), the abundance of high-value metals that form part of South Africa's critical infrastructure has become the primary target of cable theft syndicates. The railway sector bears the brunt of this attack, as Prasa and Transnet Freight Rail account for 75% of the annual direct losses due to cable theft among state-owned enterprises. During the COVID-19 lockdown, Prasa infrastructure was stolen and severely vandalized, causing the agency to formulate a reconstruction and recovery plan that would cost R2.7 billion (Leshoro, 2022). Furthermore, passenger trains are delayed due to disturbances and infrastructure damage caused by cable theft, causing passengers to either arrive to work late or pay high taxi fares to reach their intended destination (Richie 2021). Nyoka 2017). The South African Minerals Council stated that the operational inefficiency of the Transnet Freight Rail costs the mining industry R50 billion in potential earnings by 2022 (Paton 2022).

The decline in Transnet's capacity to haul bulk materials is attributed to the rise in cable theft, vandalism, idling locomotives, and procurement issues (Paton 2022). This causes miners to move bulk commodities, such as coal, manganese, and iron ore, by road, which poses a higher safety risk to motorists and reduces the lifespan of national

and municipal roads. Cable theft is a threat to the freight business, as it reduces the freight logistics market share that rail possesses in moving bulk material and reduces customer confidence. Train cancellations, train delays, volume loss, damaged infrastructure, financial loss, safety hazards, and loss of customer confidence are the reported effects of cable theft in the railway sector. Theft and vandalism undermine the former Market Demand Strategy (Transnet 2015) by reducing the capacity of freight services through the destruction of infrastructure in which the government spent R300 billion to invest.

The goal of rail transportation is to supply services within the required timeframe with the required quality (Stefancova et al.2017). In addition to the various factors affecting railway operations, cable theft has exacerbated the challenges faced by South African rail logistics companies in meeting communicated freight delivery targets. When clients are not satisfied with the quality of railway transport, they seek alternatives to reduce the market share of the rail sector in the national supply chain.

1.1 Objectives

The aim of this study is to analyze the strategies adopted internationally to combat cable theft and compare them to those used in South Africa. The objective is to a) identify which security systems are used to combat cable theft in the South African railway sector, and b) determine the challenges experienced in mitigating this rampant cable theft epidemic.

2. Literature Review

The rise in theft and vandalism of railway infrastructure has had adverse effects on the economy and the services that depend on and support railway operations (Nobanda et al.2020). The out-of-control cable theft amounts to the sabotage of the nation's future economic growth prospects, threatening investments, employment security, livelihoods, and community safety (Bezuidenhout 2022). In South Africa, cable theft is reported every day, yet it remains an unresolved problem, with numbers increasing annually (Madzivhandila et al.2022). This demonstrates the apparent ineffectiveness of strategies intended to eradicate cable theft.

This section uses peer-reviewed literature to investigate the strategies that countries across the globe have adopted to combat cable theft and compare them to the strategies used in South Africa. The aim is to assess whether the efforts being made are on par with modern developments in the security of railway infrastructure. Furthermore, the researcher will investigate the perceived reasons for the failure to effectively combat cable theft, especially in the railway sector. This will enlighten the reader on the shortcomings of South African strategies, allowing for the gaps to be closed by affected stakeholders.

2.1. Strategies Used to Combat Cable Theft

The use of scrap metal sales regulations in the United States, the United Kingdom, Australia, and Kenya has resulted in a reduction in cable theft incidence. Regulations made use of the Market Reduction Approach (Schneider 2008), which takes into consideration that theft is driven by the ease by which offenders can dispose of stolen items. These scrap regulations require (a) scrap metal dealers to have an authorized license issued by the local authority to operate their businesses; (b) scrap metal dealers to verify the seller's full name and address before receiving scrap products; (c) scrap metal dealers to make payments by checking or transferring electronic funds only; and granted (d) law enforcement of the right to enter and inspect licensed scrap metal dealerships (Cook 2015; Mares et al. 2016; Levin et al. 2022; Consumer Affairs Victoria 2023).

In the United Kingdom, the British Transport Police (BTP) is the national law enforcement agency responsible for policing railways (Ashby et al. 2016). It uses overt and covert security measures to prevent rail crime. Overt measures used by the BTP include armed and unarmed police officers, CCTV cameras, stop-and-search campaigns, police dogs, and community awareness campaigns (Power et al. 2016; BTP 2023). In addition to policing, the BTP has specialist units that are responsible for responding to and investigating railway crimes, such as metal theft and terrorism (Railways and Transport Safety Act, 2003; BTP 2023).

Robb et al. (2015) and Cozens et al. (2003) found that patrol officer visibility, CCTV footage, controlled access, alarm systems, and improved lighting have a positive effect on the prevention and solving of railway crime. Advanced smart technology is also being developed and piloted to further improve the security of the critical infrastructure. Alawad et al. (2018) explained how wireless sensor networks (WSN) can improve the safety and security of railway

infrastructure. Wireless sensor networks are smart systems that use various types of wireless sensors connected to computer software programmed to assess the degree of risk in each zone (Alawad et al. 2018). In the case of metal theft, the development and use of WSN can act as a cable theft prevention method, where high-risk areas can have continuous security monitoring and early alerts of theft attempts.

Hickey (2016) stated that Australia prevents cable theft by limiting access to critical infrastructure by upgrading the fencing, incorporating robotic surveillance, marking conductor cables using microdot technology to make the conductors easily identifiable to law enforcement, adding concrete sections around underground conductors to increase drag when an attempt is made to pull them from the ground, and using theft-deterrent conductor material that cannot be cut with common hand tools or has low scrap value.

2.2. Perceived Reasons for Failure to Combat Cable Theft in South Africa

Levin et al. (2022) state that scrap metal exports from South Africa are estimated at R10 billion, and two-thirds of the total is acquired illegally. Scrap dealers are required to register at the local police station, and Levin et al. (2022) argue that there is no centralized, easily accessible registry that can help authorities look up problematic dealers, as the system is still paper-based, unenforced, and fragmented. The SAPS (2020) reported only 382 compliance inspections of 25 000 registered scrap dealers in the 2020–21 year. Many industry actors report that scrap metal dealers do not comply with the requirements to record the identification of sellers, and they often pay for delivered scrap in cash (Levin et al.2022).

In 1934, the Department of Transport established the South African Railway Police (SARP), which is a dedicated and highly trained force specializing in preventing crime in the railway environment (SAPS 2016; Mmakwena 2022). The SARP was disbanded, and 16 000 members were amalgamated with the South African Police (SAP) as the apartheid government increased its focus on socio-economic and race-related political issues (Madzivhandila et al.2022). This left the railway environment vulnerable to crime as rail duties were neglected (Geldenhuys 2020). Railway policing was reintroduced in 2004 through the establishment of the SAPS Rapid Rail Police Unit (SAPSRRPU). The SAPSRRPU mandate was to enhance the proactive policing of the railway environment (January et al. 2018; Liebenberg, 2018; Madzivhandila 2019; Nobanda et al. 2020; Mmakwena 2022), and Madzivhandila (2019) stated that the effectiveness of the railway policing system cannot be realized for the following reasons:

- SAPSRRPU is not structured as a specialized unit. Its duties are no different from those of ordinary SAPS police officials.
- There is a shortage of manpower and resources such as vehicles and communication devices.
- SAPSRRPU does not have crime and intelligence capacity that can contribute to the effective prosecution of offenders and prevent crime by analyzing intelligence information.
- Training in crime prevention is generic and not intended for railway policing.
- Offenders know the approaches used by officers and investigators, and the police are not up-to-date on the modus operandi of cable thieves.
- SAPSRRPU does not have structured detection or intelligence capacity. The investigation of cable theft offences is reported to the SAPS, which is overloaded in many cases and does not consider cable theft as a priority.
- Police officials and prosecutors have no discretion to grant bails to persons charged with any essential infrastructure-related offences.

Poor access control and image management contribute to an increase in cable theft in the railway environment. The Railway Safety Regulator (2018) highlighted that the South African railway system is relatively open, which increases its risk of vandalism, theft, and unauthorized occupation. Nobanda et al. (2020) found that lack of fencing is a contributing factor to the theft of PRASA cables, and some fenced-off areas are dug up by perpetrators to gain access to infrastructure. Furthermore, Madzivhandila (2019) mentioned that overgrown vegetation along railway lines and abandoned buildings increases the likelihood of criminal activity. Overgrown vegetation limits the visibility of intruders, and abandoned buildings are at risk of being vandalized or unlawfully occupied. Pretorius (2012) found that having awareness campaigns through media is successful if used continuously; however, it is expensive, and the information seldom reaches people who need to see the programs. Patrolling is the preferred method of physical security, while other methods are not widely used, leading to poor incident reduction outcomes.

3. Methods

This research is deductive, as it uses existing theory, previous research findings, or a conceptual framework to attain a logical conclusion. A conceptual framework for metal theft prevention strategies worldwide was obtained from a comprehensive literature review and narrowed down to form a baseline of different strategies used to combat cable theft (Gilgun 2015; Casula et al. 2021). Furthermore, the literature review provides general insights into the challenges experienced in preventing cable theft in South Africa. This study used quantitative and qualitative methods to meet the objective of the research, which was (a) to understand which strategies are currently used to combat cable theft in the South African railway sector and (b) to understand the perceived reasons for failure to combat cable theft. According to Hammarberg et al. (2016), mixed-methods research is the integration of quantitative and qualitative research to gain a holistic view of the subject in question. This research had a cross-sectional time horizon, which is a short-term study in which the outcomes provide a snapshot of a phenomenon at that point in time (Pandis 2014; Wang et al. 2020). The study used online survey questionnaires to solicit information from experienced railway professionals in South Africa. The survey participants were selected using the snowball sampling method, which is a non-probability sampling strategy in which existing participants recruit future participants from their network (Berndt, 2020; Sharma 2017). The target sample was fifty (50), and the survey received thirty-one (31) responses.

4. Data Collection

Rowley (2014) states that deductive research uses prior literature to formulate questions for a survey. The findings from the literature review formed the basis for the questionnaire, in which a combination of closed-ended and open-ended questions was posed to the participants about their knowledge of strategies to combat cable theft and the challenges they faced in combating it.

The first section addressed ethics and demographic information. The participants were required to provide their consent to answer the questionnaire. They selected the type of railway company they work for (freight rail, passenger rail, or rapid rail), the department in which they work, and their years of experience in the organization.

The second section of the questionnaire used closed-ended questions that required participants to select the strategies used in their organization to combat cable theft from a list of strategies deduced from the literature review. An open-ended question required them to state which other strategies their organization used to combat cable theft to capture additional strategies that were not stated in the literature.

The third section used a Likert scale and open-ended questions to retrieve information about the challenges experienced in combatting cable theft in their organization. The Likert scale is a qualitative survey method that allows participants to rate their attitude towards a given statement using a given range of agreeability from ‘strongly disagree, disagree, neutral, agree, and strongly agree’ (Bhandari et al.2020). The participants were required to rate their agreement with cable theft prevention challenges deduced from the literature. The open-ended question required the participants to state the current challenges that they faced in effectively reducing cable theft in their organization. This allowed the researcher to capture the views of the participants and obtain additional information that was not covered by the literature review.

Quantitative data were analyzed using descriptive statistics, which use arithmetic and graphical representations to interpret the data (Simpson 2015; Ibrahim 2015). The qualitative data were analyzed thematically, which is a method of identifying, analyzing, and reporting recurring patterns within data (Castleberry et al.2018).

5. Results and Discussion

This section discusses the data collected from the three (3) sections of the survey questionnaire. The aim was to summarize, interpret, and discuss the implications of the research findings.

5.1 Demographical Information

The initial sample of participants from the railway sector was requested to share the link to the online survey questionnaire with the network. The survey received thirty-one (31) responses. The first section of the questionnaire collected the demographic information of the participants, as presented in Table 1. Statistical evaluation indicated that the majority (80%) of the participants worked for a freight rail company, with most (94%) of the participants working

in the infrastructure department. The majority of the participants were highly experienced, with 39% having 6–10 years of experience and 42% having more than 10 years of experience in the railway sector.

Table 1. Demographical Information

Item	Frequency	Percentage
Railway business type		
Freight Rail	25	81%
Passenger Rail	3	10%
Rapid Transit Rail	3	10%
Department		
Security	0	0%
Infrastructure	29	94%
Rolling Stock	0	0%
Operations	2	6%
Years of experience		
0 - 1 year	0	0%
1 - 2 years	2	6%
3 - 5 years	4	13%
6 - 10 years	12	39%
More than 10 years	13	42%

5.2.1. Strategies to Combat Cable Theft

This section aims to investigate which strategies deduced from the literature review were used to combat cable theft in the railway sector. A closed-ended question required the participants to select the applicable strategy adopted by their organization from a list. The data presented in Figure 1 suggest that all strategies gathered from the literature review are used in the South African railway sector; however, they range in frequency. Frequency analysis indicated that the most common (87.1%) strategies used were patrolling officers, access control (51.6%), regulation of scrap (45.2%), robotic surveillance (45.2%), theft-deterrent materials (41.9%), and adding concrete sections to underground cables (41.9%). The increased area lighting, alarm systems, and stop-and-search campaigns had a selection rate of 19.4%. The least used strategies were community awareness campaigns (16.1%), CCTV surveillance (12.9%), and wireless sensor networks (12.9%). the least (3.2%) used strategy was the micro-dot marking of cables. The data suggest that South Africa is aware of the various strategies available to combat cable theft; however, there is an over-reliance on patrolling officers and other strategies are not widely implemented. The data show that there has been some effort to control access to railway infrastructure, regulate scrap sales, use robotic surveillance, install t-deterrent materials, and secure underground cables with concrete.

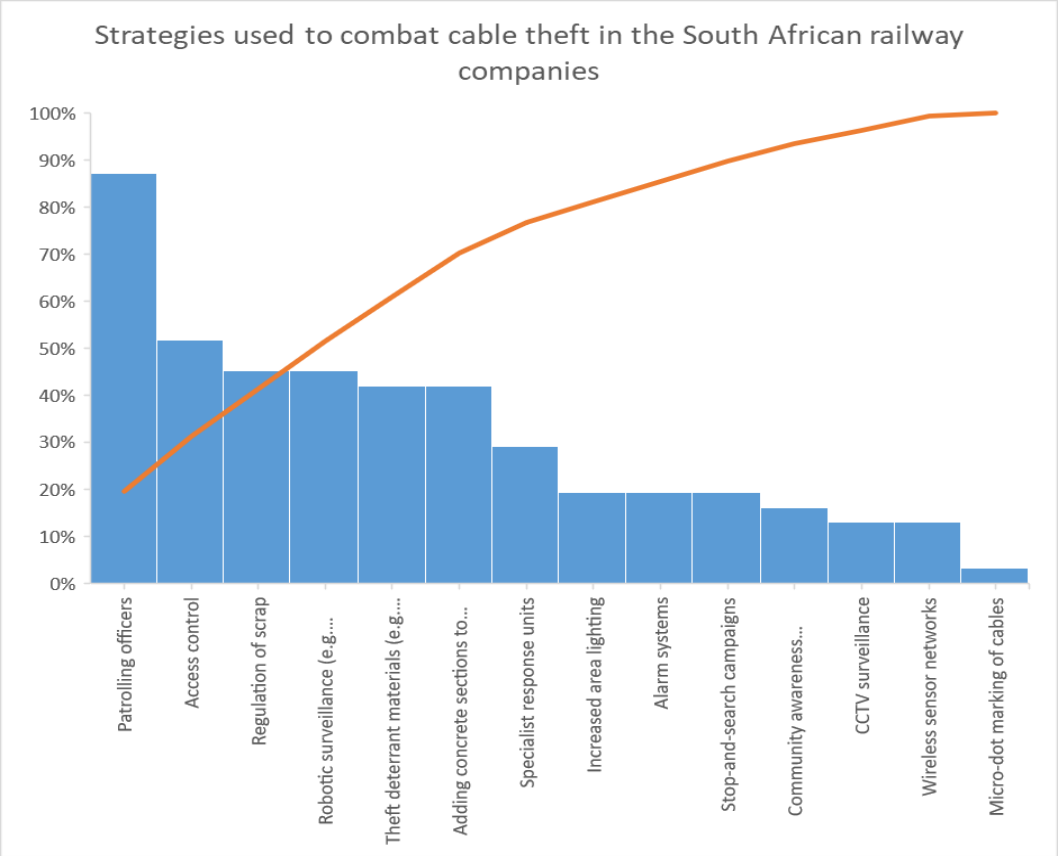

Figure 1. Strategies used to combat cable theft by South African railway companies.

5.2.2. Other Strategies Used to Combat Cable Theft

An open-ended question asked the participants to state other methods used to combat cable theft in their organization. The objective was to identify additional strategies that have not been previously reported in the literature. A thematic analysis of the responses indicated that railway organizations use anti-vandal covers on signaling equipment (3), install armed pepper spray in substations (2), increase the depth of trenches for underground cables (2), use static guarding (1), and use concrete signaling enclosures (1). This suggests that additional measures were implemented to combat cable theft, which has not been highlighted in the literature reviewed in this study. Figure 2 shows a graphical representation of the other strategies that railway organizations use to combat cable theft.

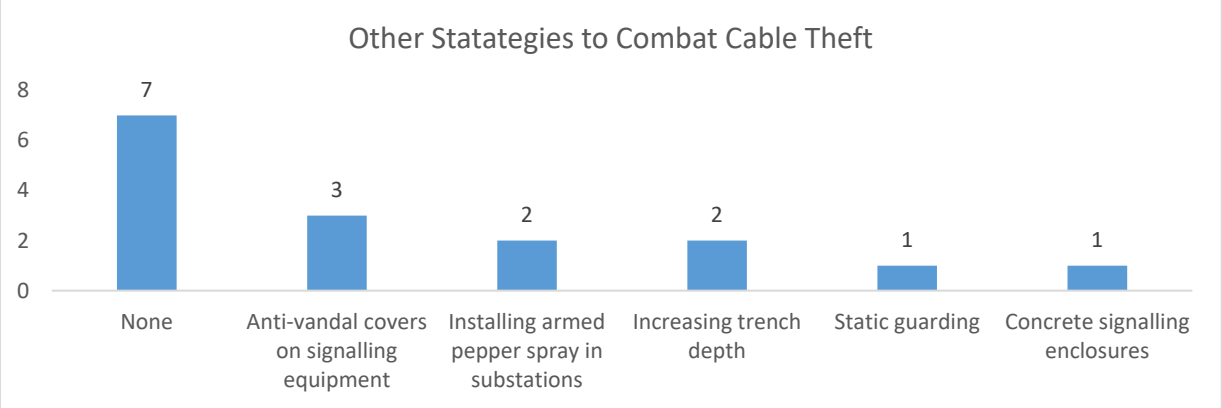

Figure 2. Other strategies used to combat cable theft in the railway sector.

The findings indicate that railway companies employ every tactic found in the literature review; however, the use of microdot marking, wireless sensor networks, CCTV surveillance, community awareness campaigns, stop-and-search campaigns, alarm systems, area lighting, and specialized response units is not as prevalent as it could be. Implementing less used tactics should receive more attention because diversifying solutions may improve the prevention of cable theft. If other preventive steps against cable theft were taken nationwide, the railway sector would benefit from them.

5.3.1. Challenges in Combating Cable Theft

In this section, we use a Likert scale to assess the challenges that contribute to the failure of preventing cable theft in the railway sector. The participants were asked to rate the reasons for the failure to combat cable theft, based on the findings from the literature review, on an agreeability scale ranging from "strongly disagree" to "strongly agree".

Scrap Sale Regulation: In subsection, the aim was to assess the role of scrap sale regulation in the challenges experienced in combating cable theft. Figure 3 presents a graphical representation of the responses to scrap sales regulation challenges. A significant proportion of individuals (52%) believe that a centralized digital database for scrap metal dealers does not exist. There was a concern among stakeholders regarding the insufficient number of inspectors to effectively monitor and enforce compliance, as indicated by 65% of the respondents. Additionally, a significant majority (77 %) of the participants held the belief that scrap metal can be readily sold to scrap metal dealers in exchange for cash.

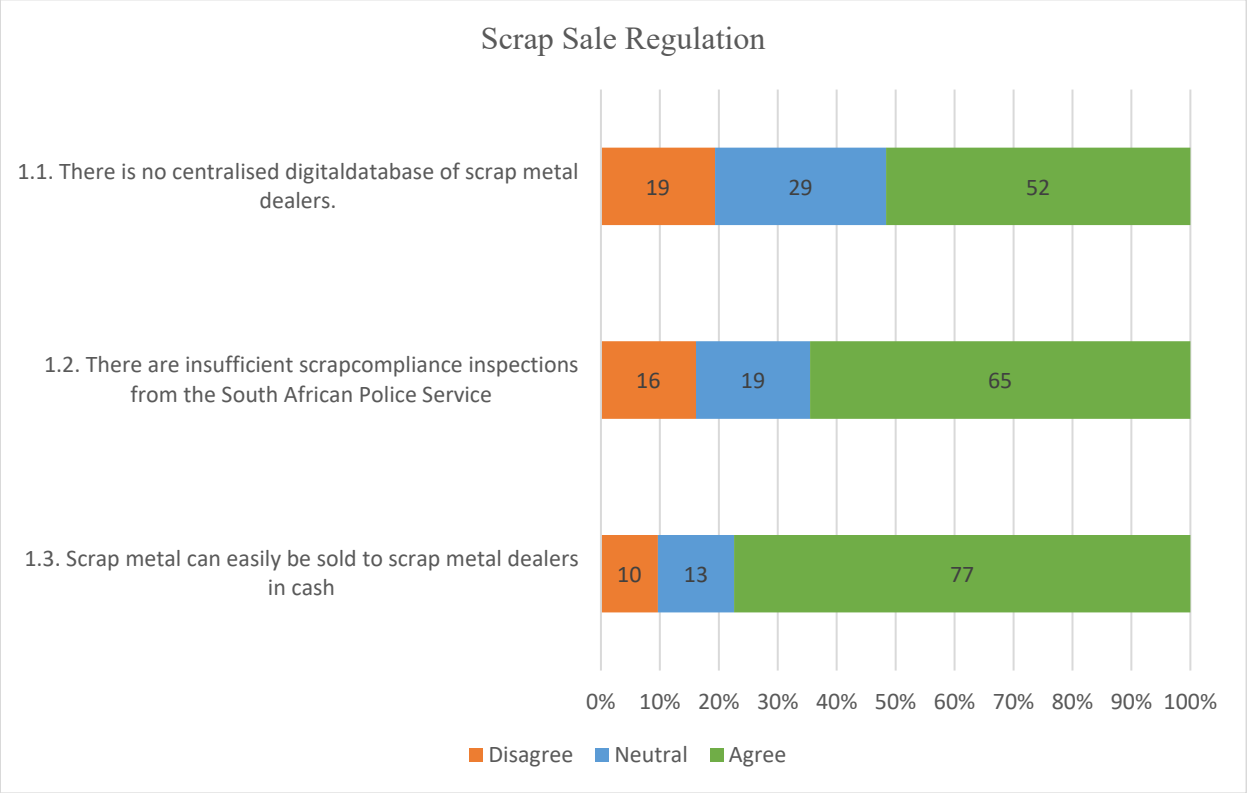

Figure 3. Scrap sales regulation challenges.

Law Enforcement: In subsection, the aim is to assess the role of law enforcement in the challenges experienced in combating cable theft. Figure 4 shows a graphical representation of the responses to law enforcement challenges. A majority (74%) of railway professionals believe that law enforcement does not prioritize prosecuting cable theft, and a significant proportion (71%) think that law enforcement does not have the capacity to investigate cable theft. Many respondents (55%) believed that law enforcement was unfamiliar with the modus operandi of offenders.

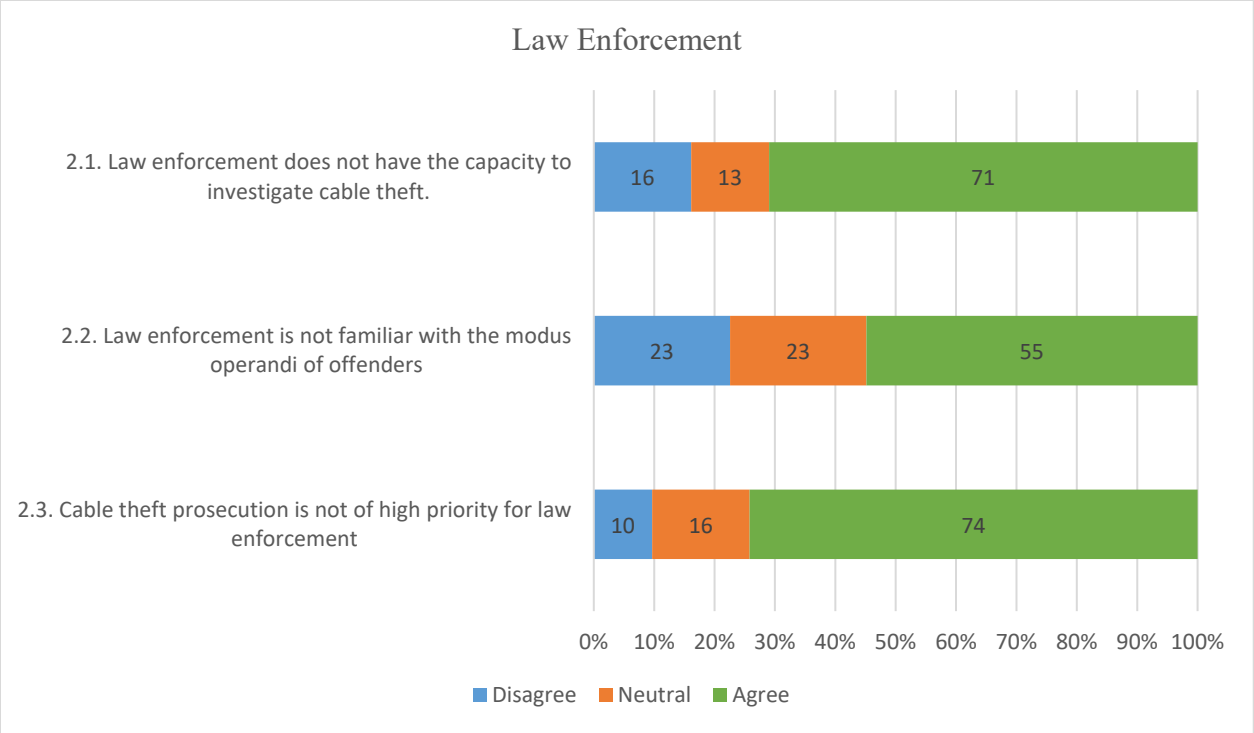

Figure 4. Law enforcement challenges.

Security Personnel: In subsection, the aim is to assess the role of security personnel in the challenges experienced in combating cable theft. Figure 5 shows a graphical representation of the responses to the security personnel challenges. The data indicate that a significant proportion (74%) of respondents believed that there was a shortage of security resources, and 71% indicated that there was a shortage of security personnel. Many (68%) respondents were of the view that security personnel are not specialized in dealing with cable theft, and 55% of respondents concur that security personnel are not trained to prevent cable theft.

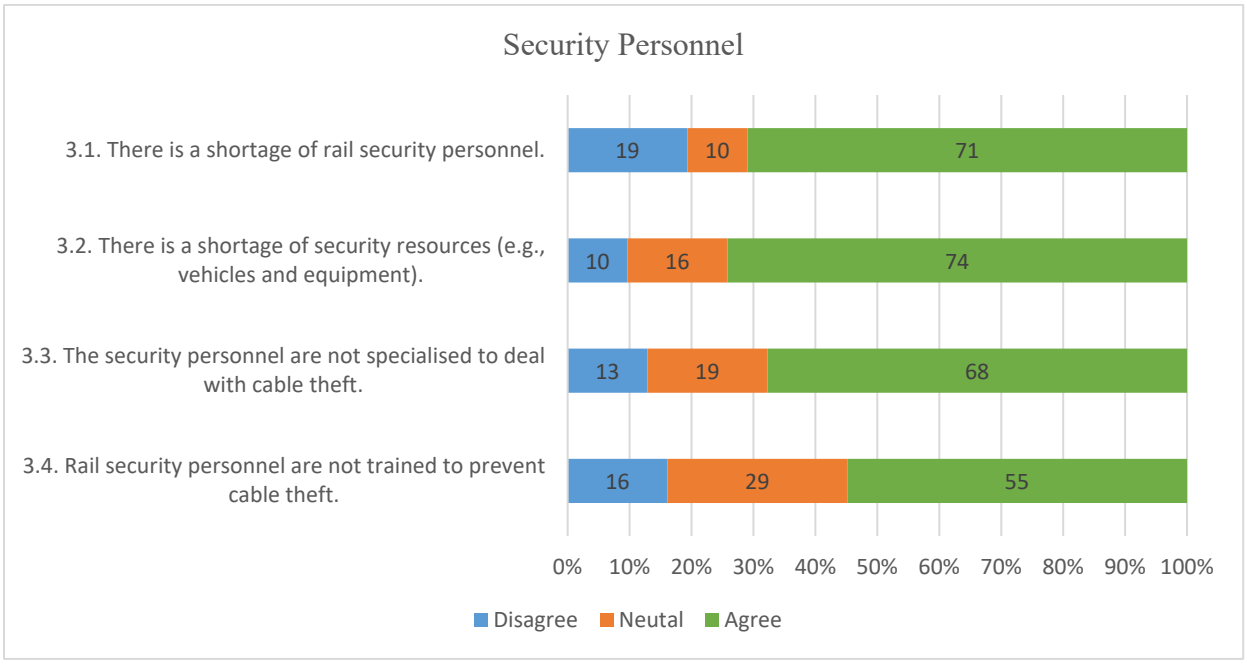

Figure 5. Security personnel challenges.

Security Systems: In this subsection, the aim is to assess the role of security systems in the challenges experienced in combating cable theft. Figure 6 shows a graphical representation of the responses to the security system challenges. The analysis revealed that the majority of the respondents (74%) agreed that there was a lack of CCTV surveillance of railway assets. The majority (71%) also believed that poor lighting and lack of alarm systems contributed to the failure to prevent cable theft. A significant proportion of respondents thought that there was poor access control for railway infrastructure. Many respondents (55%) thought that there was insufficient maintenance of the railway infrastructure and a lack of community awareness.

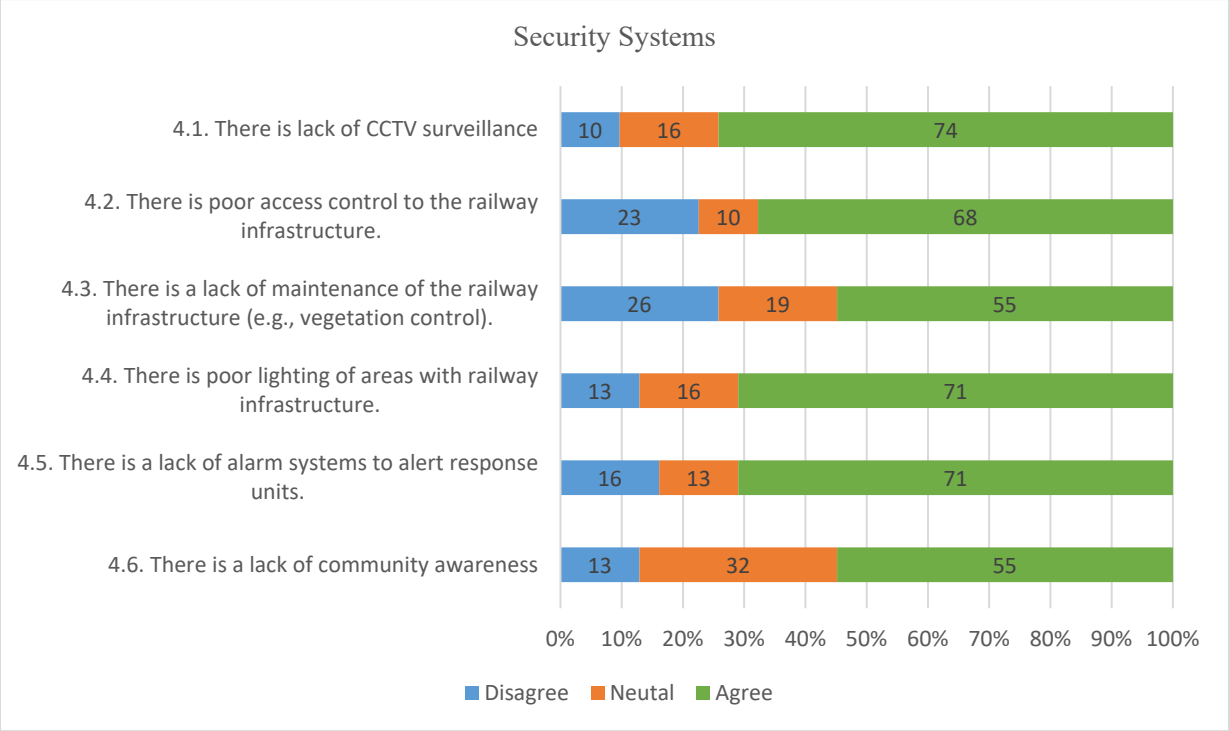

Figure 6. Security system challenges.

Descriptive statistics

Table 2 summarizes the descriptive statistics (Cronbach's alpha, standard deviation, and mean) used to analyze the findings from the qualitative data collected from the Likert scale. Security personnel (n=4, α =0.845, σ=1.151, m=3.806) were identified as the main challenges, followed by security systems (n=6, α =0.877, σ=1.241, m=3.785). Scrape sale regulations (n=3, α =0.591, σ=1.230, m=3.742) and law enforcement (n=3, α =0.853, σ=1.102, m=3.77) were among the factors responsible for escalating cable theft in South Africa.

Table 2. Descriptive statistics summary of the Likert scale.

Section	**No. of items**		**Reliability (α)**	**Standard deviation (σ)**	**Mean (m)**	**Ranking**
Security Personnel	4		0.845	1.151	3.806	1
Security Systems	6		0.877	1.241	3.785	2
Scrap Sale Regulation	3		0.591	1.230	3.742	3
Law Enforcement	3		0.853	1.201	3.677	4

5.3.2. Other Challenges

This sub-section was an open-ended question requesting the participant to state other challenges that they faced in combating cable theft in their organization. The objective was to identify other challenges that have not been previously recorded in the literature. The findings from the thematic analysis indicated that cable theft syndicates work with employees (8), security companies are not competent in dealing with cable theft (6), communities do not blow the whistle on cable theft incidents (2), there is insufficient reaction time to cable theft alerts (2), there are insufficient funds to implement mitigation strategies (2), there is informal settlement encroachment (1), and there is no follow-up on cable theft cases (1). Figure 7 shows a graphical representation of the other challenges and the number of participants who stated them.

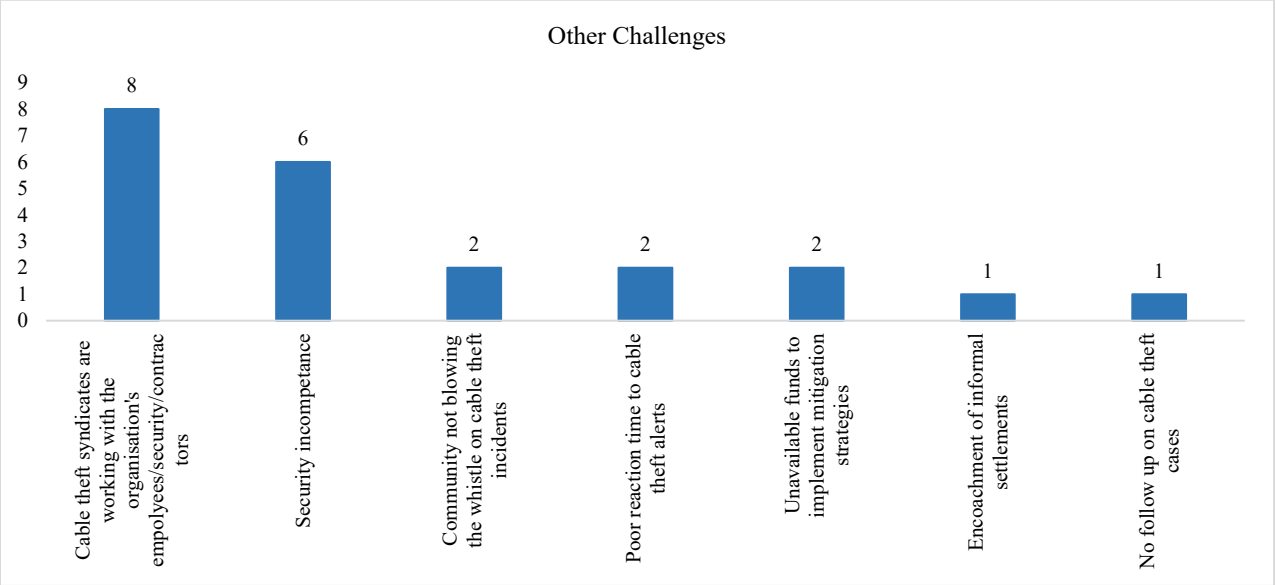

Figure 7. Other challenges experienced in combating cable theft.

The results validate the difficulties noted in the literature review. Regulations governing scrap sales, security staff, security systems, and difficulties facing law enforcement cause wire theft in the railway sector. Additionally, respondents identified several obstacles that contributed to the rise in cable theft, including internal stakeholder corruption, lack of funding for solutions, and failure to investigate reported occurrences. To improve the effectiveness of measures taken to prevent cable theft, the railway sector must concentrate on resolving these issues.

5.4 Validation

Validity and reliability ensure the quality and integrity of research as they increase transparency and decrease the opportunity for bias (Haradhan 2017). The survey questionnaire had to meet validation and reliability criteria so that the results obtained could be an accurate representation of the current security strategies used in the South African railway sector. This study used face and internal consistency reliability tests. A pilot survey was administered to a small-scale sample that had attributes similar to those intended for the main research, and the results were checked. The pilot survey assisted the researcher in determining whether the questions were framed properly, placed in the best order, understood by the participant, required addition or elimination, and achieved the desired results (Roopa et al., 2012). For the Likert scale, Cronbach's alpha coefficient was used to measure the reliability. A minimum internal consistency coefficient of 0.6 is deemed sufficient for exploratory research (Taherdoost 2016).

6. Conclusion

The study used mixed methods through a survey questionnaire with closed-ended questions, open-ended questions, and a Likert scale to investigate the strategies used to mitigate cable theft and to understand the challenges experienced in effectively combating cable theft. Snowball sampling was used to collect data from railway professionals, and thirty-one (31) participants responded to the online questionnaire.

The survey findings on the strategies used indicated that the South African railway sector applies all the strategies deduced from the literature review; however, there is an over-reliance on patrolling officers, and other strategies are not widely implemented. This lack of adoption of diverse strategies limits the effectiveness of cable-mitigation efforts. The survey findings on the challenges experienced in combating cable theft correlate with the literature review. Poor security systems, incompetent security personnel, inefficient law enforcement, and non-compliance with scrap regulations were highlighted as the main contributors to the failure to combat cable theft. Additionally, challenges such as corruption, insufficient funds to implement mitigation tactics, and community-related issues were listed.
Further research should be conducted on how current strategies can be successfully implemented. The data indicate that many strategies are being used to varying degrees; however, these strategies do not serve the intended purpose of reducing cable theft incidents. System optimization solutions should be explored to improve the implementation of cable theft strategies.

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Biographies

Muhle Mthombeni completed her MPhil (Engineering Management) from the University of Johannesburg and obtained her National Diploma (Civil) and BTech (Structural Engineering) degree from the Tshwane University of Technology. She has six years of working experience in the railway industry and is registered as a Professional Engineering Technician with the Engineering Council of South Africa. She specialises in railway track maintenance, multidisciplinary railway project management, non-destructive rail testing, and continuous improvement of rail welding.

Dr Bheki B. S. Makhanya is a senior researcher in the Postgraduate School of Engineering Management at the University of Johannesburg. He holds a PhD in Engineering Management from the University of Johannesburg. His research interest includes the cost of quality, total quality management, reliability improvement and risk management.

Prof Jan Harm C Pretorius obtained his BSc Hons (Electrotechnics) (1980), MIng (1982) and DIng (1997) degrees in Electrical and Electronic Engineering at the Rand Afrikaans University and an MSc (Laser Engineering and Pulse Power) at the University of St Andrews in Scotland (1989). He worked at the South African Atomic Energy Corporation as a Senior Consulting Engineer for 15 years. He also worked as the Technology Manager at the Satellite Applications Centre. He is currently a professor at the Postgraduate School of Engineering Management in the Faculty

of Engineering and the Built Environment where he has worked since 1998. He has co-authored over 240 research papers and supervised 61 PhDs and over 270 Master's students. He is a registered professional engineer, professional Measurement and Verification practitioner, senior member of the Institute of the IEEE, a fellow of the SAIEE and a fellow of the South African Academy of Engineering.