Addis Ababa University
Addis Ababa Institute of Technology
African Railway Center of Excellence

Assessing Railway Property Theft and Developing Engineering Protection Mechanisms: A case Study of Addis Ababa Light Railway Transport Service Enterprise and Ethio-Djibouti Railway

A Research Submitted to the School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Requirements for the Degree of Masters of Science in Railway Engineering (Civil Infrastructure)

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June, 2024

Addis Ababa, Ethiopia

Master's Program Final Thesis Acceptance Approval Form

Thesis Topic: Assessing Railway Property Theft and Developing Engineering Protection Mechanisms: A case Study of Addis Ababa Light Railway Transport Service Enterprise and Ethio-Djibouti Railway Line

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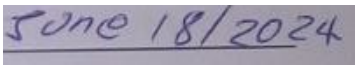
DECLARATION

I, Silenat Asrat, hereby declare that this proposal on, Assessing Railway Property Theft and Developing Engineering Protection Mechanisms: A case Study of Addis Ababa Light Railway Transport Service Enterprise and Ethio-Djibouti Railway Line, submitted to partially meet the criteria of the Masters of Science in Railway Engineering (Civil Infrastructure) degree; it conforms with university regulations; it is my original work; and it hasn't been submitted anywhere else in higher education. This research paper includes a complete list of references that lists all sources that are cited or quoted.

By

Silenat Asrat Achamyeleh Signature  Date 

ACKNOWLEDGEMENT

First, I would like to thank my Almighty God who has given me the courage and strength to proceed with my postgraduate studies. Secondly, I would like to express my deepest gratitude to my advisor Dr. Getu Segni and my co-advisor Biniyam Ayalew for their valuable advice and continuous support in providing relevant hint for the completion of this research work. Above all, I am highly grateful for their timely, detailed and untiring corrections. Finally, I would like to thank my beloved family for their moral, spiritual and financial support during my progress of this research study. Without their continuous support, this may have not been achieved.

I would like to express my deep and sincere gratitude to the EDR and Addis Ababa light rail transport service enterprise safety and security staff for their willingness to distribute and fulfill the questionnaires and to the safety managers for helping me to get the necessary documents related to my topic and the necessary data for this thesis work. Finally, the staff of the Africa Railway Center of Excellence also have my appreciation for giving me this opportunity, kindness, and help throughout the study time that I spent there.

ABSTRACT

Ethio-Djibouti railway line run from Addis Ababa to Negad, the port of Djibouti. Ethiopia also built light railway transport in Addis Ababa, capital city of Ethiopia. The construction of this rail infrastructure is essential for the development of both countries. However, after the operation start both the Addis Ababa light railway transport service and Ethio- Djibouti railway lines faced so many challenges due to different safety and security issues including theft on their property that challenge the transport service. The seriousness of theft in railway industry cannot be ignored. It highly deserves immediate notice and action. The curse's accompanying damages to the railway property are irreversible. Theft related issues cause businesses to lose millions of dollars' worth of property. This paper aimed to identify and set solutions to these major problems by developing protection mechanisms. The study further identifies the characteristics and the leading causes that motivates criminals to railway property theft. Quantitative methodological approach was adopted to accomplish this work. Both primary and secondary data were used as a source of information for the study. Primary data was taken from participants by using questionnaire survey. Secondary data was taken from AALRTSE and Ethio-Djibouti railway recorded data on occurrence of theft over the year 2018 to 2023. Quantitative analysis was conducted for both primary and secondary data sources. There were 2233 occurrence of theft to railway assets over the study period. The characteristics of criminals and property theft was identified. Numerous hotspot areas have been discovered using the information. This paper also presents that availability of scrap metal dealers and poor enforcement of law against criminals are among the top most leading cause to railway property theft and then developing solutions to prevent this issue. Previous literatures are failed to set solutions as the culture of the given systems. Due to the limited literatures related to railway property theft, developing new protection mechanisms are taken to solve the issues on railway. The findings will guide efforts to improve the safety and security of railway asset. The study recommends that the railway industry to develop a multi-stakeholder partnership strategy. In conclusion, the extra loss of costs by the Ethiopian railway industry is eliminated and solved. Once the security problems are solved the maintenance costs will be reduced once the location is identified providing the possible solution for the find out problems.

Key words: *Infrastructure, protection, railway, theft, transport*

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AALRTS	Addis Ababa Light Railway Transport Service
AALRTSE	Addis Ababa Light Railway Transport Service Enterprise
ANOVA	Analysis of Variance
CCECC	China Civil Engineering Construction Corporation
CCTV	Closed Circuit Television
Df	Degree of freedom
EDR	Ethio-Djibouti Railway
ERC	Ethiopian Railway Corporation
EW	East-West
IT	Information Technology
KZN	KwaZulu-Natal
NGOs	Nongovernmental Organizations
NS	North-South
P	Probability
PRASA	Passenger Rail Agency of South Africa
Sig	Significant
SPSS	Statistical Package of the Social Science
Std.	Standard
ZESA	Zimbabwe Electric Supply Authority

CHAPTER ONE

1. INTRODUCTION

1.1 Backgrounds of the Study

"Railway safety is defined as property of a system which does not in any way endanger neither persons nor its environment" (Silvia Cicmancova, 2013). Railway systems are affected by various possible impacts. These are unanticipated breakdowns, human error, and various harsh scenario combinations that could seriously impair the safety of multiple components or possibly the entire railway system. It is necessary to separate any potential source of hazard in order to determine the potential threat (Silvia Cicmancova, 2013). The primary objective of the railway safety system is to eradicate any human error that may have occurred (Vojtek et al., 2021). Infrastructural facilities are vital to the rapid socio-economic development of any nation. This facilities delivers the environment for productive activities to take place and enables the generation of economic growth thus eliminating or reducing urban poverty. Availability of infrastructure reduces urban failure and creates suitable urban environment. Therefore, with worthy infrastructural base sustainable urban development is easily achievable (Ola & Adewale, 2014). Recently the issue of critical infrastructure security is very practical. States around the world permit laws and recommend proper ways to safeguard critical infrastructure. Significant resources are spent for its protection, development, construction, and determination. Transportation should be widely accessible, open, and abundant. A large amount of the physical infrastructure and assets are left unprotected and unattended. Every nation's transportation system is extremely vulnerable, and if it is attacked, destroyed, or damaged, it may remain unusable for a number of years. Unintentional attacks or accidents that are directly related to the functioning of transportation networks frequently cause disruptions to the global transportation system (Janušová & Čičmancová, 2016). It is anticipated that the governing bodies will be obliged to protect the national resources that guarantee the necessities of everyday existence, such as resources that offer transportation, electricity, telecommunications, and income.

Metal theft is the term used to describe the theft of components from an infrastructure network in order to obtain the necessary metals from them. It seems that the effects of metal theft are common in many domains (Brathwaite et al, 2013). Various countries have experienced train service disruptions, telecommunications outages, lead and copper theft from church, school,

private and council roofs, street sign theft, gully and manhole cover theft, and other heinous crimes.

The study conducted in South Africa (Nobanda et al., 2020), states that thieves stole two meters of crucial signal cable on an active railroad line at Kwa Dukuza on the KZN North Coast, rendering the mechanized system on the track attacked daily by more than 4000 commuters. This system was brought to a halt and typically happening broadly and is touted to be the cause of major distractions, driving to South Africa losing millions of Rands yearly due to this crime. Moreover, Spoornet, KZN Metrorail, Eskom, Telkom and Tongaat Hulett combined losses of this activity, expected at around R5.7 million through the robbery of cables, power lines and copper wires that resulted in the major power failures and the disruption of communication and transport service. Metal thefts from transportation system and telecommunication systems are principally significant since the act of removing metal frequently causes those networks to fail, causing distraction across a wide area.

In order to understand and contextualize rail within the locality and to get it the challenges confronted. This section will give a brief history of rail development within the Ethiopia.

Ethiopia was among the first countries in Africa to build railroad infrastructure, thanks to Emperor Menelik II's vision and French aid. The Addis Ababa-Djibouti railroad, also referred to as the Ethiopia-Djibouti railroad modernization project, is the main modern, electrified railroad route in East Africa. (The Franco Ethiopian and Djibouto Ethiopian Railway - Djibouti Addis-Abeba).

The 780 km meter gauge line that connected Ethiopia's capital, Addis Ababa, with the port of Djibouti within Africa. The first segment, from Djibouti (that was in French Somaliland) to Dire Dawa in Ethiopia, started in 1901, but advance enlargement was postponed by liquidation of the initial railway company, and the line to Addis Ababa was not completed until 1917. On the freedom of Djibouti obligation for the line passed to a new company conjointly held by the governments of the two nations. Nevertheless, within the late 20th / early 21st centuries the line was permitted to break down and fail, service became broken and the line finally closed. In 2016, a modern 756km standard (1435mm) gauge electrified railroad opened from Addis Ababa to Djibouti at the coast of the Red Sea, replacing the meter gauge railroad. Around 660km of this line lies inside Ethiopia (Mohapatra, 2016). Figure1-2 shows the picture of Ethio-Djibouti railway train.

China Railroad Group and China Civil Engineering Construction Corporation (CCECC) constructed the project, which was jointly owned by the governments of Ethiopia and Djibouti. With the official launch of passenger services in October 2016, the line officially opened for cargo in October 2015 and provided landlocked Ethiopia with enhanced access to the port of Djibouti. However, official travel and cargo services began offering commercial operations in January 2018. In August 2019, the Ethiopia-Djibouti railroad was honored for capitalizing on the country's transportation requirements (Global Infrastructure Hub, 2020). Figure 1-1 shows the picture of EDR train.

Figure 1-1: Ethio-Djibouti railway train

Ethiopia is now carrying out an ambitious plan to develop over 5,000 km of national rail line and with light rail transport of around 34 km within the capital city Addis Ababa, using government financing and venture credit, more than a century after the Ethio-Djibouti rail line foundation (Fekadu, 2014).

In Addis Ababa, Ethiopia, there is a light rail system called the Addis Ababa Light Rail. On September 20, 2015, a 17-kilometer train line connecting the city's heart to industrial districts south of the city opened. On November 9, 2015, the second line (east-west) went into service. The 34.25 km total length of light rail transportation is currently split into two lines, the East-West (EW) line measuring 17.35 km and the North-South (NS) line measuring 16.9 km, with 41 stations. Trains should be able to travel at a maximum speed of 80 km/h, with a regular operating speed of 65 km/h. The Chinese contractor was awarded the railway contract. After receiving funding from

the Export-Import Bank of China, the Ethiopian Railways Corporation started building the double track electrified light rail transit project in December 2011. The Government of Ethiopia has assigned the Ethiopian Railway Corporation (ERC) the responsibility of managing, renovating, renewing, and rehabilitating the railroad network framework within the Ethiopian Metropolitan Area. On February 1, 2015, trial operations commenced, and several months of testing were conducted thereafter. It is operated by the Metro Group (Paper & Paper, 2021; Shumye Ali, 2017).

The first light rail system in sub-Saharan Africa was the Addis Ababa system (Shumye Ali, 2017). After three years of development, the railway came to a final cost of approximately 475 million dollars. The two lines of the Addis Ababa Light Rail were originally intended to serve 41 stations in total: 23 stations would be served by the north-south line and 16 stations by the east-west line. The Blue line saw 94 train rotations on average, while the Green line saw 93 train rotations (Alade et al., 2019, 2020; Tondo & Sekasi, 2021). Figure 1-2 shows the picture of AALRTSE train.

a) EW line train b) NS line train

Figure 1-2: Picture a and b shows AALRTSE Trains

If rules are permitted to be broken by offenders, the public transportation system may collapse, causing destruction and harm to the services (Russo et al., 2021). To reduce major loss increasing safety and security are mandatory. This needs to use planning methods to pass transportation corridors safely. So this thesis is undertaken to solve the major safety challenges by

developing protection mechanisms as a solution for the Addis Ababa light railway transport enterprise and Ethio-Djibouti railway line.

1.2 Statement of the problem

The conducted one-on-one interview with a railway patroller in AALRTSE. The duty of railway patrol is to guarantee that railways are guarded and that patrolling is carried out constantly. This demonstrates that theft is an everyday occurrences at the railway line, which has become a headache for the rail corporation and is becoming more prevalent. The company has wasted lots of money for trying to replace the infrastructure and fix the railway line that has been impacted by this issue, and the interview revealed that the crime is genuinely harming the business.

Theft related problems makes difficult to companies to concentrate on performance and security. Public transport system could collapse if criminals are allowed to keep on breaking rules, damaging and undermining the services (M. Zhang et al., 2018).

Cable theft remains to put challenges for railway networks such as cables play a vital role by providing signals and as power conductors for overhead lines. This leads to several challenges like loss of signals which may cause unnecessary head-on collisions and train derailments. Railway networks are intended for the safe movement of trains, however in cases where thieves temper with cables pose danger to travelers and train operators (De Cillis et al., 2015)

Criminals frequently target the railway system's infrastructure. The extensive victimization is having a negative impact on Ethiopia's railway system. According to the security report of AALRTSE and EDR, Addis Ababa light railway transport enterprise and Ethio-Djibouti railway loss of costs in millions due to property theft for years. Railway property theft is the major challenging problem for service provider sectors in Ethiopia. Throughout the years, there has been a persistent high rate of damage on railroad infrastructure particularly from year 2018 to 2021 G.C. It needs research to identify the leading causes to the occurrence of railway property theft that helps to prevent the revival of these criminal action and to set possible protection mechanisms.

Fastening systems of the rail, fishplates and fittings, and signaling system are mostly targeted by criminals. The criminal acts on rail fastening systems and cables are noteworthy because the removing and destruction of infrastructure often cause rail networks fail, such as cables play a crucial part in overhead lines by acting as power conductors and signal providers and fastening systems are responsible to maintain the track gauge and offer sufficient resistance in a vertical direction by fixing rails to sleepers. These leads to several challenges like loss of signals,

head-on collision, causes delay to passengers and freight service, hinders the transmission of train loads to the underlying track structure which cause disruption across a wide area including unnecessary head-on collisions and train derailments. These train head-on collision and derailment causes accidents to the passengers and goods inside and around the train and animals around the train(De Cillis et al., 2015; Starita & Scaparra, 2018). Especially the train is on the overpass track the accident would be severe. These makes demanding to companies to concentrate on safety and security issues.

Although railway networks are designed to ensure the safe movement of trains, there are situations in which thieves threaten travelers and train operators by tampering with cables. (De Cillis et al., 2015). If rules are permitted to be broken by offenders, the public transportation system may collapse, causing destruction and harm to the services (Russo et al., 2021). This thesis will try to address the stated problems by determining the characteristics of railway infrastructure theft, identifying the leading causes to railway property theft and developing engineering protection mechanisms as a solution for this criminal activity.

1.3 Research question

1. What is the characteristics of railway property theft?
2. What could be the leading cause to railway property theft?
3. What are the existing railway property protection mechanisms and how can they be improved?

1.4 Objective

1.4.1 Main Objective

The main objective of this study is assessing railway property theft and developing protection mechanisms to curb this criminal action on Addis Ababa Light Railway Transport Service and Ethio-Djibouti Railway.

1.4.2 Specific Objective

- To determine the characteristics of railway property theft
- To identify the leading causes that increase railway property theft
- To develop possible railway property protection mechanisms from theft

1.5 Significance of the research

The main purpose of this research was to investigate the characteristics of railway infrastructure theft and to identify the leading cause to railway property theft. It is basic to think through the characteristics of theft and the initiatives for those actions on railway property, it will help in distinguishing the basic causes and to go through them. These unlawful acts on railway property may be an upsetting phenomenon; variables capable for it have to be distinguished in order to handle it. There has to be expected to both practical and theoretical benefits to studying the characteristics of railway property theft and the leading cause of railway property theft. The study provides reliable information for the development of countermeasures and policies to theft related actions and enhance the general body of knowledge relating to railway problem researches. It is also valuable for universities and students as further referencing.

The finding of the research helps various stakeholders including AALRTSE, Ethio-Djibouti railway, Ethiopian Railway Corporation, Railway infrastructure managers, law enforcement agents, and other enterprises affected by property theft. Additionally the research help AALRTSE and Ethio-Djibouti railway to enhance understanding and do more thorough research on the best ways to stop criminal activity to railroad property. The finding of this research also guides efforts to improve the security of railway property.

1.6 Scope of the research

As railway is one of the safe and fast transportation system, avoiding the safety barrier is the mandatory work. So the scope of this thesis is to find out the major safety challenge in Addis Ababa rail transport service enterprise and Ethio-Djibouti railway line to set possible countermeasure. When safety is at high risk accident will happen so that determine the characteristics of theft incidents involving on railroad property. Those railway infrastructure theft occurrence data are used to find out the locational characteristics of incidents and relate their impact to set protection mechanism. In addition to that, questionnaire survey was also used to identify the leading causes to that criminal activity on railway property.

1.7 Limitation of the research

The study required undivided attention and the researcher needed to balance her time between her employment tasks and the demands of research project. Additionally the primary means of collecting information were conducting surveys with railway safety experts and security police. Even if a respectable response rate was obtained, non-response bias is always a possibility

because people who did not respond' viewpoints could differ from those of participants. The researcher persuaded respondents and persistently made follow ups on questionnaires to avoid delays.

The researcher obtained express authority from AALRTSE and EDR to pursue the study which enhanced access to confidential information. The study relied comprehensively on the occurrence of railway property theft from EDR and AALRTSE. Even though a thorough 6-year dataset was acquired, it's possible that accessing all pertinent documents and data was difficult, which could have affected how thorough the research was.

Despite these limitations, the researcher have faith in that the results and suggested solutions still offer insightful information and a strong basis for more study and actions to address the serious problem of theft impacting Ethiopia's railway system and operations.

1.8 Organization of thesis

A brief overview of how this thesis is structured, the study's introduction is given in the first chapter. It presents the study's background, describes the research problem, enumerates the research question and aims, and highlights the importance and scope of the research. The second chapter provides the theoretical framework and an overview of related prior research on theft and vandalism issues. The research methodology is presented in the third chapter, which also includes the target population and sampling strategies, analysis techniques, and research approach and design. The findings and analysis of this research are presented in the fourth chapter. The results of the several hypothesis tests are shown with the answers to the research questions. A thorough explanation and assessment of the quantitative analysis are given in this chapter. Chapter five summarizes and conclude the findings of this thesis and finally gives recommendations.

CHAPTER TWO

2. LITERATURE REVIEW

The author considers that it is essentially significant to any investigate to conduct a writing review. The writing survey is done to discover out what other seminal researchers have as of now learned and composed, experimentally distributed, concerning the subject to be tended to. It ought to be famous that a writing audit serves as a fundamental portion of any investigate venture. Okoli and Schabram (2010) expressed that reviews of research literature are carried out for many reasons. These include studying the depth of research on an area of interest, giving a theoretical foundation for future studies, and addressing practical issues by comprehending the conclusions drawn from previous studies. Therefore, research reviews are typically published as one of the first sections of an academic thesis or dissertation or as the introduction to an article summarizing a particular research topic. But there is another kind of literature review that stands alone as a unique and significant piece of independent research. Instead of serving as a foundation for the researcher's own pursuits, it establishes a strong point of entry for any other academic interested in that particular subject. Alongside this statement, the researcher presented the results of other investigations on the phenomena of theft, putting special emphasis on getting people to grasp these concepts. As a result, the strategies for decreasing theft in the railway system are examined in light of research findings.

The present study employed the literature review as a preamble to guide the delineation of the study's objectives and research questions. Additionally, the literature review was utilized to guide the analyses of the data that were gathered for the study. The data presented in the literature review part was used as a point of reference in the information analysis phase to determine the correlations between the study's findings.

2.1 Theoretical literatures

2.1.1 The rational choice theory

According to the rational choice approach, people can understand crime "as if" they choose to commit crimes by applying the same cost-benefit analysis techniques that they do when deciding on lawful action. The choice to offend is therefore influenced by people's preferences, attitudes toward risk and time discounting, and assessments of the availability, costs, and benefits of an illegal opportunity relative to those of a legitimate opportunity, as well as the possibility of

achieving similar or higher returns. Or, to put it more how economists put it more often, people commit crimes when they feel they would get a greater return on their subjectively expected return on investment (the benefits-costs ratio) by pursuing legal action instead of investing the same time and resources in it (Mccarthy & Chaudhary, 2016). Loughran et al. (2016) discovered that teenagers logically rearrange their schedules in reaction to anticipated shifts in the advantages of engaging in lawful and unlawful activities.

From the early prediction that there should be a decrease in crime when formal punishments get harsher and formal sanctions themselves are associated with criminal behavior, rational choice theory in criminology has advanced significantly. The rational choice framework still heavily relies on the theoretical emphasis on the cost-benefit calculus, but it has evolved into a more comprehensive view that recognizes the complexity of criminal behavior. Accordingly, the rational choice theory school has observed that a variety of contextual and individual factors influence an individual's perception of the relative costs and rewards of engaging in any given criminal activity. These factors include but are not limited to, an individual's degree of impulsivity and self-control, their own and indirect experiences with crime and punishment, their attachments to prosocial institutions, their understanding of the non-legal costs of punishment, and the limitations placed on certain criminal opportunities by the environment. (Pratt, 2008).

Mehlkop and Graeff (2010) presented gives an expanded version of the Subjective Expected Utility model, which is better in line with the needs of theory development and empirical research than previous methods, to explain criminal behavior. According to our model, an actor's choice is impacted by both the norms that forbid delinquent behavior and the predicted usefulness of the crime. Additionally, a relationship between norms and utility is proposed, which reflects various decision-making patterns and results in various probabilities for criminal activity. The reliability of the model is demonstrated with German survey data. A novel method for identifying interaction effects in nonlinear models is applied, revealing various patterns of decision making. Norms, on the one hand, probably serve to limit illegal activity by imposing cost-benefit analyses. On the other hand, it's also conceivable that cost-benefit analyses absorb normative influence.

2.1.2 Social control theory

According to Costello (2017), Social control theory are based on issues with the fundamental presumptions that underpin the strain and cultural deviance theories. According to

the strain and cultural deviance theories, people must be forced into committing crimes or taught how to do so by others, implying that human nature is inherently good or prosocial. According to the strain theory, the criminal is compelled to do crimes because they are desperate. According to the norms of his or her own subculture, the deviant in cultural deviance theories is not at all deviant. People can't actually break the rules within their own social group; outsiders simply perceive their behavior as abnormal. On the other hand, social control theory contends that social groups cannot value activities like theft, fraud, and assault and still remain social groups; rather, social order is predicated on agreement over fundamental norms and values. Additionally, the idea sees crime as a quick and easy way to escape pain and pursue pleasure since it believes that human nature is asocial. It is simpler to steal than to work hard and save money to achieve one's goals, and it may even be more pleasurable to attack the person who is causing you anger rather than having a calm conversation. While there can be a runner's high, drinking or using drugs requires a lot less effort (Costello, 2017). (Behnk *et al.*, 2017) discovered that when people operate in groups rather than alone, they are more likely to engage in antisocial behavior.

van der Put et al. (2011) and Vose et al. (2013) stated that there is a direct correlation between having friends who are deviant or criminal, engaging in serious and frequent delinquent or criminal behavior, abusing drugs, having a poor attachment to education, performing poorly academically, being placed out of home, having the drive to commit crimes, being impulsive, having pro-violent and pro-criminal attitudes, and engaging in criminal activity further.

According to Van Der Laan et al. (2009) Adolescents who believe that engaging in antisocial behavior would lead to opportunities and rewards may develop strong bonds with their deviant friends and pursue a life of crime. Adolescents who don't have enough bonding may fall prey to the influence of abnormal people. For early onset offenders, the route indicated by this theory accurately illustrates the beginning and continuation of aggressive and anti-social behavior.

2.1.3 Routine activity theory

By investigating the convergence of the essential elements of crime at particular points in space and time, the theory approached crime analysis from a different angle and did not consider the motivation of the deviant act. The routine activity theory describes how variations in everyday routines or social interaction activities, such as work, play, education, and leisure, impact disparities in crime rates. It looks at crimes as events that happen at certain times and places with particular people and/or objects involved. The primary focus of the routine action theory is an

illicit conduct, such as theft, house burglary, or robbery that involves direct physical contact between the perpetrator and the victim. It also considers stealing or causing damage to an object to be predatory. The routine activity approach focuses solely on an offender's presence and behavior. Motivated offenders choose their targets while people go about their daily business, taking into account the perceived worth, visibility, accessibility, and inertia of the target (Robert S Mueller et al., 2006).

Routine activity structures impact criminal opportunity, which in turn impacts trends in direct contact predatory offenses. They proposed, based on human ecology theories, that structural alterations in patterns of routine activity can affect the convergence of three minimal elements in space and time: competent guardianship, appropriate targets, and motivated offenders. To prevent crime, all of these things must exist (Skubak & Eck, 2010).

According to Andresen and Ha (2019) Routine activity theory arose as a purposefully simplistic explanation for shifts in the trends of violent crime, which were caused by variations in daily activity patterns. These changes may enhance modern life's enjoyment, but they may also incite criminal conduct. In contrast to criminological theories that focus on the motivations of the offender, it emphasizes crime as an event that happens in a concrete location at a specific time. By doing this, it attempts to conceptualize crime as something distinct from the three elements of crime and the controllers that accompany it, and as a result, it provides a valuable tool for crime analysis and prevention. Additionally, as an ecological explanation of crime causation, routine activity theory bases much of its explanatory schema on the spatial (and temporal) localization of people, things, and activities. The likelihood of an offender, target, and guardianship converging in location and time determines the offending patterns. Regular activities always take place in specific locations at specific times, creating variable opportunity structures for successful predation. Therefore, a key factor in determining the possibility and likelihood of an offence being committed is the spatial-temporal accessibility of targets for potential offenders. Anticipating the location and time of the crime is helpful (Yar, 2005).

In summary, this investigates the underlying causes and intents of crime. It incorporates ideas from criminology such as: Rational Choice Theory: Emphasizes the offenders' cost-benefit calculations. The informal constraints and social ties that deter crime are examined by social control theory. Routine Activity Theory: Takes into account the shortage of skilled guardians, the

convergence of motivated offenders, and appropriate targets. It is essential to comprehend these elements in order to create preventative strategies that work.

2.2 Railway property theft

Ramuhulu and Chiranga (2018) Expressed that the railroad framework is made up of the track structures, train authorization resources, bridges, overhead traction equipment and telecommunication equipment. Avci and Ozbulut (2018) categorized railway property constituents in a subway station by physical locality which are signaling system, communication, structural system, track structure and traction power system that are vulnerable to vandalism.

A railway infrastructure is made up of linear components like tracks, lengthy metro tunnels, equipment along railroad tracks, and cables, as well as nodal components like electrical substations, telecommunications equipment rooms, and train stations. Each of these components has a variety of internal conditions. For instance, a linkage or association between two stations can have an impact on or relate the status of one station to the other. Therefore, a disruption or damage to a station could have a negative impact on how the entire railway infrastructure operates. Every infrastructure component has the potential to cause an accident since the destruction or disruption of one component can have varying degrees of effect on the entire system. While certain broken components only result in one or a few other components failing, other damaged components have the potential to cause many component failures or perhaps the collapse of the entire railway infrastructure. Therefore, extra care must be taken to provide additional security resources to aspects that have a greater impact on the railway infrastructure in order to ensure its smooth functioning (Z. Zhang et al., 2015).

Infrastructures such as metro systems and railroads are susceptible to various forms of attacks, ranging from basic vandalism to sabotage and terrorist acts. This is because rail-based transportation systems move large numbers of passengers on a daily basis and are open systems, both of which make the system highly vulnerable and challenging to secure. It's common knowledge that the transportation sector supports the whole economy. The nation's rail network facilitates the movement of people and products around the nation and the globe, and modern urban metropolises offer the most environmentally friendly option for town travel. As a result, an attack on the railway or metro system is very relevant to the public and media and has the potential to seriously harm the community. Certain features of railway transportation render it susceptible to cyberattacks: trains follow predetermined routes and make planned stops; its operations rely on

people having fast and simple access to terminals and trains, leading to a high number of points of entry. To improve the security of railway and metro transportation systems while preserving their open, extensive, affordable, and accessible features, it is required to define the term "security" in this context (D'Amore & Tedesco, 2015).

Vojtek et al. (2021) Considered patterns in field of railroad security frameworks center primarily on fundamental railroad lines with tall concentrated of railroad operation. One of the primary factors that has a big impact on the quality of the transportation process is railway operation safety. Safety systems have an impact on the level of safety on railroads. It is believed that adding appropriate safety technologies to the railway infrastructure will improve dependability and safety in particular by averting incidents. Eliminating all human-caused failures is the primary goal of the railway safety system.

Ashby et al. (2017) bases his research on metal theft data from the British railway network that was documented by the police. When thinking about thefts from railroads, a distinction can be made between thefts of metal that is used in the network, like signaling and telecommunication wire (also referred to as "live" metal), and thefts of other metal, like lead taken from station roofs or palladium found in catalytic converters taken from cars parked in station lots. The main consideration for classifying a metal as live is whether it is a component of the systems required to operate trains safely; it is not essentially necessary for the metal to conduct electric current at all times (Ashby et al., 2017). Sidebottom et al. (2014) discovered that copper cable theft accounted for the majority of railway metal burglaries.

Janusova and cicmancova (2016) discussed the framework of the transportation system is extremely complex and is made up of many different types of infrastructure, including information systems, transit routes, terminal buildings, and fleets of vehicles. In most nations across the world, transportation has emerged as a crucial sector of the infrastructure. At the national and international levels, transportation is regarded as one of the most significant sectors of vital infrastructure. The needs for transportation determine the specific location of the transportation infrastructure. There should be a high degree of user accessibility in transportation, as well as vast amounts of physical infrastructure and assets that are mostly unguarded and unattended, with millions of vehicles and containers dispersed throughout the network. Additionally, transportation should be efficient and flexible (Janušová & Čičmancová, 2016).

Critical transportation infrastructure is essential to the country's security, economy, and government operations. Prioritizing the nation, supplying necessities, guaranteeing trade flows, and fostering economic expansion all depend on it. There are numerous crucial locations in the transportation infrastructure, such as elements, items, and nets. The assets are also widely dispersed geographically. Security threats may have an impact on the transportation industry and the way that transportation operates (Janušová & Čičmancová, 2016).

Ramuhulu and Chiranga (2018) Investigated the causes of railroad infrastructure failures in Transnet Freight Rail's Steel and Cement business unit. The study employed a quantitative methodology, with questionnaires distributed to 1048 business unit employees. The participants were selected based on their exposure to and experience with railway infrastructure. The analysis came to the conclusion that the main reasons why the business unit's railway infrastructure fails are theft and damage. Infrastructure maintenance departments find it challenging to focus on maintenance due to theft and vandalism, which also compromises performance, safety, availability, and reliability. Millions of dollars' worth of theft and vandalism-related failures occur, costing businesses and government both personnel and property (Ramuhulu & Chiranga, 2018).

Chingozha (2021) Investigated the framework vandalism by looking at Zimbabwe Electricity Supply Authority (ZESA) a control utility in Zimbabwe. In most cases, copper conductors, copper windings, oils, and poles are the targets of theft and vandalism of infrastructure, which has been observed to be sparked and sustained by an abundance of stimulants. Two types of research approaches were used: mixed and qualitative. According to their findings, theft and damage to infrastructure can result in deaths, lost revenue, disconnected services, and increased repair costs.

Scholars presented railway property and represents that property in the railway sector that is susceptible to theft. It consists of rolling equipment, such as trains and coaches, as well as the physical infrastructure, such as rail, rail fastenings, signals, and power supplies. This is the primary concern being addressed, which includes crimes against railway property.

2.3 Characteristics of theft

Ola and Adewale (2014) Examined the infrastructural vandalism in Nigerian Cities. They pointed out that vandals are people, not ghosts, who have consistently committed horrible crimes under the cover of darkness. Despite the obvious destruction, no noteworthy arrests of the perpetrators have been made. Information was gathered from the city's citizens and the relevant

security agency through questionnaires and interviews. A total of 270 households were chosen at random to receive questionnaires. The data that was collected was analyzed using descriptive statistics. According to the report, 46.7% of vandals are unemployed and use their acts as a way out of poverty. However, 28.3% of them are small-time criminals who make their living not only from vandalism but also from other crimes like pick-pocketing and gang violence. In addition, compared to other assets, vandalism is more common on water pipelines, electrical cables, electrical transformers, and telecommunications equipment. The governments and communities have had to expend significant amounts to rebuild or repair the damaged infrastructure as a result of this.

Torkaman and Saei (2016) discovered that criminal activities was advanced among boys than girls. This was to be expected, as boys are less likely to be questioned for such behaviors and have greater freedom of movement than girls. Men also view the ability to display their physical prowess as a luxury. Therefore, despite the fact that females are more likely than boys to engage in vandalism, women are based on physiological traits that typically enable them to control their anger. However, compared to males, their behavior is more constrained. On the other hand, they are more constrained in their behavior than boys. (Madzivhandila, 2022) emphasized that the majority of these offenders are young people and dropouts from school. The age range of those who conduct these crimes is 18 to 38 years old; the majority of these offenders are male and fall into the youth category.

Madzivhandila (2022) Revealed the incidence with that crime occurs in the environment of railway is the most challenging days and times when criminalities are committed. The execution of crime differs from time to time, depending on the existing opportunity. Crimes on property are repetitive in the transportation sector (Avci & Ozbulut, 2018).

It was not possible to use aoristic analysis at this scale, because when crimes have a long duration it is common for police to record the range of potential offence times only to the nearest hour. As such and following the recommendation of Ratcliffe (2020), only offences with a duration of 4 hours or less were included. The peak offending times are between 21:00 hours and 06:00 hours, with the fewest offences occurring during the morning and evening commuting hours. Robb et al. (2015) Studied the solvability and detection of metal theft on railway property and found that the frequency of the theft differs in localities.

In summary, the characteristics of theft shows the particulars of the theft occurrences, including their patterns and trends. It assistances in comprehending the scope, regularity, and tactics of the illicit activity.

2.4 Contributing factors to theft

Nobanda et al. (2020) examined the various obstacles that stand in the way of a successful response to wire theft in South Africa's Durban railway stations. In order to investigate and ascertain the true perceptions of the prominent "Cable Theft Investigators and Cable Theft Railway Patrollers" from PRASA Protection Services, who are all engaged in preventing cable theft in the Durban train stations, a qualitative method was used in the study. An exploratory research design was used in order to investigate and find important data regarding this topic. Data were gathered using two methods: focus groups (FGDS) and key informant interviews (KIIs), which combined snowball and purposive sampling procedures. Two cable theft investigators and six cable theft railway patrollers provided data; these individuals were selected purposively to elicit their individual perspectives and experiences regarding this topic. The data analysis method employed was Inductive Thematic Analysis. They discovered that the main causes of cable theft in the Durban railway stations are scrap metal traders, who purchase stolen cables from unapproved partners. They also discovered that the market value of copper cable encourages an exponential increase in cable theft. It was also determined that the rail infrastructure was not adequately protected.

Train derailments, unneeded head-on collisions, and delays are all caused by cable theft. Railway networks are expected to provide the safe passage of trains; but, in situations where cable thieves cause damage, passengers and train operators may be at risk. In addition, the theft of wires results in unnecessary delays, which eventually cause travelers to become frustrated. In addition to causing delays for passengers, cable theft also incurs expenditures for the train sector. For example, they have to provide compensation to families who lose loved ones in incidents caused by cable theft, and replace the stolen cables (De Cillis *et al*., 2015).

Increased travel delays following a disruption could lead to some passengers canceling the trip or using alternative transportation, which would result in user disutility and system-wide expenses. Inability to record changes in flow demand due to longer trip times (Starita & Scaparra, 2018). The most common crimes perpetrated by the offenders include robberies, theft of copper and cable, and intentional property damage caused by setting rail cars on fire. It seems that cable

theft is a significant issue in the railway industry, impacting and interfering with train operations. Until the stolen infrastructures are repaired, commuters are unable to get at their destination on time due to specific damages. Due to their tardiness, some commuters risk losing their jobs, which has a detrimental effect on them. The fact that some commuters participate in activities that put their lives in danger is another consideration. Most participants noted that some commuters had a tendency to cross railroad lines without seeing trains approaching or to engage in staff riding while the train is moving.

Sidebottom et al. (2011) investigated the connection between copper theft and market price. They argued that price increases for copper have a beneficial impact on the amount of copper stolen, making copper a more desirable target for thieves. This theory stems from economic perspectives on crime, which maintain that criminals often act rationally. Accordingly, rises in the perceived amount of money or psychological gain from crime are likely to be correlated with an increase in the number of criminal prosecutions. Furthermore, the sharp increase in metal prices is seen to be the driving force behind the spike in metal theft. In summary, the trade of prospective producers and consumers on commodity markets determines the price of commodities like copper. Among the most actively traded and volatile markets in terms of price is the copper market in particular.

Posick et al.(2012) examined crime data from April 2008 to July 2010 in Rochester, New York, to perform an exploratory research on metal theft from residential and commercial properties. A framework for opportunities guided the analysis. Metal theft was investigated and better understood through the use of multivariate logistic regression techniques. According to the study, metal theft has a favorable correlation with a wide range of factors that opportunity theories identify as contributing to or causing crime. Trend analysis revealed a positive correlation between metal theft and copper prices over time, indicating a relationship between rising and declining copper prices and metal theft. Moreover, metal theft was concentrated in high-crime regions that offer plenty of opportunities for metal theft. Lastly, multivariate logistic regression models revealed that vacant buildings were the strongest predictors of metal theft. It goes without saying that vacant buildings give thieves a chance to steal metal without running a serious danger of getting caught. However, the findings indicate that using force to obtain admission is frequent, implying that even if these facilities are secured or boarded up, motivated criminals will still be able to enter with little difficulty.

Yusuf (2011) examined the prevalence of theft on Nigerian railway. This paper has offered a preliminary clarification approximately the unintended results of railway on African industry and how individuals responded to changes to their source of livelihood. It shows that when individuals were confronted with issue that threatened their livelihood they tend to devised elective means of livelihood, which may be legitimate or unlawful depending on societal definition of what constitute great or awful. Where an activity was considered terrible and an alternative means were not put in place, individuals may proceed with it regardless of discipline and conviction as seen from the theft of railway metals. The paper has moreover pointed out that the predominance of the thefts was as a result of ready-made markets for the items (Yusuf, 2011). Since it is known that there is a link between market value and metal theft, the scrap metal industry is very important. Ashby and Bowers (2015) studied that there was a notable increase in the frequency of metal theft from railway lines in places that were close to scrap-metal dealers, easily accessible by the current road network, and highly populated areas.

According to Madzivhandila (2022) The contributing factor to theft on railway were mostly about the organization's shortage of resources, both human and physical resources. The study stressed out that human resources were not pleased satisfactorily in proportion to the functions executed in railway environs. In regard of the railway police, the staff members' concerns were with respect to the deficiency of manpower. The encounter has appeared that the more police authorities are sent within the railway environment, the more the crime level diminishes. High visibility of police in these zones dissuades criminal actions, reduce the openings for offenders to execute diverse sorts of crimes and strengthens security and security among commuters.

Literatures highlights how socio-economic, infrastructural and security factors contribute to the occurrence of theft that significantly affect companies.

2.5 Measures to theft

For homeland security, risk mitigation and readiness in the transportation sector are essential. It necessitates, among other things, an in-depth analysis of the assets' vulnerabilities, an acute awareness of criticalities, potential countermeasures, and a suitable approach to develop, scale, and optimize the security. In order to achieve this, a great deal of focus has been placed on creating a deeper understanding of vulnerabilities under the framework of transportation and telecommunication infrastructures protection and, as a result, offering solutions to act decisively

in order to reduce their negative impact on, among other things, population welfare, the national economy, and safety (De Cillis *et al*., 2015).

Keeping people safe, safeguarding vital assets, safeguarding signaling and traffic control systems (IT and telecoms), and ensuring passenger safety at stations and on trains are the primary difficulties faced by railway security systems. Achieving all of these goals will require maintaining the rail-based transportation system's continued operability. Furthermore, an asset will lose its appeal to potential attackers due to the preventive and reassuring effects of a dependable and effective security system (D'Amore & Tedesco, 2015).

A study on the solvability and detection of metal theft on railroad property was conducted by Robb et al. (2015). Their goal was to determine how important each of the main solvability indicators was in identifying metal crime on Wales' and England's state rail networks. It uses data from the British Transport Police for 4001 metal theft crimes that were perpetrated in 2009 and 2010. One possible reason for the abandonment of solvable crimes could be a lack of resources needed to examine all solvable violations with solvability factors predicting a potential detection. Because the study did not quantify resource inputs or effort, it is possible that certain examples of investigative resources were employed ineffectively. According to the report, people don't think well of being identified. Consequently, determining whether or not every possibility for resolving issues has been explored is difficult. Authorizations for scrap dealers: given the resource requirements of these appointments and the thousands of metal theft cases that occur annually, it is unlikely that every case that can be resolved will receive the attention it deserves. Furthermore, discoveries might be more profitably enhanced if scrap sellers regularly reported data on metal purchases to the police. This is especially true for dealers who have previously contributed to the receipt of stolen metal, to whom visits are likely to be worthwhile.

In the study of vandalism, terrorism and security in urban public passenger transport (Public & Transport, 2003) some methods have been applied to encounter vandalism actions. The outline for giving these methods of the measures in place implements the three chief components of criminality reduction:

- Law enforcement: - the practice of the criminal justice and the police system to catch criminals and discourage potential criminals;

- Situational crime prevention: - trials that make it more challenging to commit criminality, diminish the prize for committing a criminality or make it more possible that the criminal will be trapped;
- Criminality prevention: - procedures that diminish the “risk factors” linked with criminal, or rise the “protective factors” that make it less possible that a person to participate in crime.

Tsokota et al. (2013) concluded that persistent community collaboration with judges is required for the hasty management of vandalism incidents and the public should be advised to escape vandalism and to protect infrastructure in their societies. Residents should safeguard and defend infrastructure from vandalism and theft. Additional way of decreasing cable theft is to seriously protect the infrastructure; this might be implemented by employing either the security forces or the private security guards. An enhancing in security could avoid cable thieves who have become bold to the degree of vandalizing electrical cables within the densified areas. The supplementary option is to have warning sentences for selling, buying or vandalizing copper cables.

This section examines the several tactics, tools, and regulations that can be used to lessen the risks of theft, and it expands upon the knowledge obtained by examining the traits and influencing elements. Creating inclusive property protection mechanism is the study's ultimate objective.

2.6 Summary and gaps in the literature review

Property theft could be a rising issue for the various industries. Various scholars stressed out damage and destruction of infrastructure could cause failure to infrastructures which provided essential service to the country. If this was allowed to continue, the quality of life of citizens who utilized the service of the country would be influenced.

Most of the former studies were qualitative, however they do offer valuable descriptive arguments of incidents, their repercussions and background. It is essential for a further quantitative approach, which therefore seeks to identify the significant characteristics of theft and the motivational factors of the incident. This study engages quantitative approach for investigating the problem of railway infrastructure theft in Ethiopia. The participants might constantly vary in their thoughts and feelings towards a problem and hereafter the researcher saw it essential to collect

data using questionnaires in relation to theft in railway to gather views and thoughts from different participants. And also safety and security reports was used as a secondary data source.

The literature suggested that the behaviors of theft are specific to an area and/or system and stresses the importance of investigating the problem from local perspective to develop a better understanding.

The researcher did not found the literature conducted on railway infrastructure theft in Ethiopian context, including theft and damage, at railway infrastructure on the characteristics and the leading cause to the incidence with the rank of each factor which are discussed later in this paper. Ethiopian railway system is suffered by rail infrastructure theft. Which costs the country's economy badly. Due to large concentration of theft, railway transportation provider companies such as AALRTSE and Ethio-Djibouti railway faces difficulties to provide railway transportation service to passengers and goods. However the rail infrastructure security in Ethiopian railway system is not emphasized. Therefore it needs to be researched to understand rail infrastructure theft. This study covered the analysis of the characteristics of theft on railway infrastructure and identification of the leading cause to this crime. And this study also contribute to the knowledge of emphasizing the protection of the railway system infrastructure by developing protection mechanisms to railway property from theft.

2.8 Conceptual framework of the research

The Conceptual framework of the research provides a structured overview of the key elements and relationship within the research on the assessment of theft on railway property at Addis Ababa light railway transport system enterprise and Ethio- Djibouti railway.

Independent variables are characteristics of criminals involved in these instance, temporal and locational characteristics of theft and the leading causes to railway property theft. These variables represents criminal's profile, time of occurrence, location of occurrence, components of railway infrastructure and all of the leading causes that increase railway property theft. It serves as the factor that the study seeks to manipulate or understand better in relation to railway property theft.

Dependent variables are number of occurrence of theft incidents and the perceptions of respondents on the leading causes to theft of railway property. This research analyzes statistical data regarding the number and pattern of theft cases on the AALRTSE and EDR, and the perceptions of participants on the factors that motivates criminals to engage into railway property

theft. Which helps to identify the critical leading cause that contribute to increase property theft of railway industry. Reducing theft and vandalism is the main strategy to improve the safe and dependable delivery of railway transport services.

Moderator variable: The availability of security and protection mechanisms as well as multi-stakeholder collaboration policies put in place to raise the general safety and security of railway property.

The study aims to assess characteristics of theft on the railway property, identify the leading causes to railway property theft and develop effective protection mechanisms to curb these criminal issue. The moderator variables like protection mechanisms and multi stakeholder collaboration are proposed as a solution to address the dependent variable reduced theft incidents and improved safety/security of the railway system. Figure 2-1 shows the conceptual framework of this research.

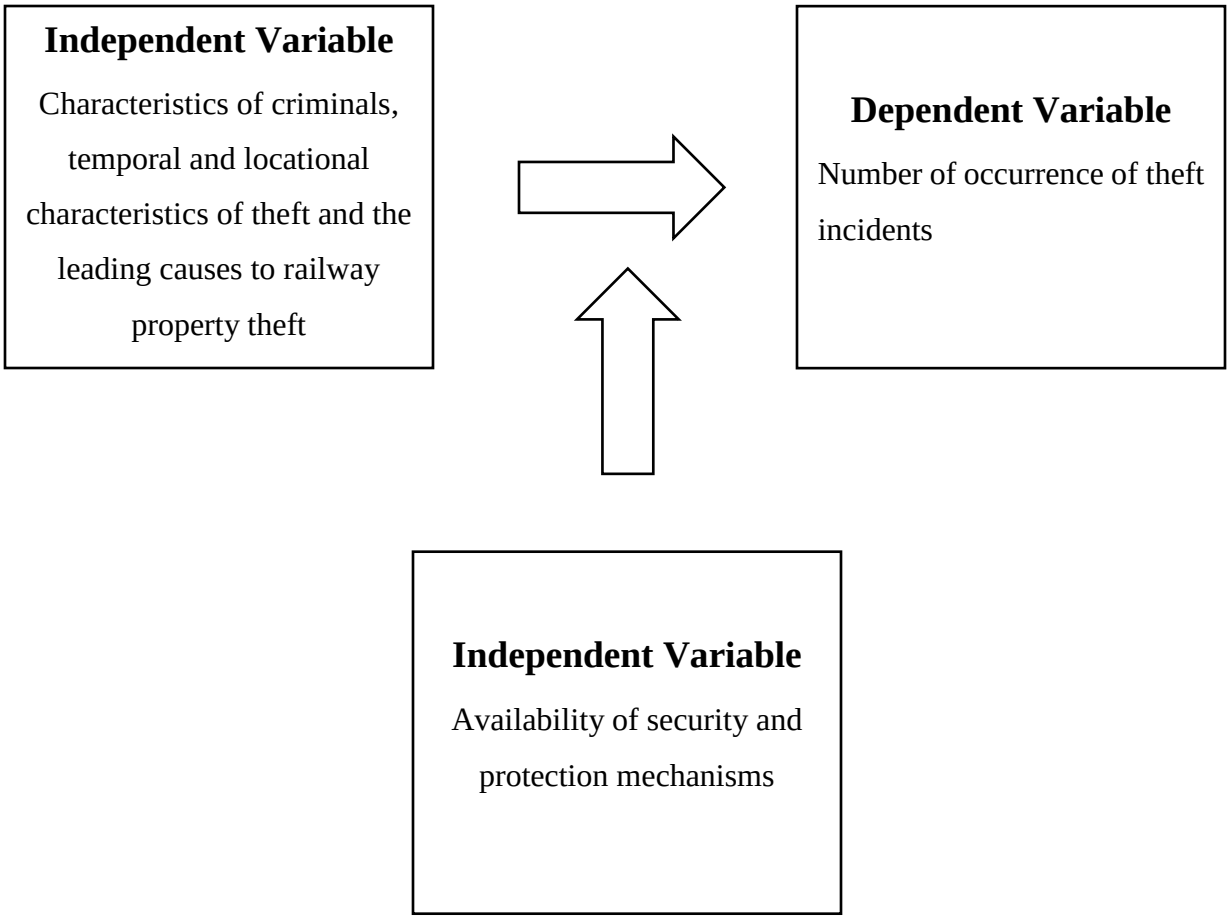

Figure 2-1: Conceptual framework of the research

CHAPTER THREE

3. RESEARCH METHODOLOGY

3.1 Research area

The study was conducted on Addis Ababa light railway transport service and Ethio-Djibouti railway line. The Ethio-Djibouti railway line is extended with 756 km standard gauge line that connected Ethiopia's capital, Addis Ababa, with the port of Djibouti, Negad (Mohapatra, 2016). The layout of Ethio-Djibouti railway line is shown by Figure 3-1 below.

Figure 3-1: Line layout of Ethio-Djibouti railway line

Addis Ababa light railway transport is extended in Addis Ababa city that is 34.25 Km. The 34.25 km total length of light rail transportation is currently split into two lines, the East-West (EW) line measuring 17.35 km and the North-South (NS) line measuring 16.9 km, with 41 stations (Shumye Ali, 2017). Figure 3-2 below shows the layout of Addis Ababa light railway transport service.

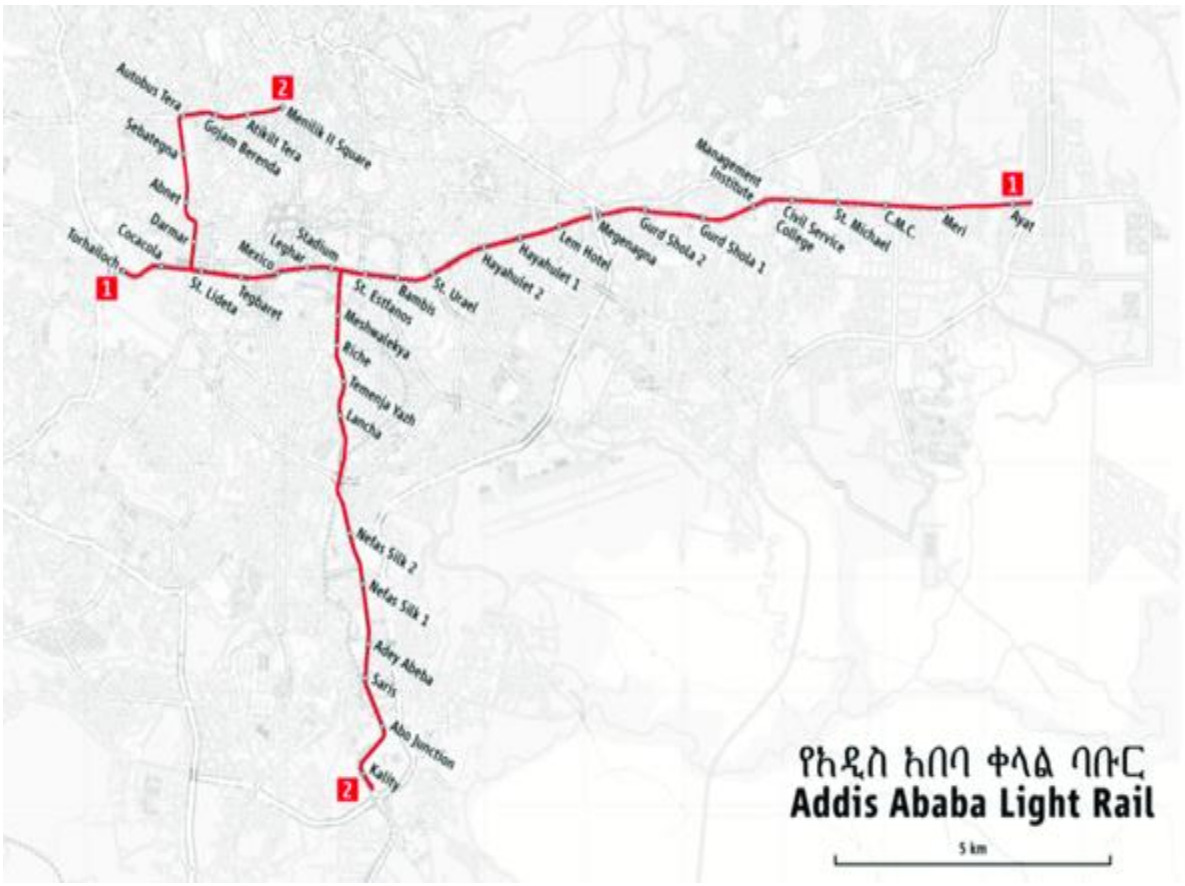

Figure 3-2: Line layout of Addis Ababa Light Railway Transport Service

3.2 Research approach

Quantitative methodological research approach were used for this study. The choice to use this approach for this specific research are due to the complexity nature of railway assets theft and vandalism and the characteristic of the occurrence.

3.3 Research design

The descriptive research design was adopted for this research that permitted the researcher to study relationships and events as they happen in normal human life situations and used to describe analytically the existing phenomena under the study. The researcher used this research design to understand property theft on railway transport system. The researcher used both primary and secondary sources of data collection. Primary data was collected by using questionnaire survey and secondary data was collected from statistical recorded data from AALRTSE and Ethio-Djibouti railway while carrying out the study.

3.4 Target population

The population in this study were consisted of all safety and security experts and rail security police from AALRTSE and Ethio-Djibouti railway. Which are directly related to the security issues of the rail system and also they should have knowledge about the day to day security issues of the system. The researcher found it difficult to access all the railway security polices and safety and security experts. Therefore it was not possible to conduct the research with all of them. These association enforced the researcher to select an accessible sub-population.

3.5 Sampling size

Random sampling technique was used to select participants for the study, which assured that there was equal representation of population along the safety and security experts, and along the railway security police.

When population are unknown with large proportion, to determine the sample size (Cochran, 1977) established an equation to determine the sample size for the large population proportion, but with unknown variability in the proportion. Consequently, assume p = 0.5 (maximum variability). The level of confidence 95% and level of precession 5% are the commonly used values for studies to increase the accuracy of statistical estimate (Cochran, 1977). A p value of 0.5 is frequently used to choose a more conservative sample size because it shows the maximum variability in a group (Sarmah *et al.*, 2013).

$$n = \frac{Z^2 * p * q}{e^2}$$

Where, n is the sample size, Z^2 is the area under the acceptance region in a normal distribution $(1 - \alpha)$, the value of Z is illustrated in statistical tables that contain the area under the normal curve and the value is 1.96, e is the preferred level of precision, p is the estimated proportion of an attribute that is present in the population, and q is 1- p. the resulting sample size is

$$n = \frac{Z^2 * p * q}{e^2}$$

$$n = \frac{1.96^2 * 0.5 * 0.5}{0.05^2}$$

$$= 384.16$$

Afshartous (2008) Stated that the probable challenges of selecting a sample from the voluminous data repository and the amount under consideration, it was advantageous for them to get the largest sample size feasible. But for the particular circumstance, the following equation will never yield a sample size larger than 385. (Naing et al., 2006) recommended that for use in follow-up analyses involving non-respondents, the researcher selects a random sample of 10–20% of non-respondents. Hence the sample size taken as 462. As at the time of this study, AALRTSE and Ethio-Djibouti railway line were at the study.

3.6 Study Variables

The study variables for this research were sex of criminals, age of criminals, time, day, month and year of theft occurrence, railway component, railway section, land use and the leading causes to rail infrastructure theft.

3.7 Research instruments

Data collection was accompanied by through questionnaire surveys and review of police recorded crime data. Questionnaires with structured questions were used to generate quantitative data. Police recorded crime data from AALRTSE and Ethio- Djibouti railway safety and security department was also used as a source for this study. Questionnaire survey was designed to determine the characteristics of criminals, to determine the most prevalence time of theft and to identify the leading causes that motivates criminals engage to railway property theft. Statistical record data was used to determine the temporal and locational characteristics of occurrence of theft on railway line.

3.7.1 Questionnaires

The questionnaire as a formal set of questions was used to get appropriate information from respondents for analysis and were engaged to gather mainly statistical information. These questionnaires was arranged based on previous literatures, it also delivered a large amount of evidence with in short time and it is a very operational means of collecting data with a minimum cost and time. Besides, it permitted greater consistency on how the questions were presented thereby ensuring greater comparability in the responses. The questionnaire was separated into the following three sections to achieve the study objectives: Background detail of respondents, Characteristics of theft and the leading cause to property theft from railway. The questionnaires were composed of closed-ended questions. In identifying the leading cause to railway infrastructure theft and theft occurrence time, Likert scale questionnaire was utilized. On a scale

of 1–7, respondents were inquired to choose the degree to which they agree with the recorded reasons as leading cause to railway property theft. The scale was itemized as: Strongly agree, Agree, Neutral, Disagree, and Strongly Disagree. Questionnaires was delivered to 470 safety and security experts of AALRT and Ethio-Djibouti railway.

3.7.2 Railway property security report data

AALRTSE and Ethio- Djibouti railway security report was used as a source for this study. The security data was collected from both AALRTSE and Ethio- Djibouti railway safety and security department. The reports are produced yearly to cover a year from January, 2018 to December, 2023, known as the reporting period. The security occurrence data is submitted to the respective AALRTSE and Ethio- Djibouti railway safety and security department daily. These recorded data contains the components of railway that are targeted by the criminals with location of theft occurrence.

3.8 Data collection procedures

The relevant data for the purpose of this study has been collected from questionnaire and recorded vandalism occurrence data. Daily railway infrastructure theft occurrence data from year 2018 to 2023 were obtained from AALRTSE and Ethio-Djibouti railway safety and security department.

Additionally, the objective of this research has been also achieved through questionnaires in person and by hand after the management of the corresponding respondent group provide permission. The questionnaire was administered on face to face to the volunteered safety and security experts and rail patrol police of AALRTSE and Ethio-Djibouti railway.

3.9 Data analysis

The collected data from the questionnaire and security reports was subjected to quantitative data analysis. Data was analyzed using SPSS for Windows (version 20) for accurate analysis and results. Analysis included descriptive analysis and analysis of variance (ANOVA). Descriptive statistics were carried out where significant to successfully describe the data. Variables describing the mean, standard deviation, frequency and percentage as proper were completed. The descriptive statistics were held by tables and graphical representations in order to describe further the data.

3.9.1 Questionnaire data analysis

A descriptive analysis was carried out on questionnaire data which contained information on the gender and age of vandals who are engaged to vandalism acts on railway infrastructure. The demographic variables have been given descriptive statistics that appropriately describe the mean, standard deviation, frequency, and percent. To fully describe the data, a variety of tables and graphic representations, such as pie charts and bar charts, are used to support the descriptive statistics. Analysis of the data was made for recorded information from questionnaire, gender of criminals (Male, both male and female but more male, equally both male and female), Age of criminals (Below 15 year, 15- 25 year, 26 – 35 year, 36 – 45 year) and time of theft occurrence. Finally, statistical hypothesis was tested. The relation between the answers and the variation in participants was checked by analysis of variance (ANOVA) in order to climax the significant variation of the means of communes, the difference of the mean is significant at level of 0.05.

To achieve the identification of the leading cause to railway property theft, the collected data from questionnaire was analyzed by using factor analysis. The descriptive statistics are supported by table. Analysis of the data was made for recorded information from questionnaire. The components were itemized as: High financial reward, Poverty, Unemployment, Illiteracy, Shortage of manpower (security police), Lack of physical and technological preventive measures, Lack of reporting structure with in the department, Availability of Scrap metal dealers, who buy stolen property from unauthorized associates, Poor enforcement of law against theft, Lack of evidence to the committed crime for prosecution, Light sentence for thieves. Furthermore these factors were distributed into four groups: Legal and external factors, Prevention related factors, evidence related factors, Socio economic factors. Finally, the relation between the response and the differences in participants was checked by analysis of variance to compare the mean value with in the group of the inclusive factors.

3.9.2 Railway property security report data analysis

Time and location based analysis was carried out for the railway infrastructure security report dataset. Data was analyzed over four year period including years 2018 to 2023.

To achieve the characteristics of vandalism One-way ANOVA was used to check in the event that there is a significant variation within the number of theft events taking place over the 12 months of the year, split into the variables for the study year periods (2018-2023) and the

months of the year (January – December). Further the hourly variation of theft events also analyzed by using One-way ANOVA.

The variation within the number of incidents for the study year and stations or regions, targeted part of railway property (civil infrastructure, mechanical and electrical), railway area (at station or other than station), rail line in the group of AALRTSE (East-West line and North-South line), railway sections (Sebeta station to Doraleh station by grouping in sections of one station to next station) and land use (Rural and Urban) was also analyzed by One-way ANOVA.

3.9.3 Statistical hypothesis testing

In scientific decision-making, human judgment or a researcher's "prior experience" cannot be entirely trusted. To determine if something has attained "statistical significance" or not, statistical significance tests are used. A "statistically significant difference" is just a statistical indicator of the existence of a difference; it is not definitive evidence of a link; rather, it is one piece of evidence supporting the research hypothesis.

The null hypothesis (H_0) is there is no significant difference between group mean (Brown, 2005). Statistical test, test the null hypothesis. Only when the null hypothesis is rejected can a statistical hypothesis test determine whether the alternative hypothesis has substantial support. The difference of the mean is significant at level of 0.05, corresponds to 95% confidence level. The null hypothesis was rejected If $p < 0.05$(significance level). To figure out which groups of data differed, further post hoc tests were performed. The null hypothesis is not rejected if $p > 0.05$.

ANOVA was used to determine whether there are statistically significant variations in the means across three or more groups. The results of all ANOVA calculations in SPSS are shown in ANOVA tables. Figure 3-3 shows the flow diagram of the research methodology designed for this thesis.

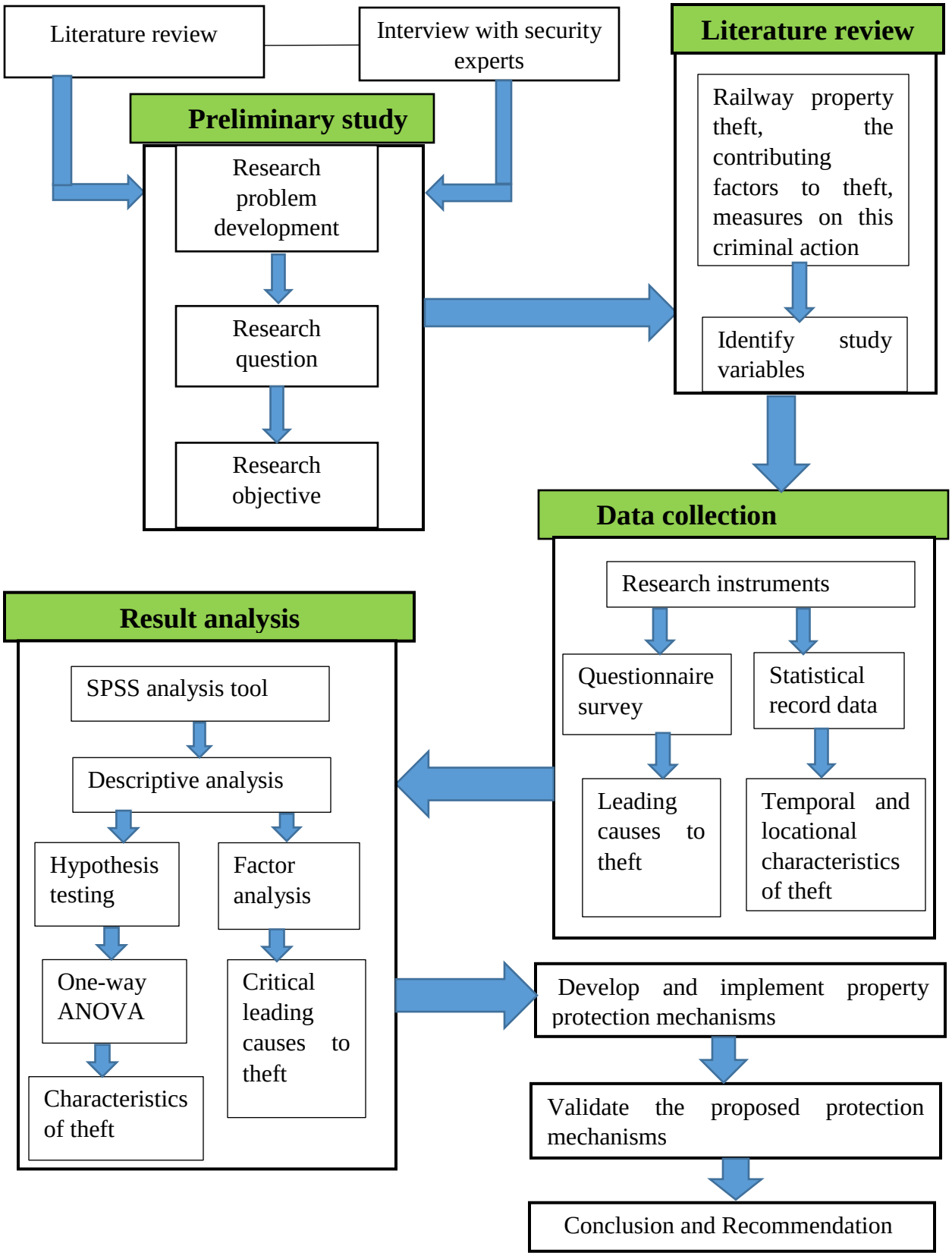

Figure 3-3: Research flow diagram

3.10 Validity and reliability

The researcher selected respondents from people that are members of Addis Ababa light railway transport service enterprise and Ethio-Djibouti railway, by working as safety and security staff. The data collection tool and procedures was tested preliminarily to identify the likely problems. A pilot study was conducted before the main data collection by using a sample of 43 participants, to assess the applicability of the prepared questionnaires to the research objective. Before the actual data collection the necessary actions was taken in time by the author. Then, the chosen sample of participants were invited to complete the questionnaire. The questionnaire was distributed and the completed questionnaires were later checked for consistency and comprehensiveness. Validity determines how accurate the study findings are or whether the research items accurately measure what they are supposed to assess (Golafshani, 2003). The opinions of experts were sought in order to verify the content validity (degree to which the sample is representative of the population). The research variables' dimensions were represented by the research items or questions in the questionnaire. To evaluate the construct validity, component analysis was applied to the data from the pilot study. Reliability is the extent to which study results are consistent over time and accurately reflect the entire population being studied (Golafshani, 2003). Cronbach alpha coefficient was computed by using SPSS and resulted a value of 0.806. The Cronbach alpha coefficient value above 0.6 shows that the measurement procedure is reliable (Kinnear & Gray, 2006). The piloted study assured that the prepared questionnaire are applicable and relevant to achieve the aimed research objectives.

3.11 Ethical Considerations

This study was carried out with careful attention for any potential ethical ramifications. Each respondent will receive a formal letter requesting the necessary data, outlining the study's objective as a partial fulfillment of the requirements of Masters of Science in Railway Engineering (Civil Infrastructure). The letter will also make it clear that the data is not meant for any other use. Each and every participant received information regarding the study's aims, purposes, and goals. Throughout the study, participants were told and reminded that participation was entirely optional. In particular, all participants in the research were asked for their informed consent before any information was utilized for any purpose other than the research itself. Additionally, the identities of the respondents were kept confidential. The respondents will also receive assurances of

confidentiality. Furthermore, the respondents will be free to ignore any questions they choose not to answer.

All conclusions were developed in a thorough and truthful manner, without purposefully distorting the results of the research or misleading others about it.

3.12 Research dissemination

This research findings are disseminated to others through publication. Researcher prepared research manuscript, describing the study, to journals in accordance with the style and formatting requirements of the journal. Hereafter, that research manuscript is published and available on internet to everyone who are interested to get it. Moreover the printed documents would be available at Addis Ababa Institute of technology library, AALRTSE and EDR.

CHAPTER FOUR

4. DATA RESULT AND ANALYSIS

This chapter presents the research findings and focuses on the presentation of data, interpretation, and evaluation of the outcomes of the quantitative analysis that was done. The organization and interpretation of the data were accomplished through the use of data presentation tools.

4.1 AALRTSE and EDR safety and security report results from 2018 G.C up to 2023 G.C

A total of 2233 theft and vandalism occurrences on railway property were recorded over the research period 2018 to 2023. Of all occurrences, 1972 incidences were happened on Ethio-Djibouti railway property. Table 4-1 shows the result of theft and vandalism occurrence on railway property that are collected from both EDR and AALRTSE.

Table 4-1: yearly occurrence of theft occurrences

Railway line	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**Grand total**
Ethio-Djibouti railway	133	146	178	374	569	572	**1972**
AALRT	19	24	20	51	67	80	**261**
Total	**152**	**170**	**198**	**425**	**636**	**652**	**2233**

(Source: AALRTSE and EDR Safety and security report from 2018-2023 G.C)

4.2 Questionnaire response rate

Table 4-2: percentage response rate for questionnaire

Respondents	Questionnaire Distributed	Questionnaire Returned	Rate (%)
AALRT Safety Department	6	6	100
AALRT Security Police	205	202	98.9
Ethio-Djibouti safety Department	20	20	100
Ethio-Djibouti Security police	239	208	87.3
Total	**470**	**436**	**92.8**

(Source: Questionnaire)

Table 4-2 displays the results, which indicate that 436 out of the 470 questionnaires that were issued were returned, yielding a response rate of 92.8 percent. Given that only 34 of the 470 surveys that were distributed were not returned, the study concluded that 92.8% is a favorable response rate.

4.3 Demographic Information of respondents

Demographic data entails personal attributes of the respondents with respect to sex, age, length of service, academic qualification, levels of management and work area, respondents drawn from the questionnaires. Of the 436 participants, 228 (52%) were EDR staff members, most of them, 270 (62%) were male and other demographic information are presented on table 4-3.

Table 4-3: Demographic information of respondents

Statement			**Frequency**
	Demographic Question		
1.	Gender	Female	166
		Male	270
2.	Age	18- 25	161
		26-35	233
		36-45	42
3.	Length of service	0-2 year	102
		2-4 year	157
		4-6 year	62
		6-8 year	34
		8-10 year	22
		10-12 year	29
		12-14 year	30
4.	Academic qualification	Primary school	12
		High school	105
		Diploma	195
		Bachelor Degree	99
		Master's Degree	25
5.	Level of management	Top management	2
		Middle management	105
		Lower management	116
		Staff	213
6.	By workplace	AALRTSE	208
		Ethio-Djibouti	228

4.4 Demographic characteristics of criminals

This section details the result and analysis of the questionnaire data on the characteristics of theft on railway property.

49.1% of the participants considered males are more engaged to theft acts on railway assets. 38.3% of respondents voted for both male and female are engaged to theft but more of them are males, presented on table 4-4. The remaining respondents assessed that the involvement is either both male and female equally or both male and female but more female.

Table 4-4: Sex of criminals

	Frequency	**Percent (%)**
Male	214	49.1
Female	0	0
Both male and female but more male	167	38.3
Both male and female but more female	0	0
Equally both male and female	55	12.6
Total	**436**	**100**

Table 4-5 shows that the majority of criminals were under age group of 26 – 35 years (70%), as found by (Madzivhandila, 2022; Torkaman & Saei, 2016). Age group of 15- 25 years (24.8%) are the secondly valued age group of criminals engaged to railway property theft and vandalism.

Table 4-5: Age of criminals

Age group of criminals	**Frequency**	**Percent (%)**
Below 15 year	14	3.2
15- 25 year	108	24.8
26 – 35 year	305	70
36 – 45 year	9	2
Total	**436**	**100 %**

Ho1: There will be no significant difference between the views of different participants on the sexual category of criminals.

Using statistical tests to check if there is a significant difference between the views of the participants on the sexual category of criminals. The opinion of respondents was calculated based on the representation made on the sexual category as: Male = 1, both male and female but more male = 2 and equally both male and female = 3. Table A-1 (Appendix) shows the result of descriptive statistics.

The null hypothesis that there will be no significant difference exists between the views of participants on the sexual category of criminals of railway assets.

For a 95% confidence level and an alpha level of 0.05:

Table 4-6: One-way ANOVA on sexual category

Source of variation	**Sum of Squares**	**Degree of Freedom**	**Mean Square**	**F-statistics**	**P value**
Between Groups	27.331	6	4.555	10.639	.000
Within Groups	183.685	429	.428		
Total	**211.016**	**435**			

One-way ANOVA result on table 4-6 shows that the p-value of 0.000 corresponding to F statistic of one-way ANOVA is lower than 0.05.

NULL HYPOTHESIS IS REJECTED

It is concluded that there is statistically significant difference exists between the views of the different participants to the sexual category of criminals that are engaged in theft on railway assets. This finding showed that both male and female are engaged to theft but more of them are male. This is consistent with the findings of (Madzivhandila, 2022; Torkaman & Saei, 2016).

Ho2: There will be no significant difference between the views of different participants on the age category of criminals.

Using statistical tests to check if there is a significant difference between the views of the participants on the age group of criminals. The opinion of respondents was calculated based on the representation made on the age category shown on table A-2(Appendix): Below 15 year = 1, 15-25 year = 2, 26 – 35 year = 3 and 36 – 45 year = 4.

The null hypothesis that there will be no significant difference exists between the views of participants on the age category of criminals of railway assets.

For a 95% confidence level and an alpha level of 0.05:

Table 4-7: One–way ANOVA based on age category

Source of variation	Sum of Squares	Degree of freedom	Mean Square	F-statistics	P-value
Between Groups	3.874	6	.646	2.096	.05
Within Groups	132.133	429	.308		
Total	**136.007**	**435**			

One-way ANOVA result on table 4-7 shows that the p-value of 0.05 corresponding to F-statistic of one-way ANOVA is higher than 0.05.

NULL HYPOTHESIS IS NOT REJECTED

It revealed that a there is no statistically significant difference exists between the views of the participants on the age category of criminals of railway assets. This finding showed that more criminals are categorized under the age group of 26 – 35 year. This result is consistent with the findings of Torkaman and Saei (2016) and Madzivhandila (2022).

4.5 The seasonal characteristics of theft occurrences on railway assets

Descriptive statistical analysis of views of respondents was used to calculate the average rating for the time of the day when occurrences of theft is prevalent on rail property. The average rating was calculated based on the extent of agreement (from strongly agree to strongly disagree) and the Likert scale (1 to 7). According to table 4-8 incidences happens more between the hour

group 10:00 pm – 2:00 am with the mean value of 1.5367. The second theft concentrated time was between 2:00 am- 6:00 am with the mean score of 1.6284. The least occurrence time was 6:00 am-10:00 am with the rating value of 5.378.

Table 4-8: Descriptive statistics for theft occurrence time

4-hour segments	Mean	Std. Deviation
6pm-10pm	3.4174	1.81312
10pm-2am	1.5367	.71183
2am-6am	1.6284	.84664
6am-10am	5.3784	1.45472
10am-2pm	5.3601	1.60492
2pm-6pm	4.7454	1.78933
Total	**3.6778**	**2.16414**

Table 4-9: Theft incidences by month, shows theft occurrences on railway property that are taken from statistically recorded data from year 2018 up to 2023. The mean of the totals for the month is 186.08 occurrences. September has the biggest number of occurrences (n=229) and February has the lowest occurrences (n=135).

Table 4-9: Theft occurrence by month

Property	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Civil components	114	89	117	190	114	89	98	142	148	119	35	90
Electrical components	42	35	51	75	72	44	53	58	77	54	54	51
Mechanical components	11	11	5	22	8	13	16	17	4	9	10	11
Total	**167**	**135**	**173**	**287**	**194**	**146**	**167**	**217**	**229**	**182**	**184**	**152**

Ho3: There is no significant differences exists between the time of day and number of theft occurrences.

Using statistical tests to check if there is a significant difference in views of respondents on theft incidence, happening over the course of a day, and four-hour segments. Table 4-10 shows the descriptive statistics for theft occurrence time.

The null hypothesis states that no significant difference exists between the time of day and theft occurrences.

For a 95% confidence level and an alpha level of 0.05:

Table 4-10: Descriptive statistics for theft occurrence time

4-hour segments	Mean	Std. Deviation
6pm-10pm	3.4174	1.81312
10pm-2am	1.5367	.71183
2am-6am	1.6284	.84664
6am-10am	5.3784	1.45472
10am-2pm	5.3601	1.60492
2pm-6pm	4.7454	1.78933
Total	**3.6778**	**2.16414**

Table 4-11:One-way ANOVA between occurrence times

	Sum of Squares	Degree of freedom	Mean Square	F	Sig.
Between Groups	6851.334	5	1370.267	662.785	0.000
Within Groups	5396.011	2610	2.067		
Total	**12247.345**	**2615**			

As shown on table 4-11, the p-value corresponding to the F-statistic of one-way ANOVA is lower than 0.05, signifying that the one or more categories are significantly different.

NULL HYPOTHESIS IS REJECTED

A statistically significant difference exists between the time of day and the number of theft occurrences.

The results of post-hoc tests on table A-3 (Appendix) showed that the theft occurrence had significantly higher on the time slot 10pm-2am (with mean scores of 1.5367) and 2am-6am (with mean scores of 1.6284) time, as opposed to other time slots 6pm-10pm, 6am-10am, 10am-2pm and 2pm-6pm. This result agrees with the findings of (Yar, 2005), the result showed that there is a difference in offence occurrence time.

Ho4: There is no significant differences exist between the months of the year and number of theft occurrences.

Using statistical tests to check if there is a significant difference in the number of theft occurrences taking place over the 12 months of the year, split into the variables for the study year periods (2018-2023) and the months of the year (January – December). Table 4-12 shows the recorded values for monthly occurrence of theft.

The null hypothesis that no significant difference exists between the months of the year and the number of theft occurrences.

For a 95% confidence level and an alpha level of 0.05:

Table 4-12: Monthly occurrence of theft

Year	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
2018	8	13	20	14	16	8	13	5	12	17	20	6
2019	12	11	14	15	14	3	6	28	16	17	15	19
2020	25	17	17	26	15	19	19	13	10	17	6	14
2021	15	21	34	31	32	13	34	68	62	38	33	44
2022	33	27	28	43	49	59	51	61	89	66	83	47
2023	74	46	60	158	68	44	44	42	40	27	27	22

Table 4-13:One-way ANOVA between monthly occurrences

Source of variation	Sum of Squares	Degree of freedom	Mean Square	F-statistics	P-value
Between Groups	3223.819	11	293.074	.416	.943
Within Groups	42249.167	60	704.153		
Total	**45472.986**	**71**			

Result from table 4-13, One-way ANOVA depicts that the p-value of 0.943 corresponding to the F-statistic of one-way ANOVA is higher than 0.05, signifying that the month categories are not significantly different for that level of significance.

NULL HYPOTHESIS IS NOT REJECTED

No significant difference exists between the months of the year for the number of theft occurrences. This would suggest that the occurrences of theft are widespread and occurs through the month.

4.6 The locational characteristics of theft occurrences on railway assets

The incidences of theft on Ethio-Djibouti railway property along the rail line area (other than train station) is higher than the incidences at station area. See Table 4-14: Areal occurrences of theft on Ethio-Djibouti railway property. The maximum occurrence was on rail line (n=536) on year 2023 and the minimum occurrence was at station (n=17) on year 2018.

Table 4-14: Areal occurrences of theft on Ethio-Djibouti railway property

Year	On rail line (other than train station)	On train station
2023	536	36
2022	501	68
2021	304	70
2020	159	19
2019	122	24
2018	116	17

Table 4-15: Occurrence by sections, shows theft incidences on sections of the Ethio-Djibouti rail line. The maximum occurrence was between Indode railway station– Bishoftu railway station with 146 occurrences on year 2023. The mean value of occurrence was 98.6 per section.

Table 4-15: Yearly occurrence by railway sections

Year	sebeta_ Lebu	Lebu-Indode	Indode-Bishoftu	Bishoftu-Modjo	Modjo-Adama	Adama-Feto	Feto-Metehara
2023	3	34	146	55	53	23	8
2022	2	31	74	6	37	23	16
2021	3	5	54	15	20	43	12
2020	1	11	6	18	3	9	14
2019	5	4	17	3	13	10	6
2018	10	18	12	6	8	8	11

Year	Metehara-Awash	Awash-Sirbakunur	Sirbakunur-Mieso	Mieso-Bike	Bike-Dire Dawa	Dire Dawa-Arawa	Arawa-Adigala
2023	13	20	8	52	98	23	2
2022	7	78	12	33	142	53	11
2021	3	15	16	28	112	22	6
2020	4	13	17	25	34	7	2
2019	6	12	15	19	20	7	5
2018	2	9	10	7	13	4	8

Year	Adigala-Aysha	Aysha-Dewale	Dewale-Alisabieh	Alisabieh-Holhol	Holhol-Nagad	Nagad-Doraleh(port)
2023	12	2	0	0	8	12
2022	24	7	0	0	6	7
2021	5	1	1	2	0	11
2020	1	7	0	4	0	2
2019	0	2	1	0	1	0
2018	2	0	0	1	0	4

Theft incidences are highest on East-West line on 2021 with 33 occurrences. Table 4-16: theft occurrence on AALRTS By line, shows theft on railway is increasing yearly. 60.92% of theft incidences happened on East-West line.

Table 4-16: Theft occurrence on AALRTS By line

Rail line	2018	2019	2020	2021	2022	2023	Total	Percent
East-West line	11	19	17	33	35	44	159	60.92%
North-South line	8	5	3	18	32	36	102	39.08%
Total	**19**	**24**	**20**	**51**	**67**	**80**	**261**	**100%**

Theft occurrences are highest on rural land use on 2022 with 457 incidents on Ethio-Djibouti railway line. Table 4-17 shows the distribution of theft occurrences on urban and rural land use.

Table 4-17: Theft occurrence by land use

Month	Urban	Rural
2018	31	102
2019	30	116
2020	27	151
2021	129	245
2022	112	457
2023	163	409
Total	**492**	**1480**

Ho5: There is no significant differences exist between railway component and number of theft occurrences.

Using statistical tests to check if there is a significant difference between the number of theft occurrences and the railway component, split into the variables for months of the year(January-December) and the railway component (Civil infrastructure, Electrical component, Mechanical component). Table 4-18 shows the descriptive statistics of theft occurrence on railway components.

The null hypothesis is that no significant difference exists between the months of the year for the number of theft occurrences.

For a 95% confidence level and an alpha level of 0.05:

Table 4-18: Descriptive statistics of theft occurrence on railway component

	N	Mean	Std. Deviation
Civil infrastructure	12	119.17	29.46
Electrical component	12	55.5	13.17
Mechanical component	12	11.42	5.07
Total	**36**	**62.03**	**48.45**

Table 4-19:One-way ANOVA on theft occurrence on railway component

Source of variation	Sum of Squares	Degree of freedom	Mean Square	F-statistics	P-value
Between Groups	70427.389	2	35213.694	99.003	.000
Within Groups	11737.583	33	355.684		
Total	**82164.972**	**35**			

Table 4-19 shows the p-value corresponding to the F-statistic of one-way ANOVA is lower than 0.05, signifying that the one or more categories are significantly different.

NULL HYPOTHESIS IS REJECTED

A statistically significant difference exists between the railway component and the occurrences of theft.

Table 4-20: Post-hoc results between the railway components

(I) Stolen Property	(J) Stolen Property	Mean Difference (I-J)	P-value	Post-hoc inference
Civil infrastructure Component	Electrical component	63.67*	.000	P<0.05
	Mechanical component	107.75*	.000	P<0.05
Electrical component	Civil infrastructure	-63.67*	.000	P<0.05
	Mechanical component	44.08*	.000	P<0.05
Mechanical component	Civil infrastructure	-107.75*	.000	P<0.05
	Electrical component	63.67*	.000	P<0.05

*. The mean difference is significant at the 0.05 level.

The results of post-hoc analysis on table 4-20 revealed that the occurrence of theft had significantly higher on civil infrastructure (with mean scores of 119.17, P=0.000) and electrical components compared to mechanical components. This result is consistent with the finding of

Ashby et al. (2017) and Sidebottom et al. (2014). On the part of Ashby et al. (2017), reported that live metals are targeted by criminals. On the part of Sidebottom et al. (2014), reported that copper cables are highly targeted by criminals.

Ho6: There is no significant differences exist between the railway area and theft occurrences on Ethio-Djibouti railway line.

Using statistical tests to check if there is a significant difference in the number of theft occurrences taking place over the railway area of station area and other than train station, split into the variables for the study year periods (2018-2023) and Rail areas (rail line or other than train station and train station).Table A-4 (Appendix) shows the descriptive statistics for areal occurrence of theft.

The null hypothesis that no significant difference exists between the railway area and number of theft occurrences.

For a 95% confidence level and an alpha level of 0.05:

Table 4-21:One-way ANOVA between rail areas

Source of variation	**Sum of Squares**	**Degree of freedom**	**Mean Square**	**F-Statistics**	**P-value**
Between Groups	188501.333	1	188501.333	10.255	.009
Within Groups	183813.333	10	18381.333		
Total	**372314.667**	**11**			

Result of One-way ANOVA on table 4-21 shows the p-value corresponding to the F-statistic of one-way ANOVA is lower than 0.05, signifying that there is a significantly difference between groups.

NULL HYPOTHESIS IS REJECTED

A statistically significant difference exists between the railway area and the theft occurrences. The result revealed that theft occurrence is significantly higher at rail line (other than train station) compared to station occurrences. This result agrees with the finding of Robb et al. (2015) which found that the frequency of the theft differs in localities.

Ho7: There is no significant differences exist between the railway section and theft occurrences on Ethio-Djibouti railway.

Using statistical tests to check if there is a significant difference in the number of theft occurrences taking place over the 20 railway sections, split into the variables for the study year periods (2018-2023) and Rail sections(Sebeta station- Doraleh station), shown on table A-7 (Appendix).

The null hypothesis that no significant difference exists between the rail sections and number of theft occurrences.

For a 95% confidence level and an alpha level of 0.05:

Table 4-22: One-way ANOVA between rail sections

	Sum of Squares	**Degree of freedom**	**Mean Square**	**F-Statistics**	**P-value**
Between Groups	34765.800	19	1829779	4.376	.000
Within Groups	41817.667	100	418.177		
Total	**76583.467**	**119**			

Result of table 4-22 shows the p-value corresponding to the F-statistic of one-way ANOVA is lower than 0.05, signifying that there is a significantly difference between groups.

NULL HYPOTHESIS IS REJECTED

A statistically significant difference exists between the railway sections and the theft and vandalism occurrences. A post-hoc analysis reveals that theft occurrence is significantly higher on the three sections, Indode station to Bishoftu station. Figure 4-1 shows theft occurrence spot at railway line from Indode railway station to Bishoftu railway station

Figure 4-1: Theft occurrence at railway line from Indode railway station to Bishoftu railway station

Mieso station to bike station and Bike station to Dire Dawa station compared to other rail sections. This result agrees with the finding of Robb et al. (2015) which found that the frequency of the theft differs in localities. Figure 4-2 shows theft occurrence spot at railway line from Mieso railway station to Dire Dawa railway station.

Figure 4-2: Theft occurrence at railway line from Mieso railway station to Dire Dawa railway station

Ho8: There is no significant differences exist between the railway line and number of theft occurrences on AALRTS.

Using statistical tests to check if there is a significant difference in the number of theft occurrences taking place over the 2 lines of AALRTS, split into the variables for the study year

periods (2018-2023) and Railway line (EW line and NS line). Table A-5 (Appendix) shows the descriptive statistics.

The null hypothesis that no significant difference exists between the railway stations and number of theft occurrences.

For a 95% confidence level and an alpha level of 0.05:

Table 4-23: One-way ANOVA between AALRTS rail lines

Source of variation	**Sum of Squares**	**Degree of freedom**	**Mean Square**	**F-statistics**	**P-value**
Between Groups	270.75	1	270.75	1.491	.25
Within Groups	1815.5	10	181.55		
Total	**2086.25**	**11**			

Result from table 4-23 depicts that the p-value of 0.25 corresponding to the F-statistic of one-way ANOVA is higher than 0.05, signifying that the line categories are not significantly different for that level of significance.

NULL HYPOTHESIS IS NOT REJECTED

No significant difference exists between the AALRTS Lines for the number of theft occurrences. This would suggest that the occurrences of theft are widespread and occurs through the AALRTS line.

Ho9: There is no significant differences exist between the land use and number of theft occurrences at Ethio-Djibouti railway.

Using statistical tests to check if there is a significant difference in the land use and number of theft occurrences at Ethio-Djibouti railway, split into the variables for the study year periods (2018-2023) on land use and month of the year (January- December). Table A-6 (Appendix) shows the descriptive statistics of theft and vandalism occurrence on land uses.

The null hypothesis that no significant difference exists between the land use and number of theft occurrences at Ethio-Djibouti railway.

For a 95% confidence level and an alpha level of 0.05:

Table 4-24:One-way ANOVA between land uses

Source of variation	Sum of Squares	Degree of freedom	Mean Square	F-statistics	P-value
Between Groups	81345.33	1	81345.333	5.992	0.034
Within Groups	135749.333	10	13574.933		
Total	**217094.667**	**11**			

Table 4-24 shows, the p-value corresponding to the F-statistic of one-way ANOVA is lower than 0.05, signifying that there is a significantly difference between groups.

NULL HYPOTHESIS IS REJECTED

The land use have a statistically significant effect on the dependent variable, number of theft occurrence. Theft incidences had significantly higher on rural areas with the mean score of 12.88, P=0.00 than urban land uses with the mean score of 4.71. This result agrees with the finding of Robb et al. (2015) which found that the frequency of the theft differs in localities.

4.7 Leading causes to railway property theft

Both AALRTSE and EDR staffs ranked availability of Scrap metal dealers, who buy stolen property from unauthorized associates as the first leading cause to railway infrastructure theft. The survey questionnaire having 12 questions of these section ware answered by respondents based on their perception towards the leading causes to infrastructure theft on railway system. The average rating was calculated based on the extent of agreement (from strongly agree to strongly disagree) and the Likert scale (1 to 7). Table 4-25: Overall mean and ranking of all leading causes, showed that the availability of scrap metal dealers is the most important leading cause to theft in the highest-ranked group with a mean of 1.31 by AALRTSE and 1.36 by EDR respondents and indicates that the average opinion among respondents to this factor which is highly influencing railway asset theft. Most of respondents disagreed that lack of reporting structure with in the department is the contributing factor to engage to railway infrastructure theft. Most participants also disagreed with the perception that poverty, illiteracy, poor quality of railway transport service are the main motivating factors that cause criminals to engage in rail infrastructure theft.

Table 4-25: Overall mean and ranking of all leading causes to theft

	AALRTSE		EDR	
Leading causes	**Overall mean Scores**	**Rank**	**Overall mean Scores**	**Rank**
High financial reward	1.93	4	2.47	6
Poverty	2.88	9	3.45	10
Unemployment	2.77	8	2.65	7
Illiteracy	3.37	11	3.23	9
Poor quality of railway transport service	3.28	10	4.17	11
Shortage of manpower (Guard)	2.28	6	2.44	5
Lack of physical and technological preventive measures	2.09	5	2.70	8
Lack of reporting structure with in the department	4.08	12	4.38	12
Availability of Scrap metal dealers, who buy stolen property from unauthorized associates	1.31	1	1.36	1
Poor enforcement of law against theft	1.63	3	1.42	3
Lack of evidence to the committed crime for prosecution	2.42	7	2.33	4
Light sentence forwarded on criminals	1.62	2	1.41	2

Factor analysis was used for analyzing the collected data related to leading causes to railway property theft. The agreement level variables was then used as the dependent variable in factor analysis. The listed leading causes to infrastructure theft on railway system was considered as independent variables for this analysis. After the analysis, the loading factors was used to identify the major leading causes to railway infrastructure theft. The variables was entered in step

wise in the factor analysis, all of the variables were hypothesized as the cause of railway infrastructure theft.

Table 4-26: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.545
Bartlett's Test of Sphericity	Approx. Chi-Square	1073.801
	Df	66
	Sig.	.000

KMO and Bartlett's test on table 4-26 shows the analysis for the proposed model. The analysis revealed that the measurement of sample adequacy KMO is 0.545 more than the minimum value, 0.5 and the data for analysis of principal component analysis. Similarly Bartlett's Test of Sphericity value were significant ($p< 0.001$), suggesting that the variables are closely related to each other.

Table 4-27: Loading factor

Leading causes	**Factor loading**
High financial reward	0.749
Poverty	0.739
Unemployment	0.769
Illiteracy	0.637
Poor quality of railway transport service	0.740
Shortage of manpower (Guard)	0.594
Lack of physical and technological preventive measures	0.721
Availability of Scrap metal dealers, who buy stolen property from unauthorized associates	0.818
Poor enforcement of law against theft	0.737
Lack of evidence to the committed crime for prosecution	0.740
Light sentence forwarded on criminals	0.794

Table 4-27 shows the values of loading factors of 11 factors were produced. This is because the factor loading values of those factors are more than 0.5. This means that these leading causes are the critical factors in the theft occurrence on railway infrastructure. The factor loading for availability of scrap metal dealers, who buy stolen property from unauthorized associates, is 0.818. Based on the perception of respondents, stolen railway infrastructure traded to the easily available scrap metal dealers. This may increase railway infrastructure theft. This result agrees with the finding of Nobanda et al. (2020), They found that scrap metal dealers, who purchase stolen cables from unauthorized associates, are the main contributors to cable theft in the Durban railway stations. Figure 4-3 shows the conceptual frame work of the leading causes of railway infrastructure theft. The result also agrees with the finding of Madzivhandila (2022), The encounter has appeared that the more police authorities are sent within the railway environment, the more the crime level diminishes. High visibility of police in these zones dissuades criminal actions, reduce the openings for offenders to execute diverse sorts of crimes and strengthens security and security among commuters.

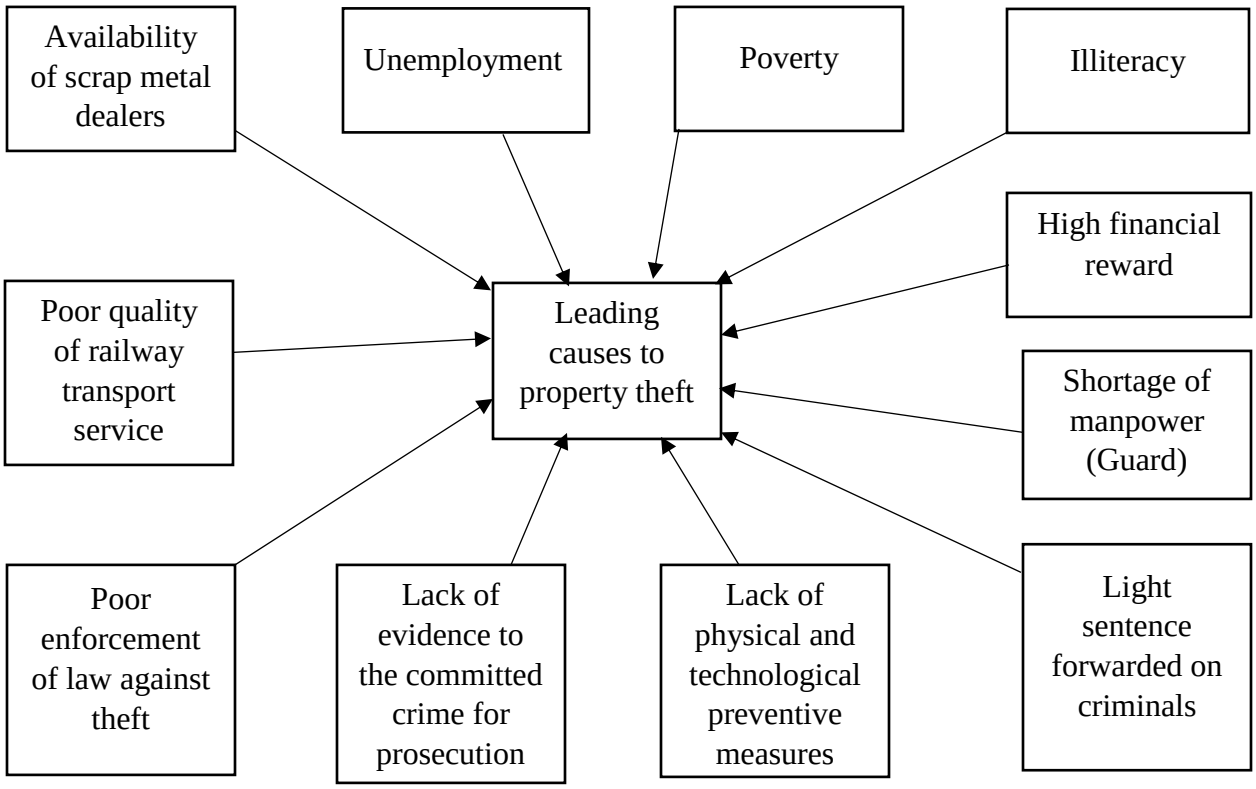

Figure 4-3: Conceptual frame work of the leading causes of railway property theft

4.8 Discussion of findings

Hypothesis 1

The first null hypothesis which states that there will be no significant difference between the views of different participants on the sexual category of criminals was rejected. The result obtained from this finding indicates that the respondents with respect to the sexual category of criminals that are engaged on railway assets theft have varied opinion. Most of the respondents believe both male and female are engaged to theft but more of them are male. This was to be expected, as boys are less likely to be questioned for such behaviors and have greater freedom of movement than girls. Men also view the ability to display their physical ability as a luxury. This is consistent with the findings of Torkaman and Saei (2016) and Madzivhandila (2022) who also discovered that vandalistic behavior was advanced among boys than girls.

Hypothesis 2

The second null hypothesis which states that there will be no significant difference between the views of different participants on the age category of criminals was retained. The result obtained from this finding revealed that the participants shared similar views with respect to age category of criminals. Participants believe that more of the criminals are categorized under the age group of 26 – 35 year. This result is consistent with the findings of Madzivhandila (2022) who also found out the majority of these offenders are fall into the youth category.

Hypothesis 3

The third null hypothesis which states that there is no significant differences exists between the time of day and number of theft occurrences was rejected. The result obtained from this finding shows that there is statistically significant difference exists between the time of day and the number of theft occurrences. Respondents believe that the theft occurrence had significantly higher on the time slot of 10pm up to 2am. Criminals prefer to commit these illegal activity in under cover of darkness. This result agrees with the findings of Yar (2005) and Ratcliffe (2020), the result showed that there is a difference in offence occurrence time. Ratcliffe (2020) also found that the least number of offenses happen in the morning and evening, with the most offending periods being between 21:00 and 06:00.

Hypothesis 4

The fourth null hypothesis which states that there is no significant differences exist between month of the year and number of theft occurrences was retained. The result obtained from this finding shows that there is no significant difference exists between the months of the year for the number of theft occurrences. This would suggest that the occurrences of theft are widespread and occurs through the month. This finding of An (2021) discovered that the effect of the season affects the way the offender commits the crime. An (2021) believed that climatic and weather condition increases the probability that offenders and victims come into contact. Contrary to the high seasonality typically shown in the studies of acquisitive crime noted above, the relative lack of seasonal variation indicates that metal thieves are frequently willing to commit crimes regardless of the weather or other elements that are commonly reported to drive seasonality. Again, the seeming persistence of metal thieves in this area points to more preparation than is usual in a lot of acquisitive crime.

Hypothesis 5

The fifth null hypothesis which states that there is no significant differences exist between railway component and number of theft occurrences was rejected. The result obtained from this finding shows that there is significant differences between railway component and number of theft occurrences. Theft occurrence had significantly higher on civil infrastructure and on electrical component as compared to mechanical component. This result is consistent with the finding of Ashby et al. (2017) and Sidebottom et al. (2014). On the part of Ashby et al. (2017), reported that live metals are targeted by criminals. On the part of Sidebottom et al. (2014), reported that copper cables are highly targeted by criminals.

Hypothesis 6

The sixth null hypothesis which states that there is no significant differences exist between the railway area and the number of theft occurrences on Ethio-Djibouti railway was rejected. The result obtained from this finding revealed that there is a significant difference in the number of theft occurrences taking place over the railway area of station area and other than train station on Ethio-Djibouti railway line. The result revealed that theft occurrence is significantly higher at rail line (other than train station) as compared to station occurrences. This result agrees with the finding of Robb et al. (2015) which found that the frequency of the theft differs in localities. The

concentration of theft on railway line that are far from train stations may suggest that train stations tend to be well-protected by technologies and guardianship.

Hypothesis 7

The seventh null hypothesis which states that there is no significant differences exist between the railway section and the number of theft occurrences on Ethio-Djibouti railway was rejected. The result obtained from this finding discovered that a statistically significant difference exists between the railway sections and the prevalence of theft occurrences. Analysis revealed that theft occurrence is significantly higher on the three sections, which are from Indode station to Bishoftu station, from Mieso station to Dire Dawa station as compared to other railway sections. This result agrees with the finding of Robb et al. (2015) which found that the frequency of the theft differs in localities. These may suggest that railway line that are around industrialized cities are highly affected by these criminal action.

Hypothesis 8

The eighth null hypothesis which states that there is no significant differences exist between the railway line and number of theft occurrences on AALRTSE was retained. The result attained from this finding showed that there is no significant difference exist in the number of theft occurrences taking place over the 2 lines of AALRTSE, (EW line and NS line). This would suggest that the occurrences of theft is widespread and occurs through both EW line and NS lines.

Hypothesis 9

The ninth null hypothesis which states that there is no significant differences exist between the land use and number of theft occurrences at Ethio-Djibouti railway was rejected. The result obtained from this finding indicated that the land use have a statistically significant effect on the dependent variable, number of theft occurrence. Theft incidences had significantly higher on rural areas than urban land uses. This result agrees with the finding of Robb et al. (2015) which found that the frequency of the theft differs in localities. The concentration of railway property theft on rural areas may suggest that urban areas are well protected by fence, technology and relevant number of security guard, and patrol police.

Furthermore, the study related to the leading causes that motivate criminals engage to railway property theft found that poor quality of railway transport service, Shortage of manpower (Guard),Lack of physical and technological preventive measures, Availability of Scrap metal

dealers, who buy stolen property from unauthorized associates, Poor enforcement of law against theft, Lack of evidence to the committed crime for prosecution, Light sentence forwarded on criminals, High financial reward, Poverty, Unemployment and Illiteracy are the critical factors to railway theft. The result also revealed that availability of Scrap metal dealers, who buy stolen property from unauthorized associates as the first leading cause to railway property theft and vandalism. These may suggest vandalized railway infrastructure are traded to the easily available scrap metal dealers. This may increase the crime on the railway infrastructure. This result agrees with the finding of Nobanda et al. (2020), They found that scrap metal dealers, who purchase stolen cables from unauthorized associates, are the main contributors to cable theft in the Durban railway stations. Sidebottom et al. (2011) also argued that price increases for copper have a beneficial impact on the amount of copper stolen, making copper a more desirable target for thieves.

4.9 Summary of findings

This section presented the summary of data result, analysis and discussion based on gathered information from the questionnaire and railway security report.

The primary data collected from participants selected of safety experts and security police from AALRTSE and EDR and secondary data on the occurrence of railway property theft incidents from year 2018-2023 were both subjected to quantitative analysis. There were 436 respondents participated in the survey.

By analyzing the survey results, it was possible to determine the behaviors, motives, and methods of operation of the criminals who steal property from railroads.

According to the secondary data analysis, there were 2094 instances of theft on railroad property between year 2018 and 2023. The locations of these incident's hotspots were determined.

The availability of scrap metal traders and the poor enforcement of the laws prohibiting theft were identified to be the main contributing reasons to these crime. The investigation sheds light on the kind and extent of theft issues that the Ethiopian railway sector is dealing with, as well as the main causes of these illegal actions.

The findings drawn from this data analysis served as the foundation for creating protection systems and recommendations that are discussed in the thesis's later sections.

this section comprehensively assessed and characterized the railway property theft concerns affecting the Addis Ababa light railway transport system enterprise and the Ethiopia-Djibouti railway systems using both primary survey data and secondary event data. The findings provide a foundation for addressing these important security issues.

4.10 Protection mechanisms to curb railway property theft

This section's main focus is on participant perspectives and information acquired from statistical data, observations, and other relevant studies. The researcher believes that the prevention techniques in this part are supported by the best available data, which has been obtained during the research study. These approaches ought to be applied to stop railroad property theft.

4.10.1 Enhancing engineering measure

A single engineering measure can accomplish several goals in practice, therefore this must be taken into account. For instance, detection systems can collect information about incidents that occur and help to better understand incident statistics or human behavior. They can also warn and prevent trespassers, alert safety personnel, and facilitate their action in cases of suspicious conduct. Furthermore, these technological systems are rarely completely automated.

In order to study operational plans aimed at preventing, managing, and overcoming crimes on railway properties that can affect the company's material and non-material resources, human resources, and processes and achieve good performances in the short-, medium-, and long-term, corporate security is becoming more and more focused on technical aspects these days. Improving lighting, utilizing a distributed modular system, adding CCTV, adding alarm systems, and installing appropriate fencing might be employed to safeguard railway property, along with physical security involvement where needed.

These include target hardening of all high-risk railway infrastructures, real-time CCTV (closed-circuit television cameras) monitoring on all high-risk infrastructures around the rail network that increase the chance of being caught, and providing training for railway security personnel as well as police officials will contribute to curbing crime. One of the most useful and popular trespass detection methods is CCTV surveillance. Many railway networks that are already heavily covered by CCTV are modifying their systems to automatically identify trespassers (RSSB, 2018). Kim (2019) found that the use of cameras decreases crime by 50 percent.

One way to address the issue of track coverage is to employ distributed modular systems that combine motion detection and non-motion detection techniques. Throughout the track, using long-range infrared cameras is especially advised. These cameras are capable of covering several hundred meters of track, and they may also be used to monitor the track at night and in inclement weather. Sensonics security solutions, which convert existing cables into sensitive vibration sensors across their whole length, may also be deployed. Existing wires can be utilized to detect vibration all the way along their length thanks to distributed acoustic sensing. The most recent model of Sensonics sensing apparatus is capable of detecting ground excavation activities as well as people walking close to the cable or track path.

To reduce or eliminate rail fastening systems theft it is preferable to utilize security fastening or theft resistant fastening systems, which make it extremely difficult to remove clips without specialized skills. In locations where track infrastructure theft is common, these are both necessary and useful. Specially made fasteners known as security fasteners are irremovable using ordinary screwdrivers or spanners. It is highly difficult for an unauthorized individual to remove the product from the track since extracting the clips requires the use of a specialized extraction equipment.

In order to control illegal access to the track, railway lines where theft are prevalent should be enclosed with well-designed fence. The previous fencing was designed in such a way that cable thieves have easily access to come and steal railway infrastructure. At every entrance/exit to the rail line, security personnel should be positioned.

Surveillance cameras helps to continuously record activity surrounding the facilities while fencing prevents unwanted access to the train track. Alarm systems allow you to respond quickly in the event of any suspicious activity or breach by instantly alerting you. According to Havârneanu et al. (2017) , fencing or other physical barriers helps to prevent pedestrian access to the rail reserve are common countermeasures to avoid trespassing-related crimes. Koorey et al. (2017) also recommend more secure fencing where trespassing or vandalism is more common.

4.10.2 Raising public awareness campaign

Rather than only focusing on what the police can do, think carefully about whether other members of your community share responsibility for the issue and can assist the police in providing a better response. Improving guardianship and putting in place an efficient reaction depend on the public being aware of the theft of scrap metal and reporting it.

To prevent theft, a radio and media campaign should be started, scrap metal dealers should be trained to recognize metal that has been stolen from the railway system, more information should be shared with law enforcement, the track should be made more secure, and staff members should be trained to recognize potential hazards from damaged property left behind after a metal theft offense has occurred. In order to discourage sellers who would rather stay anonymous, scrap metal dealers ought to be forced to keep a written record of every transaction. This record should include the seller's identity, a description of the items purchased, and the stated source of the scrap metal. Maintaining accurate records can assist police connect metal sellers to reported metal thefts and discourage thieves from trying to sell stolen metal.

A public awareness campaign can inform businesses and residents about the severe consequences of theft on railroad property, such as the annoyance of delayed trains owing to missing tracks and the damage done to the nation's economy by theft. Perhaps in addition to raising awareness, a campaign can promote informal societal pressure to refrain from stealing, damaging, and trading stolen things. Run public awareness campaigns informing people of the findings of the problem's analysis so that everyone is aware of the costs to the community. Communities must assume responsibility for safeguarding their infrastructure and educating the public about their part in preventing theft and damage of railroad property.

Educating the public and scrap metal dealers about the consequences of metal theft from railroads, such as damage to vital infrastructure and higher service costs, might be beneficial to establish an accountable culture and deter criminal conduct by They are encouraged by this to report any suspicious activity, which helps in the prevention and identification of these kinds of crimes.

4.10.3 Ensuring adequate amount of security guard

Adding security guard at rural areas where property theft are mostly prevalent is essential to prevent criminal activities including theft on the railway property. This employed security personnel should take more advanced training and also, railway protection services need to employ more patrollers and investigators so that they can be able to cover the enormous area at any given point in time. (Binderman, 2021) believes that metal theft will be curbed as a result of giving comprehensive training to police personnel on the ground.

Employees should be trained to be the operation's eyes and ears and they should receive training on how to recognize and report suspicious activity. Besides make sure that policies and

procedures for preventing theft and damage are understood by all parties. A secure environment has a firm basis when everyone is aware. Professional security guards can boost the effectiveness of security control systems by spotting possible threats and responding appropriately (Wang, X., & Li, 2021).

4.10.4 Improving the judicial process

In order to improve the security of railway system, it is critical to evaluate how well the legal system handles theft cases. The findings of the research are consistent with the state of crime and how it affects the railroad system. However, little is known about the efficiency of legal processes and why the consequences of crimes are not deterring and influencing criminals from thieving railway property.

The focus on the judicial process is motivated by the increasing number of cases that go to court but are not successfully accused; rather, it allows for a more comprehensive examination of the judicial process and railway property theft and vandalism actions in order to do better crime prevention. The emphasis on the judicial process is not intended to minimize the significance of the efforts made to reduce these crimes in the courts.

Investigators must have a thorough understanding of the case before they can arrange for trial and deliver their case in court. This thorough knowledge aids the prosecution in assessing the dangers and damages associated with property theft and vandalism that the railway transport system faces. In light of this, legal experts for the railway system ought to be included in both the court proceedings and the crime investigation process.

Nel (2017) showed that Eskom legal experts can assist investigators in advocating for higher sentences to be given to criminals who steal Eskom cables and believes that cable theft cases are not being successfully prosecuted because the investigators lack legal expertise and cannot speak the same legal language as the prosecutors.

The police investigation must be successfully concluded, the evidence must be presented in court, and all pertinent matters pertaining to the case must be resolved for criminal justice to function effectively (Dandurand, 2016). Effective criminal justice requires the community to report crimes to the police. The importance of having a positive relationship between the criminal justice system and the community is emphasized. Criminals will be deterred from committing new crimes if the criminal justice system successfully fulfills its duty (Smit *et al*., 2019). According to

Pheiffer (2022), when stakeholders collaborate, some could offer conflict resolution education, others could mentor and set an example of positive behavior, and still others could offer a safe and supportive setting where a young person can spend time away from home.

Punishment forwarded on thieves is too light, repeated criminals should be given stiff penalties since the people who steal just need money after selling the scrap metals that are valuable for the public. Offenders typically receive lesser terms, which encourage more reoffending. They receive a few-month sentence and are then freed to return to the same areas that are thought to be high-crime areas. It could be argued that the law fails to recognize the effects that this crime has on the nation's economy and the train transport infrastructure when the cables and fastening systems are taken. As a result, the researcher recommends that those who violate railroad property receive harsher penalties and longer prison sentences.

4.10.5 Influencing law enforcement agencies

Security must be integrated early and thoroughly into the security planning and protection procedures due to increasing pressure from the public and commercial sectors on Ethiopia's railway industry to keep better control over power outages. Reducing operational costs and improving the effectiveness of the railway transport system are achievable when property theft and vandalism are efficiently dealt with holistically. It is fair to discuss law enforcement's role in the security program to stop theft and vandalism of railway property because of the inclusive concept that activates it.

In order to help in the battle against property theft, the railway industry must actively involve law enforcement. It is evident that they would need instruction and training regarding the specifics of railroad property. Binderman (2021)concurred that law enforcement should step up their efforts to apprehend and prosecute cable thieves. She also pointed out that Eskom needed to collaborate with enforcement agencies and communities to enhance awareness and help those around them appreciate their role in reducing crime.

According to the data collected from participants and the literature, the police should be the first line of defense for law enforcement in the criminal justice system. Only then can they effectively investigate crimes and bring successful charges against offenders. The evidence that the investigating police present to the courts is very important. Several writers and participants have also mentioned the importance of positive relationships between the community, the police,

and outside parties. According to Smit et al. (2019), the partnership approach to crime views crime as a social issue that affects the entire community rather than just a security issue. More emphasis must be placed on the fact that all government agencies, community-based groups, and community people should share joint responsibility for preventing crime, rather than just the police. The police run awareness efforts to make commuters aware of the problem of crime in an effort to lower crime on railway property. Additionally, commuters need to be kept aware of the need of reporting any information that could help catch criminals in the railway environment. Everyone concerned, including the police, commuters, and railway administration must be committed in order to reduce crime and develop a safer railway environment. Figure 4-4 shows the conceptual model of railway property protection mechanisms

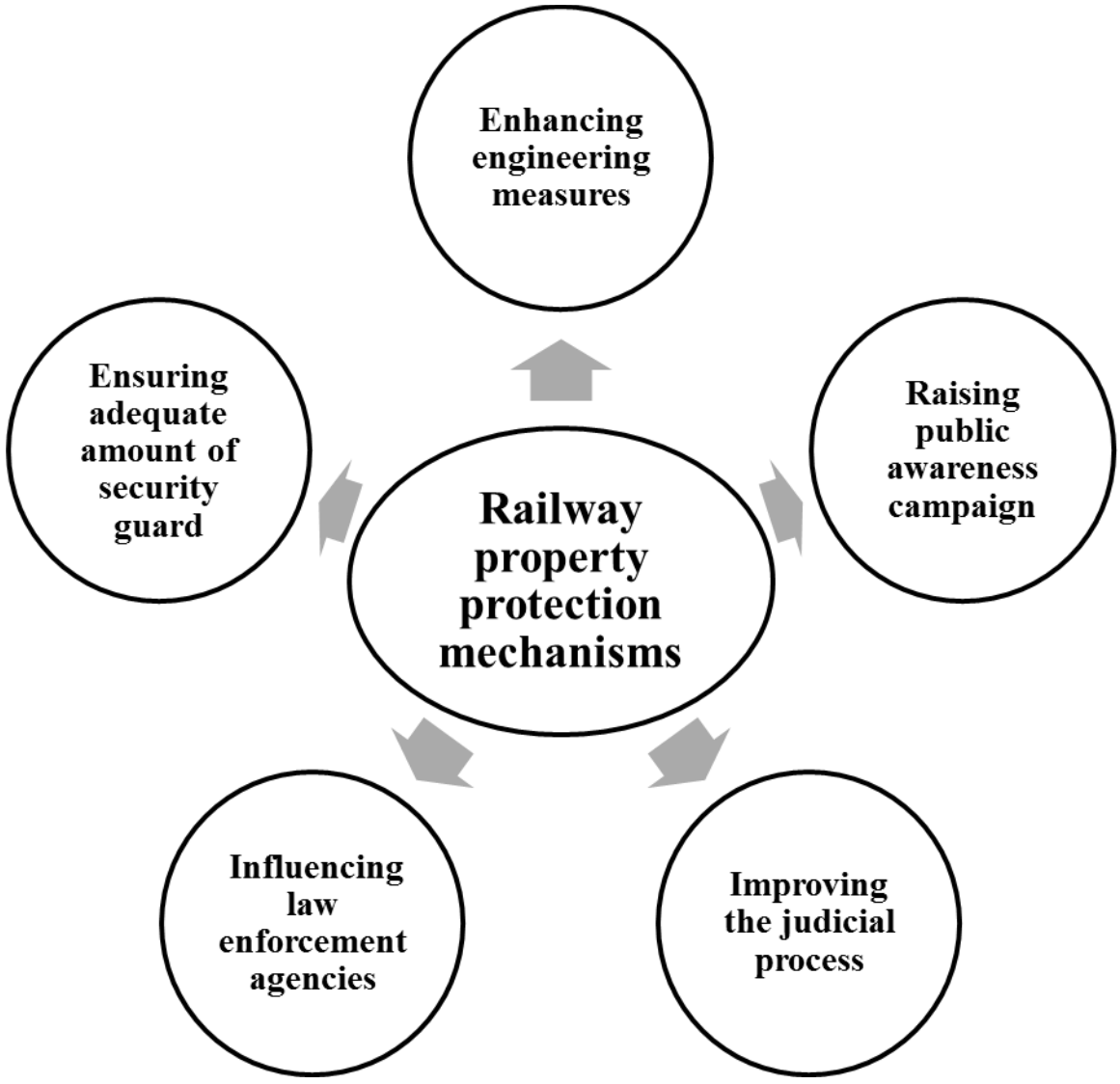

Figure 4-4: Conceptual model of railway property protection mechanisms

4.11 Validation of protection mechanism

The suggested protection systems against property theft from railway are valid due to the following grounds:

A thorough analysis of the issue: Through primary and secondary data analysis, the research comprehensively analyzed the characteristics of theft and critical leading causes of theft of railway property. This systematic evaluation gives a concrete basis for propose appropriate solutions.

Theoretical foundation: To realize the contributing factors of unlawful behavior, the study makes reference to pertinent criminological theories such as social control theory, routine activity theory, and rational choice theory. The suggested solutions are more likely to be in line with recognized thoughts when they have this hypothetical foundation.

The research involved railway safety experts and security police both AALRTSE and EDR in order to obtain viewpoints and insights. The study also utilizes the statistical record data as source. There is a greater chance that the suggested protection mechanisms will be workable and feasible because of this cooperative approach.

Rather than merely offering general advice, the research highlights specific safeguards, such as enhancing engineering protection systems, laws governing scrap metal dealers and influencing law enforcement. The execution is more feasible because of this specialization.

The developed property protection mechanisms from theft considers the local railway industries, The case studies of the Ethiopian-Djibouti Railway and Addis Ababa Light Railway service enterprise guarantee that the suggested solutions are adapted to the particular operational and cultural environment of the Ethiopian railway.

4.12 Implementation plan for protection mechanisms

The implementation plan shows how to use the developed protection mechanisms into practice. Some implementation methods for the property protection systems are proposed by the researcher that helps to curb railway property theft.

Enhancing engineering measures: to identify theft hot-spots, conduct a comprehensive site survey and assessment of risk. Based on the survey result, Improve lighting, utilize a distributed

modular system, add CCTV, add alarm systems, and install appropriate fencing to safeguard railway property, along with physical security involvement where needed, implement the proactive measures. Prior to the full implementation of the new protection mechanism make sure the new systems are tested and commissioned.

These include target hardening of all high-risk railway infrastructures, real-time CCTV (closed-circuit television cameras) monitoring on all high-risk infrastructures around the rail network that increase the chance of being caught, utilize a distributed modular system on track, and providing training for railway security personnel as well as police officials will contribute to curbing crime. Give the information technology team and security staff comprehensive training on how to utilize and preserve the installed technologies. Organize the technology into a central monitoring and control center.

Start awareness campaign: a radio and media campaign should be started, scrap metal dealers should be trained to recognize metal that has been stolen from the railway system, more information should be shared with law enforcement, the track should be made more secure, and staff members should be trained to recognize potential hazards from damaged property left behind after a metal theft offense has occurred. In order to discourage sellers who would rather stay anonymous, scrap metal dealers ought to be forced to keep a written record of every transaction. Maintaining accurate records to assist police connect metal sellers to reported metal thefts and discourage thieves from trying to sell stolen metal. Run public awareness campaigns informing people of the findings of the problem's analysis so that everyone is aware of the costs to the community. Communities must assume responsibility for safeguarding their infrastructure and educating the public about their part in preventing theft and damage of railroad property.

Provide adequate amount of security guard on the most theft vulnerable areas. Adding security guard at rural areas where property theft are mostly prevalent. This employed security personnel should take more advanced training and also, railway protection services employ more patrollers and investigators so that they can be able to cover the enormous area at any given point in time. Employees should be trained to be the operation's eyes and ears and they should receive training on how to recognize and report suspicious activity. Besides make sure that policies and procedures for preventing theft and damage are understood by all parties.

Operational enhancements: Scrutinize and renovate rules on property security, procedures and guidelines for event response currently applied. Reorganize the security organization to improve decision-making and coordination. Provide a thorough training program for security personnel to enhance their expertise, ability and situational awareness. Employ effective inventory control and property management procedures and making use of identifying technologies. Assign the security staff with defined positions, duties and performance standard. Combine the technical and physical security measures with the upgraded procedures.

Influence the judicial process and law enforcement agencies: Critically evaluate how well the legal system handles theft cases. The emphasis on the judicial process is not intended to minimize the significance of the efforts made to reduce these crimes in the courts. Investigators must have a thorough understanding of the case before they can arrange for trial and deliver their case in court. This thorough knowledge aids the prosecution in assessing the dangers and damages associated with property theft that the railway transport system faces. In light of this, legal experts for the railway system ought to be included in both the court proceedings and the crime investigation process. Repeated criminals should be given stiff penalties since the thieves just need money after selling the scrap metals that are valuable for the public. Influence the judicial process to forward to those who violate railroad property receive harsher penalties and longer prison sentences. Railway industry legal experts assist investigators in advocating for higher sentences to be given to criminals who steal railway property.

Integrated security forces early and thoroughly into the security planning and protection procedures due to increasing pressure from the public and commercial sectors on railway industry to keep better control over power outages. Reduce operational costs and improve the effectiveness of the railway transport system are achievable when property theft are efficiently dealt with holistically. In order to help in the battle against property theft, actively involve law enforcement agencies in the prevention of railway property theft. They need instruction and training regarding the specifics of railroad property. These railway industry also needed to collaborate with enforcement agencies and communities to enhance awareness and appreciate their role in reducing crime.

Monitoring and Evaluation: Establishing a set of quantifiable key performance indicators, such as the extent of security events with the railway's safety procedures, is necessary to monitor the efficiency of the protection mechanisms.

Regular safety and risk assessment and security audits are important to pinpoint new treats, weaknesses and opportunities for development. The results of these investigation are then integrated into ongoing protection strategy improvements. Continuous improvement refers to putting in place an organized procedures for evaluating how well the security measures are working, examining stakeholders input and implementing data-driven changes to make sure the railway's security posture is strong and flexible enough to respond to changing conditions

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

This chapter focuses on the conclusion and recommendations.

5.1 Conclusion

Railway infrastructure theft needs comprehensive understanding in order to control these problems. It imperative to understand characteristics of these crime and the factors that motivate criminals to engage in railway property theft. This help to develop techniques to track and subsequently control it. The research provides a comprehensive description of railway theft and its main appearance within the rail network in Ethiopia's functional group of Addis Ababa Light Railway transport service enterprise and Ethio-Djibouti railway.

The research provides evidence in the form of a conducted questionnaire and recorded security data. The questionnaire data are analyzed to describe the demographic characteristics of criminals, who are engaged in railway infrastructure theft, and revealed that railway property theft is perpetrated by both males and females but the majority of them are male, by any age group but the majority offenders are in the 26 – 35 years age old.

The analysis conducted on the railway property security report showed that the theft occurrence is higher on the civil infrastructure and electrical components. Additionally, the seasonal analysis showed that theft incidents show no monthly or weekly fluctuations, instead exhibiting a diffused temporal pattern. These incidents are prevalent with no clear temporal pattern other than an indication that incidents are more prevalent in the time slot between 10:00 pm-2:00 am. Criminals prefer operating under cover of darkness before the morning. The best time for criminal activity is before early morning when everything is dark and hidden.

Analyzing the theft occurrence data also identified the hot spot areas that can be characterized by two railway areas, a rail line and station area, and twenty railway sections. Theft occurrences are significantly higher along the rail line that is away from the train station. Railway asset theft appears to concentrate on the sections of the bike station to Dire Dawa station. Railway property theft appears to be highly concentrated in rural areas rather than urban areas. One reason for this may be urban railway lines tend to be well-protected by guardians and fences to stop trespassing.

Railway infrastructure theft in countries including Ethiopia, need to be curbed. It is therefore imperative to understand the causes that motivate people to engage in theft of railway infrastructure to develop solutions to control it. This paper identified and ranked the causes that motivate criminals to engage in railway infrastructure theft, mainly due to the availability of scrap metal dealers, poor enforcement of the law against railway infrastructure theft, light sentences forwarded on criminals, high financial rewards, mass unemployment, shortage of manpower (security police), lack of physical and technological preventive measures, and lack of evidence to the committed crime for prosecution. Poverty, high level of illiteracy among the population, poor quality of railway transport service, and lack of reporting structure within the department also influence criminals to engage in railway infrastructure theft.

If more attention can be paid to these leading causes, rail property theft can be decreased. These findings also suggest that using enhanced engineering measures, raising public awareness campaign, ensuring adequate amount of security guard, improving the judicial system and influencing law enforcement agencies are solutions prevents railway property theft.

5.2 Recommendations

The following practical recommendations are made based on the research carried out:

The railway industry should improve the protection mechanism to prevent their infrastructures from theft.

The Ethio-Djibouti railway should develop effective multi-stakeholder partnership strategy involving social service providers, NGOs, municipal and provincial governments, and policymakers. In order to identify and report illegal activities as soon as feasible, a monitoring technique is necessary. AALRTSE have a multi-stakeholder partnership that are helping to reduce the criminal occurrence on their property. But the company should keep up their improvements and base their improvements on the identified leading causes that helps the company to prevent the revival of those criminal actions.

Ethiopian federal police should concentrate purely on the scrap metal dealers and control scrap metal market. If police control the metal trade in the metal theft supply chain and scenario, then which can control all the second-hand metal trade, inclusive of illegal trading. In this instance, the Ethiopian federal police members can then saturate the scrap metal traders, which will be easier to manage and to police infrastructure theft over a vast area with limited resources and capacity.

Lawmakers and implementers enhance law enforcement against railway infrastructure theft, improved sentence forwarded to criminals, and effective implementation of policies to improve security is essential. The crime must be comprehensively investigated so that the criminal justice system achieves its purpose effectively. If offenders are arrested and prosecuted efficiently which leads fewer repeat of this criminal action.

5.3 Recommendation for further research

Socio-economic status of criminals, the characteristics of theft on passengers and goods and the effectiveness of railway property protection mechanisms and the efficiency of legal processes like the length of sentence forwarded to railway property thieves needs further research.

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APPENDICES

Appendix A- Analysis tables

Appendix B – Questionnaire

Appendix A- Analysis Tables

Table A-1: Descriptive statistics on the sexual category

Experience of participants	N	Mean	Std. Deviation
0-2 years	102	1.97	.764
2- 4 years	157	1.68	.709
4-6 years	62	1.61	.554
6- 8 years	34	1.29	.524
8-10 years	22	1.23	.429
10-12 years	29	1.52	.634
12-14 years	30	1.13	.346
Total	**436**	**1.64**	**.696**

Table A-2: Descriptive statistics on the age category of criminals

Experience group	N	Mean	Std. Deviation
0-2 years	102	2.70	.483
2- 4 years	157	2.62	.693
4-6 years	62	2.73	.548
6- 8 years	34	2.82	.387
8-10 years	22	2.82	.395
10-12 years	29	2.69	.471
12-14 years	30	2.97	.183
Total	**436**	**2.71**	**.559**

Table A-3: Post-hoc results between the occurrence times:

(I) Timing of theft	(J) Timing of theft	Mean Difference (I-J)	P-value	Games-Howell Inference
6pm-10pm	10pm-2am	1.88073*	0.000	P<0.05
	2am-6am	1.78899*	0.000	P<0.05
	6am-10am	-1.96101*	0.000	P<0.05
	10am-2pm	-1.94266*	0.000	P<0.05
	2pm-6pm	-1.32798*	0.000	P<0.05
10pm-2am	6pm-10pm	-1.88073*	0.000	P<0.05
	2am-6am	-.09174	0.511	Insignificant
	6am-10am	-3.84174*	0.000	P<0.05
	10am-2pm	-3.82339*	0.000	P<0.05
	2pm-6pm	-3.20872*	0.000	P<0.05
2am-6am	6pm-10pm	-1.78899*	0.000	P<0.05
	10pm-2am	.09174	0.511	Insignificant
	6am-10am	-3.75000*	0.000	P<0.05
	10am-2pm	-3.73165*	0.000	P<0.05
	2pm-6pm	-3.11697*	0.000	P<0.05

(I) Timing of theft	(J) Timing of theft	Mean Difference (I-J)	P-value	Games-Howell Inference
6am-10am	6pm-10pm	1.96101*	0.000	P<0.05
	10pm-2am	3.84174*	0.000	P<0.05
	2am-6am	3.75000*	0.000	P<0.05
	10am-2pm	.01835	1.000	Insignificant
	2pm-6pm	.63303*	0.000	P<0.05
10am-2pm	6pm-10pm	1.94266*	0.000	P<0.05
	10pm-2am	3.82339*	0.000	P<0.05
	2am-6am	3.73165*	0.000	P<0.05
	6am-10am	-.01835	1.000	Insignificant
	2pm-6pm	.61468*	0.000	P<0.05
2pm-6pm	6pm-10pm	1.32798*	0.000	P<0.05
	10pm-2am	3.20872*	0.000	P<0.05
	2am-6am	3.11697*	0.000	P<0.05
	6am-10am	-.63303*	0.000	P<0.05
	10am-2pm	-.61468*	0.000	P<0.05

*. The mean difference is significant at the 0.05 level.

Table A-4: Descriptive statistics for areal occurrence of theft

Railway Area	N	Mean	Std. Deviation
On rail line (Other than train station)	6	289.67	190.207
On train stations	6	39.00	24.166
Total	**12**	**164.33**	**183.975**

Table A-5: Descriptive statistics of occurrence on AALRTSE rail lines

	N	Mean	Std. Deviation
East-West line	6	26.5	5.188
North-South line	6	14.199	5.797
Total	**12**	**13.772**	**3.976**

Table A-6: Descriptive statistics of occurrence on land uses

	N	Mean	Std. Deviation
Urban	6	82.00	60.00
Rural	6	246.64	153.46
Total	**12**	**164.33**	**140.48**

Table A-7: Sectional occurrence of property theft

Railway Sections	N	Mean	Std. Deviation
Sebeta station to Furi lebu station	6	4	3.225
Lebu station to Indode station	6	17.17	12.922
Indode station to Bishoftu station	6	51.5	53.411
Bishoftu station to Modjo station	6	17.17	19.426
Modjo station to Adama station	6	22.33	19.117
Adama station to Feto station	6	19.33	13.486
Feto station to Metehara station	6	11.17	3.71
Metehara station to Awash station	6	5.83	3.971
Awash station to Sirbaknur station	6	24.5	26.463
Sirbaknur station to Meiso station	6	13	3.578
Mieso station to Bike station	6	27.33	15.029
Bike station to Dire Dawa station	6	69.83	54.363
Dire Dawa station to Arawa station	6	19.33	18.403
Arawa station to Adigala station	6	5.67	3.502
Adigala station to Aysha station	6	7.33	9.245
Aysha station to Dewale station	6	3.17	3.061
Dewale station to Alisabieh station	6	0.33	0.516
Alisabieh station to Holhol station	6	1.17	1.602
Holhol station to Nagad station	6	2.5	3.564
Nagad station to Doraleh station	6	6	4.858
Total	**120**	**16.43**	**25.368**

Appendix B - Questionnaire

Addis Ababa University

Institute of Technology

School of graduate

African Railway Center of Excellence

Hello, my name is Silenat Asrat, and I am conducting research towards a Master of Science in railway Engineering (Civil Infrastructure) at Addis Ababa University Institute of Technology.

I am collecting information to do a small study on the occurrence of railway property theft in Ethiopian railway environment. And I would like to invite you to participate in the research.

The participants for this survey are selected randomly from the population. Participation in the survey is voluntarily and anonymous, and I request the participants of the questionnaire to cooperate with me by providing accurate information and filling out the questionnaire as soon as possible.

First of all, thank you very much for taking the time to fill out this questionnaire.

- There is no need to write your name to fill the questionnaire
- You can give your answer by putting a (√) mark in the space provided for the questions.

If you have any question on the questionnaire, you can ask by phone number **0972-80 43 90** or by Email: **silenatasrat@gmail.com.**

Questionnaire for Railway patrol and safety staff members

Section I: Background detail of respondent

1. What is your sex?_____.
2. What is your age?_____.
3. Please state the length of your service in your organization?_____.
4. Indicate your academic qualification

Primary school	☐	Diploma	☐
High school	☐	Higher education	☐

5. At what level of management are you at your organization?

Top management	☐	Middle management	☐
Lower management	☐		
Staff	☐		

6. You are working for?

AALRTSE	☐
Ethio –Djibouti	☐

Section II Characteristics of theft and vandalism

1. Are criminals (thieves) likely to be male or female?

Male	☐	Both male and female but more male	☐
Female	☐	Both male and female but more female	☐
		Equally both male and female	☐

2. At what age criminals likely to be?

Below 15 year	☐	15 – 25 year	☐
26 – 35 year	☐	35-45 year	☐
Above 45 year	☐		

1. Please indicate your extent to which you will agree that the time of day in which theft and vandalism is prevalent. Strongly agree(SA), Agree(A), Somewhat agree(SWA), Neutral (N), Somewhat disagree(SWDA), Disagree(DA), Strongly disagree(SDA)

	Extent						
Time	**SA**	**A**	**SWA**	**N**	**SWDA**	**DA**	**SDA**
12:00 Am – 4:00 AM							
4:00 AM – 8:00 AM							
8:00 AM – 12:00 PM							
12:00 PM – 4:00 PM							
4:00 PM – 8:00 PM							
8:00 PM – 12:00 AM							

Section III. Leading causes to railway property theft

2. Please indicate the extent to which you will agree that the under listed factors that will motivate someone to engage in railway property theft. Strongly agree(SA), Agree(A), Somewhat agree(SWA), Neutral (N), Somewhat disagree(SWDA), Disagree(DA), Strongly disagree(SDA)

Factors	**Extents**						
	SA	**A**	**SWA**	**N**	**SWDA**	**DA**	**SDA**
High financial reward							
Poverty							
Unemployment							
Illiteracy							
Poor quality of railway transport service							
Shortage of manpower (Guard)							
Lack of physical and technological preventive measures							
Lack of reporting structure with in the department							
Availability of Scrap metal dealers, who buy stolen property from unauthorized associates							
Light sentence forwarded on criminals							
Lack of evidence to the committed crime for prosecution							
Poor enforcement of law against theft							