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EDITORIAL: SECURITY, TECHNOLOGY AND INFRASTRUCTURE RESEARCH IN AFRICA

Dear Africa Experts, Africanist Scholars and Fellow Enthusiasts,

Several previous editions of the Journal of Central and Eastern European African Studies have dealt with the history, economy, security policy and sociology of Africa. The researchers explored deeply the important affairs and problematic issues of the continent. Most of the important thematics were thoroughly revised and various interesting findings were published. This made us content, as we felt that the journal contributes to the improvement and cultivation of the Africa Studies. However, there was always a topic that we wanted to build an edition around about Africa but so far somehow, we unfortunately avoided it: the military-technical analysis of special issues concerning the continent. We, the guest editors, are proud to present in the name of the editorial board of the magazine that the time has eventually come for the publication of an issue that almost exclusively addresses military-technical, infrastructural and engineering matters concerning mechanical aspects of African security life. We sincerely wish for all our experts and average readers to have a good time reading this edition, and we also hope that this special issue will provide profound ideas for future research as well.

In the first article, János Besenyő and Máté Attila Kovács instantly grab our attention by categorizing cyber-attacks in a strict framework according to three built-in instruments: the Damage Severity Index (KSM), the Complexity Index (Kol) and the Criticality Indicator (KrI). The authors illustrate the comparison of the measured data by twelve examples; this way they are able to present unbiased research data.

The second paper concerns the railway network of modern Africa. The author, Győző A. Szilágyi uses mathematical equations to deduce the rail coverage on the continent. Since the rail system of a large territory reflects on the development level of the economy, community or security of that area, it is important to comprehend such measurements to further understand the infrastructural improvement of Africa. By comparing African countries to European ones, this article further analyses the mathematical data concerning the railway coverage and future opportunities regarding it as well.

The third article is a truly military-technical one. Alex Kádár analyses Timed Elastic Band based trajectory planning for car-like autonomous vehicles. The main idea is to present the hierarchical control architecture for a car-like autonomous vehicle. For enthusiasts of automotive engineering the military-technical analysis of these vehicles will be certainly fascinating.

The fourth work discusses the structural positioning of Afrocentric Intelligence Studies. The author, Ngboawaji Daniel Nte claims that the West (Europe, the US and the former large empires) has a special perspective on these studies, and would rather put it beneath the historical sphere, while Africa – which had no global political dominance previously – would prefer to place it in the department of Sociology and Social Anthropology. He tries to prove that his claim is true using definite arguments.

The fifth paper concerns the modern liberal democracy-types in post-conflict Africa. The author, Antonetta Lovejoy Hamandishe, draws on election result from Liberia, Somalia, Somaliland, and Zimbabwe and other democracy models. Building on previous own research, the article refuses the concept of exported democracy and instead it proposes a type of democracy that is organic and takes into consideration the gender values as well.

The sixth article is about SMEs (Small and Medium-sized Enterprises) and their leadership in Ghana. The authors of the paper, Mensah Marfo et al. argue that the leadership duality that exists among the SMEs in Accra and Tema in Ghana significantly influences the strength of investment decisions, thus this duality should be enforced.

The next, the seventh study written by Tibor Polonyi and Endre Szűcs addresses the situation of infrastructural regulations in South Africa. The authors take the codes of law into consideration since the National Key Point Act (NKPA) in 1980 until the Critical Infrastructure Protection Act (CIPA) in 2019. Along the 40 years of regulation development, some critical points are examined: risk management, responsibility, oversight, and incident management. According to the authors, the regulation structure improved from an ad-hoc system to a shared-responsibility complex structure.

The following, eighth article deals with a special theme: how do African Giant Pouched Rats help with humanitarian mine clearance. The writer of this paper, Tímea Hillender gives us an interesting insight into the evolution of mine clearance, also with biological help. According to several reports, interviews and sufficient local data collected by the author, it seems to be legitimate to deduce that the future of mine clearance lies in biosensor-hybrid systems that are paired with AI-based technology.

The ninth work is written by István András Türke, who gives a thorough profile on the Democratic Republic of the Congo, regarding the Great Lakes Region. The theme is extremely complex, as with the expression of the author, this area is an "ethnic-geopolitical 'hornet's nest'". Especially when we compare the countries created in the region: three of them were organic (DRC, Rwanda, Burundi), but one was artificially created (Uganda). Türke gives a comprehensive work on the issue.

The tenth article is about the community-based vigilante groups in Gombe State, Nigeria, that help the government in countering crime prevention between 2013 and 2023. The article is based on the Broken Window Theory, which strengthens the usefulness of these brigades. According to quantitative research made by the authors, Rukayya Maisara Wali and Abubakar Adamu Bappah, 76.28% of the responders admired the effectiveness of the vigilante groups. The outcome of these surveys was that the circumstances of these groups should be amended which would help the whole society.

The last paper addresses the Military Information Support Operations (MISO) in comparison to Nigeria's Counterinsurgency Operation. The author, Obinna Ukaeje, is of the opinion that the neglect of these MISO is seriously damaging the governmental counterinsurgency manoeuvres. The article analyses these operations in the Northern part of Nigeria, where officially these MISO have been rather unfortunately omitted. To achieve better efficiency, this study advances the preference of MISO operations in CTCOIN counterinsurgency-operations in Nigeria.

The issue has a review section as well, which provides plenty of interesting themes. The first review is written by Szilvia Juhászné Veress and examines the book *Sustainable Food Systems in Sub-Saharan Africa: Plant Derived Nutritious Foods* edited by Bal Ram Singh et al. The book consists of five parts, each of which addresses themes concerning food, nutrition, soil and agriculture. The important message of the book is that sustainable food systems are important to be analysed, and effective to be evaluated.

The author of the second review is Abdallah Abdel-Ati Al-Naggar, who reviews the book by Atef Moatamid: *Russia and Ukraine: An Undeclared World War*. The Egyptian author has the perception that positions him in between the great political forces: thus, he can provide a unique report on the Russian-Ukrainian war. Historically and geopolitically the work is outstanding, and combines Arabic, Russian and English sources.

The third review is by Miklós Szakali, who analyses the book by Tomas Hamilton: *The Arms Trade and International Criminal Law: Reframing Accountability for Complicit Weapon Suppliers*. The work concerns the problematics of arms trade and the weapons to be used against it. The author tries to evaluate the antidote for complicit weapon suppliers and examines the issue in depth.

The last review is written by András Málnássy, who deals with the book entitled: *Drones in the African Battlespaces* edited by Wayne Stephen Coetzee and Dries Putter. The book addresses the unmanned aerial systems (UAS), with a special focus on Africa. The usability and functionality of drones are also discussed, as well as their effects on governments and geopolitical situations.

In conclusion, one might add that this issue turned out to be extremely broad-minded and interesting. All these new special and thrilling topics and themes can refresh the human mind. Unfortunately, the length of our issue is limited, so we could only include this much material. Nevertheless, we honestly feel that this edition is so captivating that it will draw the reader in, and hopefully, the publication will attract a large readership. Finally, we recommend this issue not only to expert researchers but also to general readers, as we are confident that both groups will enjoy reading it.

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Table of Contents

J. Besenyő and A. M. Kovács: Separating Damage, Complexity and Criticality in African Cyber Incidents: An Evidence-Constrained Framework with Twelve Illustrative Cases……**7**

Gy. A. Szilágyi: To What Extent Does the Railway Network Cover Africa?……..…**27**

A. Kádár: Timed Elastic Band Based Trajectory Planning and MPC Based Adaptive Cruise Control for Car-like Autonomous Vehicle……..…**46**

N. D. Nte: Afrocentric Intelligence Studies: Resolving the Challenges of Domains of Intelligence Pedagogy in African Non-Military Universities……**74**

A. L. Hamandishe: Rewriting Democracy from the Margins: Hybrid Political Orders, Gendered Exclusion, and the Limits of the Liberal Template in Post-Conflict Africa……..……...**88**

M. Marfo, E. Annan, E. F. Ofei and E. Hope: Investment Decisions and Firm Growth Among SMEs: The Moderating Role of CEO Duality in Ghana……..……**109**

T. Polonyi and E. Szűcs: The Development of Critical Infrastructure Regulation in the Republic of South Africa……..……..…**161**

T. Hillender: Humanitarian Mine Clearance with the Involvement of African Giant Pouched Rats: Methods, Challenges and Future Directions…….……**171**

I. A. Türke: Contemporary History of the Democratic Republic of the Congo with a Perspective on the Great Lakes Region…… ……..……**197**

R. M. Wali and A. A. Bappah: Community Based Security and Crime Prevention: Evaluating the Effectiveness of Vigilante Groups in Gombe State, Nigeria (2013-2023)……..…..**223**

O. Ukaeje: Contextualizing Military Information Support Operations (MISO) in Nigeria's Counterinsurgency Operation: Toward Enhancing Operational Effectiveness……..**241**

Sz. J. Veress: Book Review: Sustainable Food Systems in Sub-Saharan Africa: Plant Derived Nutritious Foods..……..……..…**257**

A. A.-A. Al-Naggar: Book Review: Russia and Ukraine: An Undeclared World War – Buffer Zones, Energy Weapons, and the Return of Great Power Politics……..……..**263**

M. Szakali: Book Review: The Arms Trade and International Criminal Law: Reframing Accountability for Complicit Weapon Suppliers……**268**

A. Málnássy: Book Review: Drones in the African Battlespaces ……..……**273**

Author Guide:……..**276**

Separating Damage, Complexity and Criticality in African Cyber Incidents: An Evidence-Constrained Framework with Twelve Illustrative Cases[1]

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Abstract:

Public discussion of cyber incidents tends to merge four separate questions: whether a target is socially important, whether an attack was technically complex, whether systems were exposed or compromised, and whether the event caused real operational harm. In African analysis this blurring is costly, because public reporting is highly uneven. The article develops a closed framework around three instruments built and tested on 15,789 event records in the Maryland Cyber Events Database: the Damage Severity Index (KSM), an ordinal measure of technical-operational consequence; the Complexity Index (KoI), a transparent sum of observable persistence, lateral movement, evasion and multi-stage execution; and the Criticality Indicator (KrI), which flags critical-sector status without inflating severity. Rather than a new composite score, it adds two evidential rules: functional criticality is described apart from legal sector labels, and missing technical detail is recorded as not assessable rather than as absence. Twelve public incidents illustrate the approach: severe operational disruption can coincide with sparse reporting, data compromise can be serious without equivalent service interruption, and socially essential digital services can be critical outside conventional utility categories. The framework thus supports consistent comparison without letting importance, identity or reputation replace evidence.

Keywords:
African Critical Infrastructure; Cyber Incident Measurement; Damage Severity Index; Complexity Index; Functional Criticality; Mobile Money; Public Digital Services; Evidence Quality; Missingness; Ransomware.

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1. Introduction

Cybersecurity in critical infrastructure is usually discussed in terms of threats, vulnerabilities and attackers, yet the question that matters most to operators and public authorities is what an event actually did. A vulnerability may sit unexploited for years; a compromise may occur with no lasting interruption to operations; a denial-of-service attack can take a socially important portal offline while the underlying records remain untouched. A ransomware label, similarly, describes how a piece of malware behaves without telling anyone whether the incident reached operational technology, a clinical workflow or payment settlement, or stayed inside a limited administrative segment. These are not semantic differences. They decide whether an incident calls for an information-security response, a business-continuity response, a safety response, or some combination of the three. Work on critical-infrastructure resilience treats continuity, layered protection and organisational preparedness as separate from the naming of threats (Kovács, 2024a, 2024b).

The analysis here rests on three instruments defined at the level of the individual incident: the Damage Severity Index (KSM), an ordinal 1–5 measure of documented technical-operational consequence; the Complexity Index (KoI), a 0–4 sum of four observable attack behaviours; and a separate Criticality Indicator (KrI) for critical-sector status. All three were constructed and tested on the Maryland Cyber Events Database (MCED), a manually reviewed corpus of publicly reported cyber events maintained by the Center for International and Security Studies at Maryland (CISSM, n.d.-a, n.d.-b; Kovács, 2026). Their governing rule is that consequence, sophistication, sector importance and actor category must not define one another: an incident is not severe because it hit a utility; an attack is not complex because it has been attributed to a state; and a service is not a confirmed vulnerability because an automated scanner raised a warning.

This separation is especially useful for African cases. Digital transformation across the continent is rapid but uneven, touching telecommunications, finance, government, energy, health and logistics at very different speeds. The African Union's Digital Transformation Strategy treats digital infrastructure, digital government, digital financial services, digital health, digital identity, cybersecurity and data protection as interdependent parts of development (African Union, 2014, 2020, 2024). Mobile technologies contributed 140 billion US dollars, or 7.3% of gross domestic product, in Sub-Saharan Africa in 2023, and mobile-money systems now carry household, commercial and public-service transactions on a scale that makes their resilience a societal matter rather than a narrow application-security concern (GSMA, 2024, 2026). The World Bank likewise frames affordable, productive use of digital technology as a route to employment and economic transformation (World Bank, 2023).

The evidence available for the region is uneven in ways that matter for measurement. The Global Cybersecurity Index scores national commitment across legal, technical, organisational, capacity-building and cooperation pillars, but it does not measure how frequent or how severe attacks actually are (International Telecommunication Union, 2024). INTERPOL's Africa Cyberthreat Assessment draws on member-country reporting and partner evidence to describe threats such as scams, ransomware, business email compromise and digital extortion, yet it is not an incident-level, regionally balanced

corpus (INTERPOL, 2025). What reaches the public record depends on regulation, media access, institutional incentives, language and whether a forensic investigation was even possible. When a report says nothing about lateral movement, that may mean lateral movement did not happen, or that the investigation was limited, the detail withheld, or the statement written only to reassure users.

The article therefore sets itself a bounded question: how can publicly documented African cyber incidents be read consistently, without letting visibility, sector status, country identity or an attacker's reputation stand in for measured harm and observable behaviour? The answer offered here is an evidence-constrained framework resting on four rules. Damage is assigned only from documented technical-operational consequence. Complexity is assigned only from observable behaviours, and is left unscored where the source record does not support it. Legal and functional criticality are recorded outside the damage scale. And the strength of the source, together with any remaining uncertainty, travels with every conclusion. The twelve incidents that follow illustrate what these rules buy in practice; they are worked examples, not a representative sample, and they support no claim about how common any of this is across the continent.

Measured against the original MCED analysis (Kovács, 2026), the contribution of this article is specific. The constructs and the coefficients summarised in Section 3 belong to that earlier work. What is added here is the explicit three-state treatment of evidence, which stops missing technical detail from being read as absence; the functional-criticality layer, which complements legal sector classification; and the structured application of the three instruments to publicly documented African incidents. These are methodological adaptations demonstrated on twelve cases, not independently validated new scales.

2. The Measurement Problem: Four Concepts That Should Not Be Merged

A typical incident account starts from the organisation and the attacker: a hospital hit by ransomware, a central bank attacked, a government portal taken offline, a telecommunications operator leaking data. That form works for news reporting but is analytically thin, because it leaves four things tangled together: exposure or compromise, technical complexity, operational damage, and criticality. To compare incidents properly, each of these has to answer a different question.

Exposure and compromise describe what was technically reachable or affected, and on their own they do not settle consequence. An internet-facing service, an out-of-date software version or a stolen dataset can all represent serious risk, but the actual effect still has to be established. The reverse also happens: an organisation can suffer major operational disruption even when the public record carries little forensic detail. Keeping this dimension distinct guards against two opposite mistakes, reading unverified exposure as confirmed harm, and playing down a severe service interruption because the technical story is thin.

Complexity describes observable characteristics of how an attack was carried out. KoI uses four binary components mapped conceptually to MITRE ATT&CK: persistence,

lateral movement, defence or detection evasion, and multi-stage execution (MITRE, n.d.). These were chosen because each can be traced back to evidence rather than inferred from an attacker's reputation or from the fear a label evokes. A ransomware event does not earn a high KoI by default; ransomware is a broad operational category, not proof of a complete intrusion sequence (Kovács, 2022b). Encryption may be the last stage of a long intrusion, yet the public source may say nothing about initial access, dwell time, privilege escalation, internal movement or evasion. If every unknown component were scored as zero, under-investigated or under-reported events would automatically look technically simple.

Damage describes the technical-operational outcome that was actually realised. KSM is a five-level ordinal proxy, adopted because comparable financial figures are rarely made public. The lower levels cover contained or short-lived technical effects; the higher levels cover sustained service interruption, system-wide unavailability and physical-operational consequences, with KSM=5 reserved for a documented physical-operational effect. What matters here is that the scale is independent of sector. A data breach at a social-security institution can carry deep privacy and trust consequences and still sit below the damage level of an event that halts laboratory processing or port operations. That does not make the breach less important; it simply means confidentiality loss and operational damage are different outcomes and should be recorded as such.

Criticality asks why the affected function matters to society. KrI is kept separate from KSM and KoI and rests on critical-sector classification. In African settings a purely legal sector label may not capture the real dependence on a service. Mobile money, digital identity, government service portals, prepaid electricity vending and central-bank payment infrastructure can be socially essential because large populations, or several dependent services, have no realistic substitute for them. Functional criticality should therefore complement the legal classification, but it must stay out of KSM. Folding it in would make the analysis circular: a service would be judged highly damaging because it is critical, and then judged critical because its assigned damage is high.

A cross-cutting dimension is the quality of the evidence itself. Analysis based on public sources records not only what happened but also what could be observed and disclosed. Each coded state should therefore distinguish confirmed present, confirmed absent and not assessable. The same care is needed in low-noise technical validation, where silence from a probed host at a given time is not proof that a service is absent, and an automated candidate finding is not a validated vulnerability. Applied to incident reports, 'no published evidence of persistence' is not the same as 'persistence absent'. The framework is intentionally cautious on this point: where the record is insufficient it prefers an explicit unknown to a precise-looking score.

Why these instruments rather than others is a fair question, and the answer lies in fit. Any measure intended for African incident comparison has to satisfy three conditions: it must work from public reporting, because that is usually all there is; it must keep damage, complexity and criticality apart, because they answer different operational questions; and it must handle missing detail explicitly, because disclosure varies more than incident reality does. The familiar candidates each fail at least one of these. CVSS scores vulnerabilities, not incident consequence. Financial-loss figures are rarely disclosed

and rarely comparable. National indices measure state commitment, not events (International Telecommunication Union, 2024). Composite risk scores merge the very dimensions that need separating. KSM, KoI and KrI were built for exactly this evidence class, public event-level reporting, and have been tested on it at scale; Section 3 summarises the empirical behaviour that makes them usable here.

3. The Measurement Instruments

3.1 How the Instruments Behave on Large-Scale Data

The instruments were developed on 15,789 MCED records spanning January 2014 to October 2025; after cleaning and the removal of records with an undetermined actor label, 15,166 incidents supported the severity and complexity tests, and 14,938 formed the predictive sample over the three sufficiently represented actor categories (Kovács, 2026). The analysis behind them was longitudinal and incident-level, with temporally separated training, validation, calibration and out-of-time testing rather than a random split, so the reported performance reflects prediction on genuinely later events.

Three tested properties matter for how the instruments are used here. First, the top of the damage scale discriminates. In the MCED Utilities category 10.07% of incidents reached KSM=5, against 0.28% outside it; a year-controlled logistic regression put the odds ratio at 40.52 (95% CI 23.83–68.92) with discrimination of AUC=0.892 (Kovács, 2026). The figure expresses the conditional odds of a documented physical-operational effect given an attack in that category, not a claim that utilities are attacked forty times more often, and it is not an estimate for Africa. What it establishes for present purposes is that KSM=5 marks a rare, well-separated outcome class rather than a rhetorical superlative.

Second, complexity can be scored without attribution. Across actor classes the four KoI components differ significantly, with Welch's $F=342.67$ ($p<0.00001$) and Cliff's delta=0.42 for the state versus non-state comparison (Kovács, 2026). This does not mean sophisticated operations must be state-sponsored. It means the components register real differences in observed behaviour, so complexity need not be inferred from an attacker's reputation.

Third, on this data simpler prediction won. On the out-of-time test period a rule-based baseline reached Macro-F1=0.6429, logistic regression 0.7678, and a stacking ensemble only 0.6439; the logistic model improved on the rule baseline by 19.4% in relative terms while remaining interpretable (Kovács, 2026). That result carries directly into this article's design choices: no composite index, no free parameters, and explicit abstention where evidence is missing, because added machinery has to demonstrate benefit before it earns its complexity.

3.2 The Four-Part Incident Representation

Each incident is represented through four linked fields that cannot substitute for one another:

- **KSM – realised damage:** an ordinal 1–5 placement based on documented technical-operational consequence. The placement is provisional when the public record does not support a precise level.

- **KoI – observable complexity:** a 0–4 sum, formed only when persistence, lateral movement, evasion and multi-stage execution can each be assessed. Where they cannot, the relevant components stay not assessable and no total is forced.
- **KrI and functional criticality:** a separate description of legal sector status and of the societal function of the affected service, covering dependence, replaceability, concentration and the availability of manual alternatives.
- **Evidence state:** the source basis, the confidence, and the reason for any missingness attached to each conclusion. Official post-incident reports and operational records carry more weight than attacker claims or unattributed summaries.

For the illustrative coding in this article, KSM is assigned to the highest consequence level directly supported by the documented event, never to a hypothetical worst case, using the following anchors. KSM=1 covers a confirmed technical security event with no documented effect on services. KSM=2 covers partial or contained disruption of selected applications, where the sources document a partial effect rather than the loss of a function to its users, and confirmed data compromise without documented material service interruption. KSM=3 covers the documented loss of a public-facing service, or of a specific service function, to its users, or a complete internal outage with bounded operational effect, while core institutional functions continue. KSM=4 covers sustained or system-wide interruption of core institutional services, including national payment or vending functions, without documented physical-process effect. KSM=5 is reserved for a documented physical-operational consequence, such as halted port logistics or interrupted laboratory processing. The boundary between KSM=2 and KSM=3 is therefore set by the documented extent of the interruption (partial disruption of selected applications as opposed to the loss of a function to its users), not by the importance of the affected service, which belongs to the criticality layer. Confidentiality loss is recorded separately and does not, by itself, justify a placement above KSM=2. A single level is assigned only where the documented consequence meets one anchor; a range is reported only where the record supports two adjacent anchors. These anchors guide the illustrations and are not a substitute for the full coding specification of the original analysis (Kovács, 2026).

Each KoI component is coded as present only on an explicit statement in a cited source: persistence requires a maintained foothold or documented re-entry; lateral movement requires spread beyond the initially affected segment; evasion requires disabled or bypassed defences; multi-stage execution requires a described sequence of distinct phases. A component is coded as absent only on affirmative evidence ruling it out within the scope of the investigation; silence in a press statement counts as neither. Where any component is not assessable, no 0–4 total is formed. For these illustrative cases, Tables 1 and 2 summarise the available complexity evidence and its limitations rather than presenting a complete component-level coding matrix. Malware family, a DDoS label and claimed actor identity are not proxies for any component.

These fields are kept apart on purpose rather than collapsed into one overall score. A single composite number would hide whether the concern comes from high realised damage, high technical complexity, critical societal dependence, weak evidence, or some mix of these, and operational decisions turn on exactly that difference. A port

operator facing KSM=5 disruption with an unknown KoI needs recovery and continuity measures at once, whatever remains unresolved about attribution or intrusion depth. A social-security institution facing a large confidentiality breach but limited service interruption needs a privacy response, credential-risk management and public communication, even though its KSM placement is lower.

The framework also holds event consequence apart from recovery context. Manual fallback, backup power, analogue procedures, alternative providers, spare parts, institutional coordination and the speed of restoration all shape how a society experiences an incident. None of them changes what the attack technically did, but they explain why two events at the same KSM can differ in duration and social reach. This matters most where digital and physical infrastructure sit side by side with uneven redundancy.

4. Materials and Analytical Procedure

The article uses twelve purposively selected incidents from 2020–2025 to show the framework at work across different functions and consequence types. The cases span South, East, West and North Africa and cover logistics, health, justice, legislative administration, electricity distribution, digital government, mobile money, central banking, telecommunications, social security and public websites. A case was included when an official statement, institutional report, regulator document, peer-reviewed account or established news source described at least the target, the timing and a confirmed consequence. The set was chosen for conceptual variety, not statistical representation.

Selection drew on public reporting of African cyber incidents from 2020–2025 across government and institutional statements, regulator publications, annual reports, peer-reviewed accounts and established international news services. Inclusion required an identifiable African target or affected service, an identifiable period, and a publicly documented operational, availability or confidentiality consequence from at least one attributable source. Incidents supported only by attacker claims, leak-site listings or uncorroborated aggregation were excluded. From the documented candidates, the twelve were chosen purposively so that the four regions and the consequence types distinguished in Section 2 are each represented: physical-operational effect, sustained service interruption, availability disruption, confidentiality loss and third-party transmission. No claim is made that they exhaust the incidents meeting these conditions, and no screening denominator or rejected-case register was produced. Public reporting itself reflects disclosure practice rather than incident reality, which is a further reason the set supports illustration and not prevalence estimation.

The order of preference among sources was cautious. Official operational and annual reports came first, since they establish the state of a service and the organisation's response. Peer-reviewed medical analysis was used to read the clinical implications of the South African laboratory incident. Regulator statements were used where they confirmed a telecommunications incident. Reputable news reporting was used where it quoted an official statement, or where the event concerned the temporary availability of a public website. Attacker claims were never the sole basis for a judgement about impact or attribution.

Each case was worked through the same four questions in order. What consequence is directly documented? What provisional KSM level, or narrow band, is consistent with it? Which KoI components can actually be established from the source record? And what legal or functional dependency makes the service critical, while which contextual factor limits or amplifies the outcome? Taking them in this order stops the importance of the organisation from fixing the severity in advance, and stops the name of a threat group or malware family from fixing the complexity in advance.

The KSM placements in Figures 1 and 2 are therefore analytical illustrations, not adjudicated dataset labels. A range is reported only where the public record supports two adjacent anchors. KoI appears mainly as an evidence state, because most public institutional communications do not publish the internal technical detail a defensible 0–4 total would require. The method refuses to turn missing information into a zero. Nothing about prevalence, regional ranking, causation or model performance is drawn from the twelve cases.

Reliability was handled in two layers. For fixed structured MCED inputs and a fixed rule-based mapping, the derivation of KSM and KoI in the original analysis is deterministic and involves no additional inter-coder judgement at that calculation stage (Kovács, 2026). The twelve case placements here are provisional, author-derived interpretations of the cited public sources; the level anchors in Section 3.2 were made explicit during revision and the placements were re-checked against them. No independent multi-coder assessment was conducted, and no inter-rater agreement coefficient is therefore reported (Cohen, 1960). A subsequent reproducibility study on a larger African corpus should give independent coders the same source material and coding definitions, record scores before reconciliation, and report agreement separately for the ordinal KSM levels and the categorical KoI component states.

5. Twelve illustrative African Incidents

The cases below show how one framework reaches different conclusions for availability disruption, physical-operational effect, confidentiality loss and third-party dependency. “Not assessable” means the cited public sources do not give enough evidence to code the relevant KoI components; it does not mean those behaviours were absent.

Incident	Documented consequence	Provisional KSM	KoI / evidence note
Transnet, South Africa (2021)	A cyber incident disrupted port/container operations; manual processes and force majeure were reported before full port operations were restored.	5	Operational effect is confirmed; public sources do not support a complete KoI.
NHLS, South Africa (2024)	Ransomware severely affected IT systems, laboratory processing and result delivery, jeopardising continuity of diagnostic services.	5	Ransomware is confirmed, but persistence / lateral movement / evasion are not fully public.

Incident	Documented consequence	Provisional KSM	KoI / evidence note
Department of Justice, South Africa (2021)	The incident shut down departmental IT systems and disrupted digital justice administration; one official report records four months of ICMS unavailability.	4	Sustained system-wide service effect; KoI not assessable from public reporting.
Western Cape Provincial Parliament (2023)	A ransomware attack rendered servers inoperable and internal ICT services inaccessible, while parliamentary business continued through response and fallback arrangements.	3	Material technical disruption with bounded operational effect; KoI not assessable.
Electricity Company of Ghana (2022)	The company later confirmed ransomware and approximately one week of inability to vend prepaid electricity, with major revenue and operational consequences.	4	Payment / vending operations were impaired; no confirmed grid-process manipulation is established.
eCitizen, Kenya (2023)	A DDoS attack caused downtime in the national digital-government platform; services resumed and public statements reported no data breach.	3	Availability attack is documented; complexity beyond distributed traffic is not assessable.

Figure 1. Illustrative cases 1–6.

Incident	Documented consequence	Provisional KSM	KoI / evidence note
Pegasus / MTN Uganda integration (2020)	A third-party aggregator breach affected Bank-to-Wallet transfers; selected inter-network functions were suspended while core MTN Mobile Money services remained intact.	3	Third-party concentration transmitted impact without full core-platform compromise.
Bank of Zambia (2022)	A cyber incident disrupted selected IT applications; the public website was down for part of several days and a monitoring system was affected, while core systems remained up.	3	Public-facing website outage documented, core systems held; KoI not assessable from the cited public sources.
Central Bank of Lesotho (2023)	A cyber incident led to isolation or suspension of systems and disruption of national payment services before restoration.	4	High functional criticality and payment-system interruption; intrusion detail remains limited.
Telecom Namibia (2024)	The operator and regulator confirmed a ransomware-related incident and unauthorised data disclosure; public evidence of broad service outage was limited.	2	Confidentiality impact is clear; the cited sources do not document a service interruption sufficient for KSM=3.
CNSS, Morocco (2025)	Authorities confirmed cyberattacks and leakage of some social-security data, while warning that circulated documents included false, inaccurate or truncated material.	2	Serious confidentiality / trust event; large-scale operational outage is not established.

Incident	Documented consequence	Provisional KSM	KoI / evidence note
Government websites, Senegal (2023)	Multiple public websites were made unavailable through DDoS attacks; the event affected public information access rather than demonstrating compromise of underlying systems.	3	Confirmed availability effect; actor claims do not establish deeper compromise.

Figure 2. Illustrative cases 7–12.

5.1 Operational Disruption Reaching Physical or Clinical Processes

The Transnet and NHLS incidents show most clearly why KSM has to be tied to realised operations. In July 2021 South African government reporting stated that Transnet had restored full port operations after an IT security breach, allowing the national supply-chain and logistics system to return to normal (Government of South Africa, 2021). What matters analytically is not the ransomware label but the move from digital compromise to real-world container and port processes. The shift to manual operation, and the declaration of force majeure, show that the event crossed from information-system availability into physical logistics. A provisional KSM=5 is consistent with the scale's top level, while the KoI stays incomplete because the public sources do not establish all four technical behaviours.

5.2 Healthcare Dependency and the Difference Between Data and Care

The 2024 National Health Laboratory Service incident is a second case of realised operational consequence. The NHLS annual report describes a ransomware breach that severely affected IT systems and put the continuity of diagnostic services at risk (National Health Laboratory Service, 2025). A peer-reviewed account in the South African Medical Journal reports that affected files and servers became inaccessible and that laboratory operations, and stakeholders across the service, were disrupted (Cassim & Chapanduka, 2024). The consequence that counts here was not simply loss of data confidentiality. Laboratory orders, sample processing and result distribution are part of clinical decision-making, and when they become unavailable a cyber incident can affect patient care even without any direct manipulation of a medical device (Besenyő & Kovács, 2023). This supports a provisional KSM=5, with the KoI components left unscored where public forensic evidence is missing.

5.3 Sustained Public-Service Disruption Without Physical-Process Evidence

The South African Department of Justice incident sits one level lower. Departmental annual reporting describes ransomware that affected operations, and a statutory implementation report records a complete shutdown of departmental IT systems, including the Integrated Case Management System for Child Justice, lasting four months (South African Department of Justice and Constitutional Development, 2022). The duration and scope justify a high damage placement. The documented consequence, though, concerns the availability and administration of justice services rather than any

confirmed manipulation of a physical process. KSM=4 keeps the line between a sustained, system-wide service interruption and the physical-operational top category.

5.4 Response Capacity as Context Rather than Damage Inflation

The Western Cape Provincial Parliament case shows why organisational response should not be mistaken for attack severity. The institution's 2023 report states that ransomware left all servers inoperable, while its public communication stressed that parliamentary business carried on (Western Cape Provincial Parliament, 2023). The incident caused a real technical outage, but continuity arrangements held down the functional consequence, and a provisional KSM=3 captures that bounded disruption. A strong response does not mean the attack was trivial; it means recovery capacity limited how far the attack reached operationally. The quality of that response belongs in the context layer, not in a retrospective redefinition of the technical event.

5.5 Electricity Vending: Operational Importance Without Proven Grid Manipulation

The Electricity Company of Ghana case calls for the same restraint in the other direction. ECG later confirmed a ransomware event and reported that it could not vend prepaid electricity for about a week, with losses put in the hundreds of millions of Ghanaian cedis (Electricity Company of Ghana, 2024). Prepaid vending is central to revenue collection and to customer access, but the public account does not establish any direct manipulation of grid control, or a physical electricity outage caused by the attack. A provisional KSM=4 says more than treating the event as an administrative inconvenience, yet stays more defensible than a KSM=5 assigned on sector importance alone.

5.6 Availability Attacks on Core Digital Government Services

Kenya's eCitizen incident and Senegal's government-website incident illustrate availability harm with no evidence of deeper system compromise. Kenyan public statements described a DDoS attack that caused downtime and reported that services returned without a confirmed data breach (Citizen Digital, 2023). Reuters reported that several Senegalese government websites were made unavailable by DDoS attacks (Reuters, 2023). In both, KSM=3 is a reasonable illustration: public access to government information or services was disrupted, but the evidence does not show destruction of core records, sustained internal system loss or physical-operational effect. Both cases also show why a DDoS claim should not be stretched into an intrusion claim without evidence.

5.7 Third-party Concentration in Mobile-Money Ecosystems

The Uganda incident matters analytically because the affected object was an integration layer. According to MTN Uganda, the security breach occurred at Pegasus Technologies rather than in the operator's own core systems, and it affected the bank-to-wallet transfer channel; everyday services, from cash deposits and withdrawals to transfers between individual users and merchant payments, continued to operate (MTN Uganda,

2020). The case should not, then, be described as a total failure of mobile money. Its significance lies in the concentration of dependency: a third-party aggregator carried disruption across financial and telecommunications relationships even as the core platform stayed available. KSM=3 captures the affected transaction path, while functional criticality records why even a bounded integration failure can matter to users and institutions.

5.8 Central Banks: Partial Application Disruption Versus National Payment Interruption

The Bank of Zambia and Central Bank of Lesotho cases show the value of differentiating by consequence within a single institutional category. The Bank of Zambia's annual report confirms a cybersecurity incident in 2022, and contemporaneous reporting of the bank's statements records that the incident disrupted the bureau de change monitoring system and the public website, which was down for part of several days, while core systems remained up (Bank of Zambia, 2023; News24, 2022). Under the anchors in Section 3.2 that is the documented loss of a public-facing function with core institutional functions continuing, which supports a provisional KSM=3. The Central Bank of Lesotho, by contrast, confirmed a cyber-security incident that affected systems, and official communications recorded disruption and the subsequent restoration of payment services (Central Bank of Lesotho, 2023). Here the consequence reached national payment infrastructure, supporting a provisional KSM=4. Describing both simply as 'central bank cyberattacks' would hide the operational difference between them.

5.9 Confidentiality Loss Versus Service Interruption

Telecom Namibia and Morocco's National Social Security Fund illustrate incidents dominated by confidentiality and trust. Telecom Namibia and the Communications Regulatory Authority of Namibia confirmed a ransomware-related event and data exposure (Communications Regulatory Authority of Namibia, 2024; Telecom Namibia, 2024). The cited sources confirm data compromise but do not document a service interruption sufficient to support KSM=3, so the provisional placement is KSM=2 rather than a level lifted simply because the target is a national operator. In Morocco the government confirmed attacks on the CNSS and the leakage of some data, while warning that the circulated materials included false, inaccurate or truncated documents (Government of Morocco, 2025). The Associated Press reported that the social-security agency acknowledged data theft and leakage (Associated Press, 2025). KSM=2 reflects the limited documented operational interruption, while the separate functional-criticality and confidentiality fields capture the scale of the identity, employment, salary, pension and insurance dependencies involved.

6. Cross-Case Analysis

6.1 Impact and Sector Importance

The cases support the framework's basic separation between impact and sector. Ports, laboratories, justice systems, electricity distributors and central banks are all socially important, yet their incidents did not produce the same consequences. Transnet and

NHLS reached real-world operational processes; the Department of Justice and the Central Bank of Lesotho suffered sustained service interruption; the Western Cape Provincial Parliament kept its business running despite serious server loss; the Bank of Zambia saw a bounded outage of its public website with core systems intact; and the CNSS suffered a major confidentiality event without comparable evidence of system-wide service loss. A framework that starts from sector labels would push most of these to the top of a single risk scale, whereas one that starts from documented consequence keeps the variation that matters.

None of this denies that criticality shapes harm; it only changes where that influence is recorded. Functional dependence, the availability of substitutes, geographic reach and concentration all explain why the same technical consequence can matter more in one setting than another. A one-day outage of a lightly used portal is not the same as a one-day outage of a payment platform that carries essential transactions. But writing dependence into the damage score would make cross-case comparison impossible. The answer is a two-step statement: first record what the incident did, through KSM, then record who and what depended on the affected function, through the criticality layer.

6.2 Sparse Reporting and the Risk of Under-Scoring Complexity

The twelve cases say far more about consequence than about intrusion path. Official statements are generally written to communicate restoration, continuity and reassurance, and they rarely publish dwell time, privilege escalation, credential access, internal movement, defence evasion or the sequence of technical stages. For most of these cases, then, a defensible KoI total simply cannot be formed. That is less a weakness of the index than a finding about the evidence environment itself.

A binary coding rule would introduce a predictable bias. Suppose persistence, lateral movement and evasion were each scored zero whenever a press release failed to mention them. Organisations with mature forensic disclosure would then appear to suffer more complex attacks, because they publish more detail, while institutions that disclose little would appear to face simple ones. The model would end up measuring reporting maturity rather than adversary behaviour. The three-state approach (present, absent, not assessable) prevents this conversion of silence into negative evidence. Complete-case KoI values can still be used where the record supports them, provided any comparison also reports how many components were assessable.

The same logic applies to attribution. A public claim by a group can help establish motive or campaign context, but it does not prove operational control, sponsorship or state responsibility, and country, language or infrastructure location must not stand in for actor identity. Nigeria-focused research has treated cybercrime as an evolving institutional, economic and policy problem rather than a national characteristic (Kovács, 2022a). Evidence-constrained attribution is more than cautious wording: it keeps the analysis clear of circular, and potentially stigmatising, inference.

6.3 Functional Criticality Beyond Utility Lists

The case set shows that criticality in Africa cannot be read off the traditional energy, water, transport and health categories alone. Work on water-sector cybersecurity shows

that disruption can spread through health, production and wider social pressures even when the initiating event is purely technical (Kovács, 2024c). eCitizen concentrates access to public services; the CNSS concentrates employment, pension, insurance and identity information; mobile-money integrations connect banks, operators, agents, merchants and households; and central-bank payment systems coordinate national financial settlement. What makes these functions critical is that the effects of unavailability or integrity failure spread across many dependent services, not that a foreign regulatory list happens to label them critical.

The African Union's digital strategy and data-policy framework link digital infrastructure, digital government, financial services, digital identity, cybersecurity and personal-data governance (African Union, 2020, 2024). This article carries that policy insight into incident analysis without touching KSM. Functional criticality can be set out through four questions: how many essential functions rely on the service; whether a practical non-digital or alternative route exists; whether the dependency is concentrated in a single provider or intermediary; and whether an integrity failure can spread through shared identity, payment or data interfaces. The Uganda case is a good example, since the core mobile-money platform stayed intact and yet a third-party connection still disrupted a meaningful transaction path.

6.4 Recovery Capacity as Context

Manual operation and substitute processes recur across the cases. Transnet moved to manual port processes; the Department of Justice faced prolonged system loss and administrative backlog; the Western Cape Provincial Parliament carried on parliamentary business despite inoperable servers; and the NHLS relied on alternative communication and processing arrangements during a clinically sensitive outage. These measures shape duration, backlog and safety, but they should not be used to score an attacker's sophistication or to erase the initial damage.

The distinction earns its keep operationally. A KSM finding tells leadership what class of consequence occurred; the recovery context tells them how quickly the organisation, and the society that depends on it, can absorb that consequence. Two incidents at the same KSM can call for very different investment, because one institution has manual fallback, distributed capacity and tested restoration while another has a single digital path and no workable alternative. The payoff is a clearer risk register, in which event severity, service criticality and resilience capacity stand as separate reasons for action.

6.5 Different Consequence Types, Different Responses

The cases also push back against treating every severe cyber event as the same problem. The CNSS and Telecom Namibia call for privacy, identity-protection, legal and trust responses, because confidentiality loss is at the centre. eCitizen and Senegal call for availability protection and DDoS resilience. The Bank of Zambia and the Western Cape Provincial Parliament call for application and infrastructure recovery. Transnet, NHLS and ECG call for continuity analysis tied to physical logistics, clinical workflow or customer access to electricity. The Central Bank of Lesotho calls for payment-system

resilience and sector coordination. A single, undifferentiated 'cyber severity' number would hide all of these response pathways.

KSM is best understood as one axis, not a complete risk judgement. KoI answers a separate question about observable execution; KrI and functional criticality explain societal role; and the evidence state governs how firmly any conclusion may be stated. Taken together, the fields make up an auditable incident card, and they can be read together, and acted on together, without being merged into a single number.

7. Operational and Policy Implications

For operators, the framework changes the first question after an incident from 'How sophisticated was the attacker?' to 'What is confirmed, what function is affected, and what is still unknown?' Asked in that order, it puts containment and continuity ahead of attribution. A port or laboratory does not need a confident actor label before it activates manual procedures, preserves evidence, isolates systems and coordinates with the organisations that depend on it. Nor should an institution announce that an attack was simple just because its public report shows no lateral movement or persistence.

For regulators, the framework makes cross-sector comparison less hostage to disclosure bias. Reporting templates can ask for separate fields for operational interruption, confidentiality or integrity effect, recovery time, scope of dependency, source confidence and coverage of technical detail. A regulator can then tell a low-KSM but high-confidentiality event apart from a high-KSM continuity event, or spot sectors where low KoI values only reflect low assessability. That is more informative than ranking institutions by incident counts or by unqualified severity labels.

For security operations and risk management, the incident card supports a proportionate response. KSM guides continuity and safety escalation; the KoI components guide how deep an investigation goes and where threat-hunting should focus; KrI and functional criticality identify the dependent services and stakeholders; and the evidence state decides whether the organisation is acting on a confirmed fact, a plausible hypothesis or an open gap. Where early actor probabilities are used, they should allow an abstention state and should never hold up basic defensive action. When predictions feed operational triage, calibration and class-sensitive metrics matter more than headline accuracy (Niculescu-Mizil & Caruana, 2005; Sokolova & Lapalme, 2009).

For research, the immediate contribution is comparability held in check. Shared definitions let knowledge accumulate, while explicit unknown states stop the appearance of precision from running ahead of the sources. Distributional tools such as Jensen–Shannon divergence can tell whether two observed samples differ, but the reading still depends on whether their language, source class and reporting process are comparable (Lin, 1991). And where human coders turn narrative evidence into ordinal or categorical variables, inter-rater agreement and label-noise analysis remain essential (Cohen, 1960; Frénay & Verleysen, 2014).

8. Limitations

The twelve incidents are purposive illustrations. They over-represent events that became public and that produced accessible official or high-quality reporting, and they cannot

estimate how frequent ransomware, DDoS, physical impact, particular actor types or sector exposure are across Africa. Countries and institutions with stronger disclosure practices are more visible in such a set, and accessibility in English remains uneven even where French-language and official national sources were consulted.

The provisional KSM placements are interpretations of public evidence, not final adjudicated labels from a completed African incident corpus. Several cases could shift within a narrow band if fuller technical or operational records came to light. KoI totals are withheld wherever the four components cannot be assessed. Functional criticality, too, involves contextual judgement, and should be documented openly rather than presented as an objective property of a country or a sector.

Finally, the coefficients and performance figures in Section 3 belong to the original MCED analysis (Kovács, 2026). They justify using the constructs as an empirical baseline, but they are not estimates for Africa. What this article claims is conceptual and analytical applicability, not a completed regional validation.

9. Conclusion

African cyber incidents are often read through the importance of the victim, the name of the malware, the claimed actor or the sheer scale of leaked data. Any of these can be relevant, but none can stand in for a structured account of consequence, behaviour, criticality and evidence. The twelve cases show what conflation costs in practice. Transnet and NHLS show digital compromise reaching physical logistics and clinical operations. The justice and payment-system incidents show sustained public-service disruption. eCitizen and Senegal show availability attacks with no evidence of deeper compromise. Uganda shows third-party concentration carrying impact across an otherwise functioning mobile-money ecosystem. Telecom Namibia and the CNSS show how confidentiality loss can be severe even when operational interruption is harder to establish.

The framework handles these differences by keeping the dimensions apart. KSM records the technical-operational damage that was realised. KoI records only observable complexity. KrI and functional criticality say why the affected function matters, without manufacturing severity. The evidence state stops missing detail from turning into false absence. Recovery capacity explains societal consequence without rewriting the event. The fields can be read together while staying analytically independent.

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Data availability statement

The Maryland Cyber Events Database underlying the original analysis is publicly available from the Center for International and Security Studies at Maryland

(https://cissm.umd.edu/cyber-events-database). All African incident sources examined in this article are publicly accessible at the URLs listed in the references.

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To What Extent Does the Railway Network Cover Africa?[1]

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Abstract:

The railway network is one of the most important infrastructure elements that connects different regions within a country. The extent to which the railway network is able to make a given area economically and socially accessible affects a country's economic performance and development opportunities. The research examined the spatial coverage properties of the African railway network using chaotic mathematical methods. In this context, the fractal dimension was used as a measure of the planar coverage of linear networks. The research determined the fractal dimension of the entire railway network in Africa, as well as the fractal dimension of those countries that have a significant railway network. The research compared the fractal dimension of the railway networks of the two most significant African countries with a railway network, with those of some European countries. The results obtained quantitatively characterize the railway coverage of individual countries and the African continent as a whole, which allows for a numerical interpretation of the structural differences in the railway infrastructure. The fractal dimension values determined in the research quantitatively reveal the coverage inequalities of individual areas, so they can be used as indicators when determining the priorities of railway network developments.

Keywords:
Africa; Railway Networks; Fractal Dimension; Box-Counting Method.

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1. Introduction

Africa's railway network constitutes a complex system that goes beyond its mere transport function, and its geopolitical, economic and historical dimensions are crucial in its development. The continent's development path - from colonial conquests in the 19th century to regional integration in the 21st century - is closely linked to the development of its railway infrastructure. The network is highly fragmented, with links between individual countries often lacking and lacking a coherent system in many regions.

There are approximately 75 000 kilometers of usable railway tracks on the continent. (African Union, 2015). By comparison, the United States' rail network is over 250 000 kilometers long, but when you consider the area, the difference is even greater. Africa is roughly three times the size of the United States, yet it has less than a third of the size of the American rail network (Thelo, 2024). Equally important is the highly heterogeneous spatial distribution of the network. Some regions – notably South Africa – operate infrastructure comparable to developed countries, while other states have extremely low rail coverage, and there are countries where there is no rail coverage at all. (Bullock, 2009).

The fragmentation of the network is a direct consequence of Africa's specific history and the logic of colonial economic policy. (Fourie & Herranz-Loncan, 2015). Railway lines built at the turn of the 19th and 20th centuries were typically not geared to local mobility needs or to promoting economic integration between regions but primarily served the extraction of mineral resources and transport to export ports (Kerby, et al. 2017).

The British, French, German, Portuguese and Belgian colonial powers accordingly created an infrastructure network that mainly supported the profit interests and trade policies of the mother countries, rather than strengthening internal relations. A significant part of this structural legacy survived even during the period of independence aspirations starting in the 1960s, and neocolonial economic relations continued to significantly influence the development directions and spatial patterns of the railway network (Jedwab & Moradi, 2016).

2. Research Objectives and Methodology

The main objective of the research is to determine the fractal geometric characteristics of the African railway network and interpret them in a mathematical context. In the research, the fractal dimensional investigation of the spatial structure of the African railway network focused on three topics:

- continent-level analysis, which is an examination of the railway network of Africa as a whole,
- examination of the railway network of the African regions (North, South, East and West Africa),
- examination of the railway network of the two countries with the most developed railway networks (South Africa, Egypt).

- comparison of the obtained results with research results for European countries.

The research used the box-counting method to determine the fractal dimension of railway networks. In the box-counting method, a shape to be examined (in this case the railway network) is covered with an increasingly dense square grid, and the number of covering cells is plotted as a function of different cell sizes. The slope of the function plotted on a log-log scale determines the fractal dimension.

3. The Logic and Effects of Colonialist Railway Development

In order to understand the railway network in Africa, it is essential to understand the goals and considerations that guided railway development during the colonial era. The first African railway line was built in 1856 in Egypt, between Alexandria and Cairo, and the pace of railway construction increased rapidly during the colonial period. However, the development of the railway network did not serve a "civilizing" purpose. The colonial powers – especially the United Kingdom, France, Germany, Portugal and Belgium – mostly created lines that connected the interior of the continent to ports, facilitating the export of mineral raw materials and tropical products (Erdős, 2011).

A well-known example of colonial logic is the idea of the Cape Town-Cairo railway, conceived in 1874 by the British-South African businessman and politician Cecil Rhodes (Weinthal, 1923). Rhodes envisioned a continuous north-south railway axis that would connect the African territories of the British Empire and strengthen Britain's political influence on the continent (Storey, 2025).

The entire project was ultimately not realized, as the economic consequences of World War I, the geographical and political circumstances of the German East African colonies, and later the decolonization process all hindered its completion. However, the railway constructions related to Rhodes – especially in South Africa, Zimbabwe and Zambia – determined the economic relations and raw material-oriented structure of these regions for a long time.

Similar patterns can be observed in other colonial zones. The French administration in West Africa built railways that connected Senegal, Mali, and Guinea, primarily to transport goods from the Gulf of Guinea coast and the wider Lake Chad region (Roberts, 2011). German colonial ambitions also involved the construction of railways in what is now Tanzania, and in the Portuguese colonies – in Angola and Mozambique – export-oriented transport systems organized around ports were established (Meier zu Selhausen, 2025). The Congo Basin became a central arena of colonial competition, and under Belgian rule a railway structure developed that served the needs of copper production (Mavhunga, 2023).

A common feature of these projects is that the railway networks were not adapted to the mobility needs of local societies or to the development of trade between the interior areas of Africa. The lines typically connected the extractive regions with the coastal export ports, and the spatial structure of the network was fundamentally determined by export processes (Gwaindepi, 2019). This asymmetry has led to extreme fragmentation in several places. Even within a country, lines were not connected to each

other, and they often did not fit into the networks of neighboring states at all. (Jedwab & Moradi, 2014)

The fragmentation was further reinforced by the diversity of railway track gauges. In the northern regions of Africa, the 1435 mm (standard) gauge was widespread, in the southern regions the 1067 mm gauge was common, and in Central and West Africa the 1000 mm gauge. In addition, many other variants are present on the continent, and even smaller sections, such as 600 mm and 950 mm gauges, have been created. Such a wide range of gauges and their mixing posed a significant technical and organizational obstacle, and in many cases made continuous cross-border rail transport practically impossible.

4. The Impact of Mineral Extraction and Rail Logistics on the Network

The geographical distribution of mineral resources and their associated transport logistics are key to understanding the spatial structure of the African railway network. The location of mineral deposits, sea and river ports, and economically accessible routes connecting them have all shaped the development of the railway network and continue to strongly influence development directions today. (PPIAF, 2014). After the first diamond deposits were discovered in the Orange River region in 1867, South Africa gradually became a major exporter of gold, diamonds, coal and other valuable minerals. (Janse, 1995). The Democratic Republic of the Congo accounts for 70% of the world's cobalt production (Gulley, 2023), while Zambia and Zimbabwe are famous for their copper mining (Perrings, 1977). In Egypt and Sudan, the development of the railway network was partly adapted to the agricultural production of the Nile Valley and, after the construction of the Aswan Dam, partly to the expansion of energy supply and industrial and transport needs (Bouraima et al., 2023).

The extraction of raw materials is particularly important from a logistical perspective, as deposits are often located far from the coast and major ports. For example, copper from the Katanga region of the Congo and the associated processing facilities required rail corridors that opened up the interior to the Atlantic Ocean. An important element of this was the Benguela Railway to Angola, which was once an important colonial railway network. It connected the port of Lobito with Luau on the eastern border, and also Congo, Angola, Zaire, Zambia, Zimbabwe and Mozambique (Perrings, 1977). It was closed during the Angolan Civil War, but reopened in 2014. Copper from Zambia and Zimbabwe was transported by rail to South Africa, as well as through corridors between British colonies. The spatial configuration of the railway lines was essentially determined by where the transport route between deposits, processing centers, and ports was continuous and could be operated at the lowest cost (Jedwab & Moradi, 2014). The continent's terrain, routes crisscrossed by rainforests and mountains, and the limited capacities of port and related logistics infrastructure in many regions also played a role in this (Naudé & Matthee, 2007).

All this resulted in the development of a single, integrated railway system in many parts of Africa, but rather a collection of relatively separate railway corridors organized

for the export of raw materials (Graff, 2019). As a result, for example, Zambia became dependent on South Africa for its copper exports, and even the TAZARA railway network connecting Tanzania and Zambia, built with Chinese support in the 1970s during the Cold War, was only an indirect solution (Brazinsky, 2024).

5. Development Periods of Africa's Railway Network

The historical development of African railway infrastructure can be divided into four distinct periods (Jedwab & Storeygard, 2017). The first period was the era of colonial expansion between 1850 and 1920, when European powers began to compete intensely for political and economic control over African territories. Following the Anglo-Boer Wars, British influence stabilized, especially in South Africa, while the French sphere of influence expanded its railway development into West Africa, while German colonial structures also consolidated in certain regions of the continent.

The second is the period between 1920 and 1960, when the First and Second World Wars and the intervening global economic crisis slowed down developments due to limited investment capacities and the impossibility of long-term planning. Nevertheless, great power rivalry continued to influence where and in what form railway infrastructure developments were implemented.

In the fourth period, from 1980 to the present, the picture is twofold. In many regions, the condition of railway lines has deteriorated, some sections have become less functional or have disappeared altogether. At the same time, new development programs and financing models have emerged in recent decades, which once again emphasize the strategic role of railways. This trend is reflected, for example, in the increasing participation of China in African railway projects, as well as in the integration-oriented infrastructure development ideas formulated within the framework of the African Union. Such is the case of the AU PIDA program, which aims to modernize and interconnect the network in the longer term (Cokoye et al., 2025). Kenya's "Standard Gauge Railway (SGR)" program, which aims to standardize the country's entire railway network, is also being funded by China (Stölczer et al., 2025).

6. Application of Fractal Dimension in Structural Analysis of Railway Networks

Fractal geometry is a field of mathematics that is specifically suited to describing complex, often self-similar or near-self-similar structures (Mandelbrot, 1977). Mandelbrot's work showed that the geometric properties of many natural and man-made shapes cannot be described satisfactorily by the tools of classical Euclidean geometry but can be well captured by fractal concepts. The spatial patterns of railway networks, such as the system of junctions, branches, main and branch lines, often form such complex fractal structures, therefore the use of the fractal dimension allows for the structural comparability of different railway networks. (Benguigui & Daoud, 1991). Fractal analysis of railway networks is based on the fundamental recognition that these

networks exhibit a hierarchical organization that is repeated at multiple scale levels (Fokasz et al., 1997).

One of the earliest and most fundamental fractal analyses of rail-transport networks was Benguigui's 1995 research on the Paris transport network, which showed that transport networks exhibit characteristic fractal structures (Benguigui, 1995). Batty and Longley's early work on fractal simulation of urban structures also fundamentally influenced this field (Batty & Longley, 1994).

7. Basic Concepts of Fractal Geometry

7.1. Self-Similarity and Scale Invariance

One of Mandelbrot's fundamental insights was that there are many objects in nature and human systems that repeat similar structural patterns at different scales. Classic examples include the contours of coastlines, mountain ranges, the branches and leaves of plants (Mandelbrot, 1977) and the layout of cities or transportation networks. (Helbing et al., 1977). Self-similarity is a fundamental property of fractals, according to which smaller, nested parts of a structure resemble the entire shape, and this similarity can be observed over a wide range of sizes. (Stewart & Golubitsky, 1992). Important geometric features of the system do not “disappear” and do not change significantly when the shape is examined at a different magnification or spatial scale. This idea is particularly relevant in the analysis of railway networks. The organization of the network can in some cases show similar patterns from the level of local line sections to large corridors spanning countries. The hierarchical structure of railway systems – main lines, regional connections, local branches – naturally offers opportunities for the use of the concepts of self-similarity and scale invariance in structural characterization (Fokasz et al., 1997).

7.2. Basic Fractals

The Cantor set is a classic yet easily illustrated example of fractal geometry (Figure 1). Its starting point is the interval [0,1], from which in the first step we remove the middle third of the interval, the interval (1/3, 2/3), as an open interval. In the second step, we do the same for the remaining sections [0,1/3) and (2/3,1]. By repeating this series of steps, we obtain a shape consisting of more and more, but smaller sections. The shapes resulting from each step are similar to the shape obtained in the first step, so the Cantor set is self-similar. By repeating the procedure to infinity, we obtain a shape characterized by the fact that the length of the removed sections is the same as the length of the initial section. Since we have cut open intervals, in the extreme case the length of the Cantor set is zero, but its number of elements is infinite. The initial section has been transformed into a point cloud.



Figure 1: Cantor set (Gyires, 2021).

The Sierpinski carpet is one of the best-known examples of planar fractals (Figure 2). It can be constructed using a simple rule, yet it creates a very complex structure. The starting point of the construction is a unit square, which is divided into a 3×3 grid, and then the middle square is removed. The same operation is then repeated for each of the remaining eight squares. In each subsequent step, the remaining squares are divided into 3×3 parts and the middle square is removed from them. The end result, after an infinite number of iterations, is a shape whose removed area is equal to the area of the starting square, but whose perimeter tends to infinity. The Sierpinski carpet is therefore no longer a plane shape, but has become much more line-type, while maintaining its self-similarity.

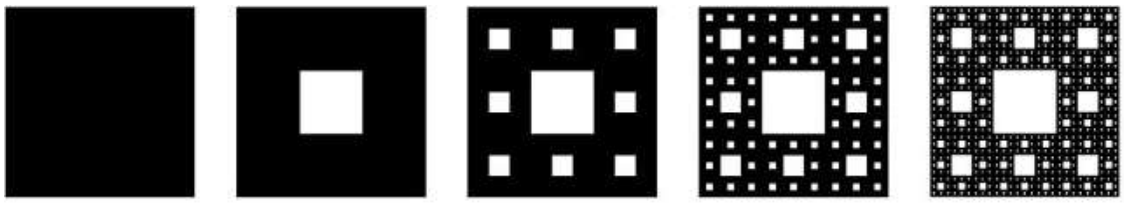


Figure 2: Sierpinski carpet (Kuznetsova et al., 2025).

Like the Cantor set, the Koch curve starts with a straight-line segment (Figure 3). This segment is divided into three equal parts, the middle third is removed, and two new segments are inserted in its place, creating an equilateral triangular bulge. The same step is repeated for each of the remaining four segments, and then the process is repeated infinitely. The Koch curve is also self-similar. At each step, a segment is replaced by four segments reduced to 1/3 of its original length. The length of the Koch curve thus increases with each iteration, up to infinity, while the entire curve remains within a limited range.

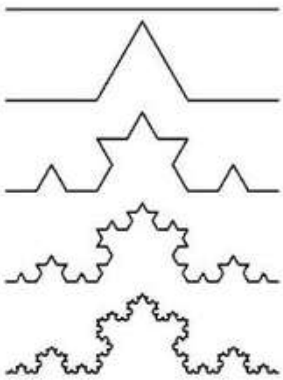


Figure 3: Koch curve (Purnomo et al., 2019).

The Peano curve is a space-filling type of shape that also starts from a straight-line segment. In the first step, we divide the segment into three equal parts, then we fit a square at the top and bottom of the middle segment. In the next step, we replace the two squares with a continuous line that traverses all edges of the squares and connects the two original 1/3-length segments (Figure 4). The Peano curve has the property that although it starts as a line, it can cover a larger and larger part of the plane with infinite iterations. The length of the Peano curve increases exponentially with each iteration, and eventually goes to infinity, while the shape itself remains in a bounded, square domain. The Peano curve is topologically one-dimensional, but in terms of its space-filling ability, it behaves like a two-dimensional object.

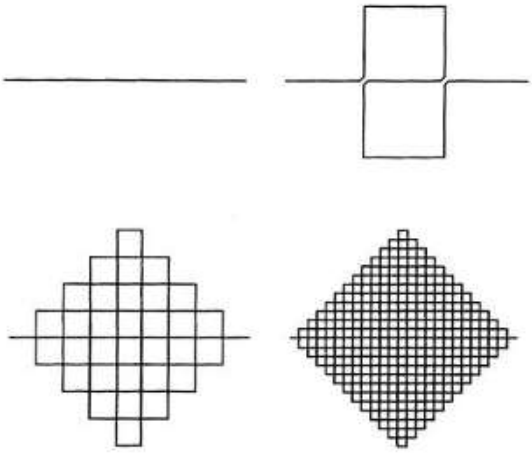


Figure 4: Peano curve (Bovill, 1996).

7.3. The Fractal Dimension

In spatial dimensions, a point has zero dimensions, a line or plane curve has one dimension, a plane figure has two dimensions, and a solid has three dimensions. The number of spatial dimensions reflects the topological structure of the object. However, we can also test the one-dimensional nature of a curve by seeing how it can be covered

with smaller and smaller sections. We find that the smaller sections we cover of the curve under consideration, the larger the value we get for its length, and even if we use a measuring device of the same accuracy, the measured result still depends on where we start measuring on the curve. This is the so-called shoreline problem. (Richardson, 1961). Figure 5 shows that although the curve of the coastline of Great Britain is the same in all cases, we still get different results when using measuring instruments of different accuracy.

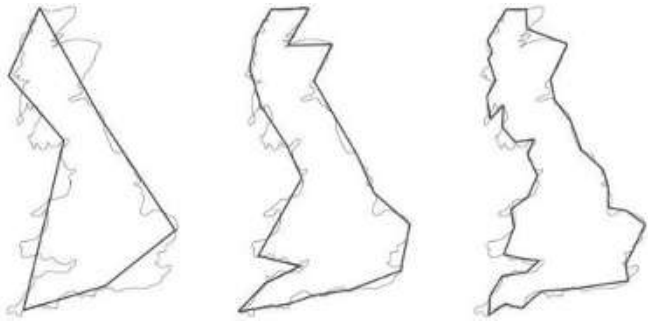


Figure 5: The shoreline problem (Mandelbrot, 1977).

Fractal dimension is a generalized geometric measure that characterizes how a shape or network "fills" space at different scales. In the classical approach to Euclidean geometry, dimension is an integer for different shapes. However, in the case of fractals, dimension is often not an integer, but rather expresses the extent to which the object can fill space. For example, a Koch curve is more than a simple line, but less than a complete plane surface. Fractal dimension is a quantitative measure of geometric complexity. The larger the fractal dimension of a shape, the more structurally complex the shape is. (Skums & Bunimovich, 2020).

7.4. Box-Counting Dimension

When we want to determine the fractal dimension of an irregular plane figure, the similarity dimension method is often not applicable, since irregular shapes are not constructed in such a way that the entire shape is self-similar. In such situations, box counting is one of the most commonly used methods for numerically estimating the fractal dimension. In the box-counting method, a square grid is placed over the shape under consideration, and then the cell size is gradually reduced, and at each step we count how many cells have a point in common with a point on the shape. For example, if we initially use a 10×20 grid and then reduce the cell size by half, the number of cells needed to cover the 20×40 grid increases but typically does not double. The rate of increase depends on the “complexity” of the shape. As the cell size becomes smaller, a typically power-law relationship develops between the number of cells required for coverage and the cell size:

$$N_r \propto r^{-D_b}$$

where N_r is the number of cells that have a point in common with the shape, r is the cell size, and D_b is the box-counting dimension. Therefore, the box-counting dimension:

$$D_b = \frac{\log N_r}{\log(1/r)}.$$

The method is applicable not only to regular, deterministic fractals, but also to general planar shapes. Due to the nature of the method, randomization does not change the fractal dimension, and the box-counting method can be widely used to estimate the fractal dimension of any planar shape (Benguigui & Daoud, 1991).

8. Applicability of Fractal Analysis to the Analysis of Railway Networks

In the case of fractal analysis of railway networks, the box-counting method is easy to apply and allows for the rapid analysis of large networks. The map of the railway network must be covered with a grid, and then the number of cells covering the network must be assigned to each cell size by continuously reducing the cell size. The values are displayed on a logarithmic scale, and the slope of the line that best fits the points gives the value of the fractal dimension. The fractal dimension is an indicator that can be used in practice because it expresses how efficiently the railway lines fill the geographical area under study (Batty & Longley, 1994).

The application of fractal analysis to the study of railway networks has several advantages. It allows the measurement of complex morphology, as the fractal dimension expresses the topological complexity of the network in the form of a single number, which allows for objective comparison. Due to the scale-independent nature of the box-counting method, networks of different sizes and organization can be compared. If individual temporal changes are documented, the change in fractal dimension can be used to examine how the railway network reflects infrastructural and geopolitical priorities (Cai et al., 2023). Fractal analysis can also be used to verify whether rail network developments produce structures that correspond to real, known fractal values. However, the application of fractal analysis has several limitations that must be taken into account. The value of the box-counting dimension depends on the chosen grid sizes and the scale range examined. Distortion can occur if the analysis is performed on a scale that is too large or too small. In practice, it is recommended to use a grid size reduced in 5–10 steps. In line with this, we halved the grid size in 8 steps in the research.

Railway networks are not natural systems, but the result of human decisions that take into account the location of economic resources and political considerations. It should therefore be noted that fractal analysis does not explain these causal factors but only makes the structural complexity of different networks measurable and comparable.

Data quality issues also affect the results. The accuracy of digital maps, incomplete or outdated data, and topological variations can all affect the results of fractal analysis. If we want to compare the fractal dimension of different railway networks, we need to use maps with the same scale. It is also important that the line thickness representing the

railway lines on the maps is the same, because the line thickness also sets a limit to the reduction of the grid size (Szilágyi, 2025).

9. Material and Methodes

To examine the railway network, we used the online, interactive map of OpenRailwayMap (OpenRailwayMap, 2025), which is part of the OpenStreetMap (OSM) community database. OpenRailwayMap contains detailed data on the railway networks of all countries, and the interactive map displays the following information for each railway line:

- railway infrastructures and their identifiers (e.g. bridge, tunnel, stations, etc.),
- speed limits,
- type of railway signaling system,
- operating voltage values of electrified lines,
- gauge width.

The map displays elements with the same properties in the same color, which also facilitates visual identification. The map is zoomable and provides a kilometer and mile scale at the current zoom level. It refines the geometry of the route as you zoom in, while displaying it with a constant line thickness. These features are particularly useful for using the box counting method when using a large, high-resolution display.

The study was conducted separately for several territorial units. For each territorial unit, an image crop with the same scale and display settings was used to make the results comparable. We performed a fractal analysis of the railway network of the following territorial units:

- the entire territory of Africa,
- regionally divided into North Africa, East Africa, South Africa, West Africa,
- and two countries, Egypt and the Republic of South Africa.

Since the railway network of the African continent is very rare not only compared to other continents, but also in itself (Figure 6). The railway network of most African countries consists of only a few railway lines, so the continental railway network does not form a continuous, complex network. Only the two countries under study have a railway network for which fractal geometry analysis makes sense.



Figure 6: The railway map of the Earth (OpenRailwayMap, 2025).

For the analysis, we used the FrakOut software, which uses a box-counting method to determine the fractal dimension of the given shapes. In order to increase the accuracy, the relevant cells were selected not with a mouse, but with an XP-pen Deco 01 V3 digital drawing tablet. This tool allowed us to continuously select the relevant cells in the image, not by clicking one by one, but by dragging the associated pressure-sensitive digital pen along the line. The software applies a square grid to the map crop, on which the cells that have a common point with the examined shape, in this case the given railway network, have to be selected. Then, we increased the grid density using the software, thus reducing the cell size, and repeated the identification of affected cells with the smaller cell size.

The software counted the number of cells that have a common point with the examined shape at each step, and as a result of the iteration steps, it calculated the fractal dimension of the examined shape. In the research, we reduced the cell size in eight steps, which is consistent with the empirical value of research conducted using the box-counting method. The individual cell sizes r and their corresponding box numbers used in the analysis were plotted on a log-log diagram, and a straight line was fitted to them using linear regression. According to the box-counting method, the slope a of this straight line gives the fractal dimension D_b :

$$N(r) \propto r^{-D_b} \quad \Rightarrow \quad \log N(r) = a \log r + b, \quad D_b = -a.$$

9.1. Interpretation of Fractal Dimension in a Railway Context

The fractal dimension of the railway network is closely related to the spatial complexity, flexibility and economic organization of the network. D_b values close to 1.0 can be interpreted as a linear, one-dimensional network with a single, not excessively winding railway line. In such a network, there is usually only one possible route between two points, its capacity is low, and its vulnerability is high. Such a network is very sensitive; if an error occurs, its transmission capacity is significantly reduced or may even be zero. A value of D_b around 1.5 indicates a slight complexity, but the network's space-filling capacity is still low. In such a network, points can be reached via several possible routes, and due to the possible detours, its disturbance tolerance is higher, but even small disturbances affect its capacity. A value of D_b above 1.8 indicates high complexity and area-filling characteristics, which are typical of dense, highly branched networks that cover a larger area. These networks have high fault tolerance and are able to maintain their capacity within certain limits even in the event of faults. (Cai et al., 2023).

10. Research Results

10.1. The Fractal Dimension of Africa's Entire Railway Network

Based on the map of the African railway network, it was already visually likely that the analysis would yield a low fractal dimension for the continent as a whole, which was confirmed by the results of the box-counting analysis. The map clearly shows that the railway coverage of some regions of the continent is asymmetrical (Figure 7).



Figure 7: Africa's railway network (OpenRailwayMap, 2025).

The railway network of most African countries is characterized by the fact that it consists of main lines and branch lines connecting to them, and these local lines correspond to tree-graph type that are not connected to each other. There are only two regions where the railway network is not tree-graph type, and each main and branch line form a complex network that is also connected to each other. One of these is the Southern African region, and within it, typically the Republic of South Africa, and the other is the railway network of the areas near the Mediterranean Sea in the North African region. Figure 8 shows the results of the analysis for the entire continent of Africa, performed using the box-counting method, in a log-log diagram.

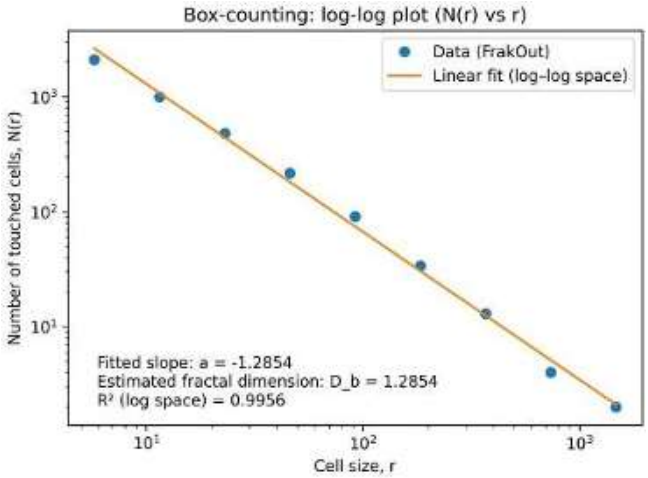


Figure 8: Africa's $D_b^{AFR} \approx 1.2854$; $R^2 \approx 0.9956$ (Own figure).

The resulting fractal dimension is significantly lower than, for example, the fractal dimension of the European railway network $D_b^{EUR} \approx 1.74$ (Fokasz et al., 1997), but no conclusions should be drawn from this alone. The population density of a given continent must be taken into account, as rail transport develops between populated and

industrial areas. The African continent has large areas of uninhabited land due to climatic conditions, while in the case of Europe the proportion of uninhabited land is small.

10.2. The Fractal Dimension of the North African Railway Network

The coastal regions of North Africa, in the northern parts of Egypt, Morocco and Tunisia, have relatively well-developed railway networks, but Algeria, apart from a short section, has almost no railway network. Figure 9-12 shows the results of the fractal geometry analysis of the region. The low fractal dimension value ($D_b^{NAFR} \approx 1.1208$) is also influenced by the fact that the railway lines are located in a more densely populated zone close to the Mediterranean coast, while there are no railway lines in the Saharan areas. The West African region also includes a significant amount of sparsely populated land, and therefore the fractal dimension of the region is also strongly influenced by regional borders defined based on political and economic considerations. The fact that the fractal dimension of East Africa ($D_b^{EAFR} \approx 1.2568$) is higher than that of West Africa ($D_b^{WAFR} \approx 1.2179$) may also be a consequence of this effect, but a causal verification of this is beyond the scope of this research. Although in the case of South Africa ($D_b^{SAFR} \approx 1.4164$), in addition to the colonial effect, the geometric shape of the continent also plays a role in the high fractal dimension value. Despite all these effects, since the research followed regional boundaries determined based on economic and political considerations, the fractal dimension can be considered an economically relevant indicator for strategic decisions in railway developments.

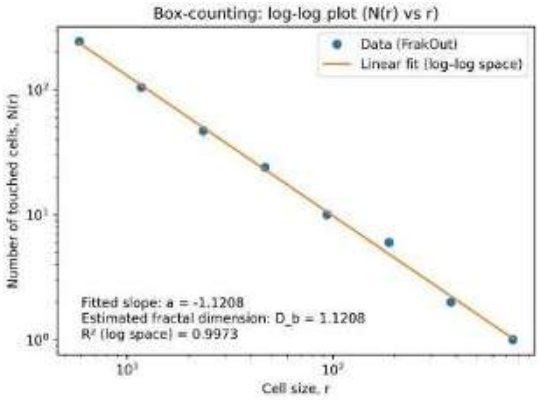


Figure 9: North Africa's $D_b^{NAFR} \approx 1.1208$; $R^2 \approx 0.9973$ (Own figure).

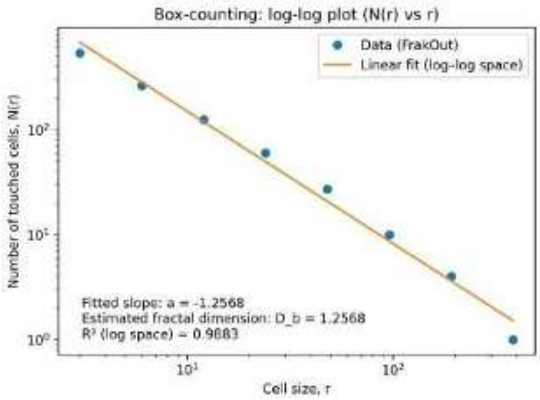
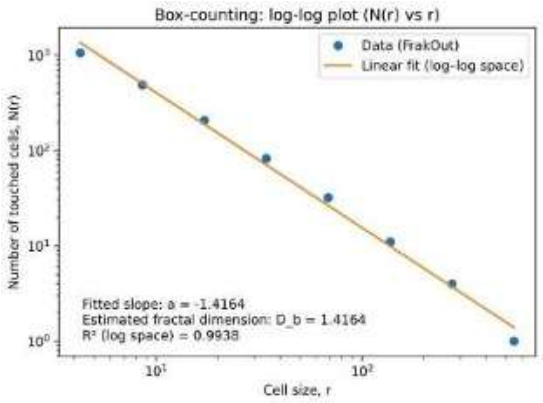


Figure 10: East Africa's $D_b^{EAFR} \approx 1.2568$; $R^2 \approx 0.9883$ (Own figure).



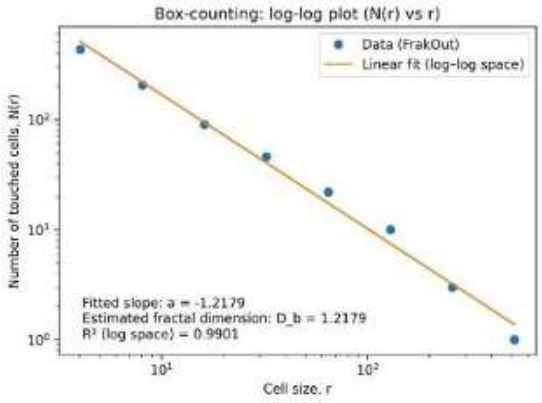
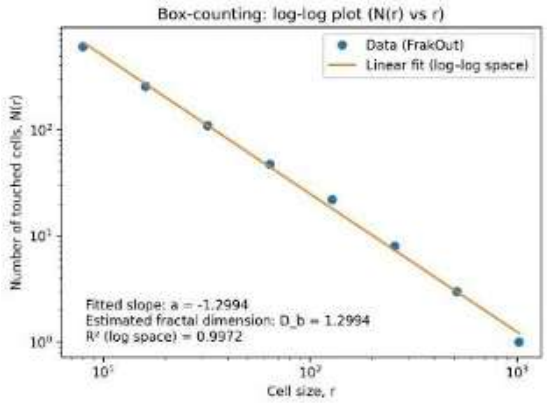


Figure 11: South Africa's $D_b^{SAFR} \approx 1.4164$; $R^2 \approx 0.9938$ (Own figure).

Figure 12: West Africa's $D_b^{WAFR} \approx 1.2179$; $R^2 \approx 0.9901$ (Own figure).

10.3. Fractal Dimension of the Railway Network of Egypt and the Republic of South Africa

The two African countries with the most complex railway networks are Egypt and the Republic of South Africa. The results of the fractal analysis of these two countries are shown in Figures 13 and 14. Although the fractal dimension of Egypt is lower than that of the Republic of South Africa, using the results of Fokasz et al. (1997), we find that Egypt, with its $D_b^{EGY} \approx 1{,}2994$ is ahead of Turkey ($D_b^{TUR} \approx 1{,}18$) and Greece ($D_b^{GRE} \approx 1{,}24$).



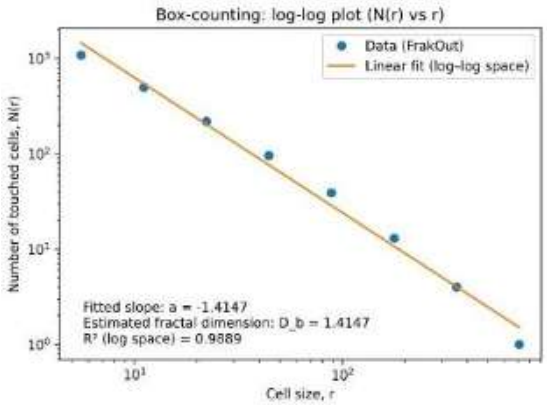


Figure 13: Egypt's $D_b^{EGY} \approx 1.2994$; $R^2 \approx 0.9972$ (Own figure).

Figure 14: Republic of South Africa's $D_b^{SAR} \approx 1.4147$; $R^2 \approx 0.989$ (Own figure).

South Africa is the best-covered African country with a railway network. Its fractal dimension ($D_b^{SAR} \approx 1{,}4147$) is close to that of Italy ($D_b^{ITA} \approx 1{,}48$), but still significantly lags behind the values of European countries such as Great Britain ($D_b^{GBR} \approx 1{,}68$), Germany ($D_b^{GER} \approx 1{,}78$), France ($D_b^{FRA} \approx 1{,}76$) (Fokasz, Kopper, Maródi, & Szedenics, 1997). An interesting result is that the country's tail dimension is almost exactly the same as the value obtained for the Southern African region. This is probably due to the country covering a significant area of the region.

11. Summary

This study examined the spatial coverage and structural characteristics of the African railway network using fractal geometry methods and demonstrated how historical periods influenced the development of the railway network on the continent. The research aimed to quantitatively determine the spatial coverage of the network of the continent, its regions, and the two most advanced countries in terms of railways. The methodological basis of the research was the box-counting procedure, which allowed the quantification of the spatial coverage of the network using the fractal dimension. The analysis used the OpenRailwayMap digital database and FrakOut software, and a digital drawing board for the box-count procedure to ensure accuracy. The results highlighted the extremely low level of coverage of Africa's railway network. The value obtained for the entire African continent's fractal dimension is far below the Europe's value, reflecting the low level of area coverage of the network. The regional analysis also revealed significant infrastructural inequalities. The highest complexity was shown by the Southern African region and the Republic of South Africa's value, where the network density is already approaching the level of some Mediterranean European countries. In contrast, in North Africa the network is concentrated in the coastal area, while in West Africa the fragmented, tree-graph type structure dominates. Low values indicate a lack of real connectivity in most regions. The research findings can inform the African Union's integration programs in railway development strategies, helping to prioritize development and promote economic connectivity at the continental level.

Conflict of Interest

The authors hereby declare that they have no financial interest in this manuscript.

Notes on Contributor

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Timed Elastic Band Based Trajectory Planning and MPC Based Adaptive Cruise Control for Car-Like Autonomous Vehicle[1]

Alex Kádár [2]

Abstract:

This paper presents a hierarchical control architecture for a car-like autonomous vehicle. Lateral motion is handled by a Timed Elastic Band (TEB) local planner that repeatedly optimizes a short-horizon waypoint band, while steering is generated by a Pure Pursuit controller tracking the optimized local path. Longitudinal behaviour is governed by a model predictive control (MPC) based adaptive cruise control (ACC) that regulates speed and inter-vehicle distance in free-driving and car-following modes, explicitly respecting acceleration and braking limits and enforcing a minimum safety distance. Safety is addressed through constraint-aware planning and control: the TEB optimization penalizes proximity to obstacles and violations of lane boundaries using smooth penalty terms that support stable gradient-based updates, while the MPC-ACC embeds hard bounds and distance constraints to prevent unsafe following. The integrated stack is evaluated in representative driving scenarios, including lane keeping and car-following, and is benchmarked against the MathWorks Path Following Control System (PFCS) reference model to quantify tracking behaviour and constraint compliance under identical conditions.

Keywords:

Autonomous Vehicle; Timed Elastic Band; Steering Control; Model Predictive Control; Adaptive Cruise Control.

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1. Introduction

Autonomous road vehicles must generate collision-free motion while remaining stable, comfortable, and compliant with physical limits. This requirement becomes harder in everyday traffic because the environment is only partially known, other actors move unpredictably, and the feasible maneuver set is restricted by nonholonomic kinematics and actuator constraints. Practical systems therefore rely on repeated local re-planning and constraint-aware control that can react to new measurements without sacrificing dynamic feasibility.

A common and effective structure is a hierarchical separation of lateral and longitudinal tasks. Lateral motion is treated as a geometric path-following problem under steering constraints, while longitudinal motion is regulated to meet speed targets and safe headway constraints in free-driving and car-following modes. This separation reduces complexity, supports modular verification, and allows each loop to be tuned for the dominant safety risks it controls.

This paper presents a MATLAB/Simulink implementation of such a hierarchy in which a Timed Elastic Band (TEB) local planner optimizes a short-horizon band of waypoints, a Pure Pursuit controller tracks the resulting local reference, and a model predictive control based adaptive cruise control (MPC-ACC) regulates speed and distance. The safety rationale is explicit in both layers. The local planner is formulated as a constrained optimization that discourages trajectories that approach obstacles or violate lane boundaries and promotes smooth, dynamically feasible motion, reducing abrupt curvature and control spikes that can trigger loss-of-control events. The longitudinal MPC embeds hard bounds on acceleration and braking and enforces a minimum following distance, which directly targets the dominant rear-end collision mechanism in car-following scenarios. The combined effect is a system that prioritizes clearance, constraint compliance, and stable closed-loop behavior during continuous re-planning.

Performance is evaluated in representative lane-keeping and car-following scenarios and benchmarked against the MathWorks Path Following Control System (PFCS) reference model under comparable conditions to quantify tracking, constraint adherence, and safety-relevant behavior. Beyond the immediate technical contribution, the same safety-oriented local planning and predictive distance control paradigm can support advanced driver assistance and automation in regions where traffic is heterogeneous and infrastructure and enforcement are uneven, including many African road networks, with potential gains in crash reduction and transport efficiency when deployed within appropriate operational limits.

2. Literature Review on Steering and Acceleration Control

The vehicle dynamics literature commonly describes lateral motion using the bicycle model, where the vehicle is represented by a single front and a single rear wheel, and the key state variables are the lateral displacement, yaw angle, and their derivatives [1],

[2]. ISO 8855 defines the vehicle-fixed coordinate system widely used in automotive engineering, in which the x-axis denotes the longitudinal direction, the y-axis the lateral direction, and the z-axis the vertical direction. This convention forms the basis for defining path-tracking errors and for selecting the state variables used in bicycle-model formulations [1].

A large share of classical lane-keeping algorithms is geometric in nature. The Pure Pursuit method computes the required steering angle from the curvature of the circular arc defined by the current vehicle position and a look-ahead point, and it is widely used for path tracking of autonomous ground vehicles [3]. The Stanley controller combines lateral position error and heading error [4]. These methods offer simple implementation and robust operation, but they handle vehicle dynamic limits explicitly only to a limited extent.

Model-based linear controllers such as LQR, LQI, and LQG build on linearized forms of the bicycle model and compute the steering command by minimizing a quadratic cost function [2]. A key advantage of LQR and LQG-type solutions is that stability properties are well analyzable and adequate robustness can be achieved against parameter variations [8], [9]. More recent work extends the LQR structure using, for example, feedforward terms and iterative variants with soft constraints to improve tracking performance and passenger comfort [8], [9].

Nonlinear and MPC-based lateral controllers emerged to address higher-speed maneuvers and operation near tire friction limits. Nonlinear MPC schemes consider the full nonlinear bicycle model and also account for speed constraints, optimizing tracking behavior over a prediction horizon [10]. Such approaches are particularly effective for lane-change and obstacle-avoidance maneuvers, where lateral stability and accurate reference tracking are simultaneously critical [10].

Several approaches have been developed for local path planning. The Elastic Bands method treats the discrete path produced by a global planner as an energy-minimizing elastic band that continuously deforms according to nearby obstacles and the vehicle's kinematic constraints [5]. Timed Elastic Band (TEB) extends this concept by introducing an explicit time dimension and optimizing a trajectory between time-stamped path points while considering execution time, obstacle clearance, and kinematic and dynamic constraints [6]. In ROS-based environments, TEB has been extended specifically to differential-drive and car-like robots, making it suitable as a real-time local planner that can support the generation of steering commands [6].

Artificial potential field methods are also common for obstacle avoidance and local planning. Khatib's classical approach models the interaction between the robot and obstacles using virtual attractive and repulsive forces, whose resultant defines the desired motion direction [7]. Potential field methods enable reactive real-time behavior, but they suffer from local minima. MPC-based trajectory optimization provides a local planning framework that incorporates the vehicle dynamics model, path geometry, and obstacles directly into the optimization problem, and it can be used to generate a reference steering angle and or path curvature [10].

2.1 Longitudinal Acceleration Control and ACC Solutions

A classical starting point for longitudinal motion control is cruise control, which aims to maintain vehicle speed at a set reference, typically via PID control [2]. Adaptive Cruise Control (ACC) extends this concept by maintaining a safe following distance to the lead vehicle, often using a time-gap policy where the desired spacing is proportional to vehicle speed [2], [11].

Modern ACC implementations increasingly rely on model predictive control. MPC-based ACC formulations model the relative kinematics between the ego and lead vehicles in state-space form, where the state variables typically include spacing and relative velocity and may also include acceleration, while the control input is the ego vehicle acceleration [11], [12]. The objective function commonly combines spacing and speed tracking errors with penalties on acceleration and jerk, balancing comfort and safety requirements [12]. The MPC framework naturally supports explicit constraints on acceleration, speed, and minimum following distance, making it well-suited for practical implementation in embedded controllers [11], [13].

Many studies address switching between ACC operating modes (free driving, following, emergency braking) and adaptive selection of the reference speed and time gap according to traffic conditions. Alongside MPC-based approaches, alternative nonlinear control schemes are also used. Sliding-mode controllers provide strong robustness against model uncertainties and external disturbances, making them suitable for spacing-control tasks in both hybrid and conventional vehicles [14]. Fuzzy-logic ACC systems aim to capture driver experience in a rule base and achieve comfortable and safe motion by distributed regulation of speed and spacing [15]. Such systems are particularly popular on small experimental platforms and model vehicles due to their straightforward real-time implementation [15].

Neural and neuro-fuzzy approaches aim to handle the nonlinear nature of vehicle dynamics and traffic situations. For example, Takagi-Sugeno fuzzy-model-based ACC approximates longitudinal dynamics as a weighted combination of linear subsystems, enabling more effective handling of parameter variations and different speed ranges [16]. These methods often appear in combination with MPC or sliding-mode frameworks, enabling simultaneous treatment of hard constraints and robustness considerations.

2.2 Integrated Lateral and Longitudinal Control Architectures

Integrated control solutions aim to avoid treating lateral and longitudinal dynamics as independent subsystems and instead coordinate them within a single optimization problem. MPC-based integrated formulations define a predictive control task whose states include lateral tracking errors and longitudinal variables, while control inputs include steering angle and acceleration and, in some cases, braking force [17], [18]. This allows the controller to exploit the full maneuvering capability of the vehicle, for

example during emergency avoidance maneuvers where coordinated braking and steering is required [18].

Several works focus specifically on solving path tracking and speed control jointly within an MPC framework. Jeong and Yim present an integrated path-tracking and velocity-control algorithm that applies MPC to a vehicle with independent four-wheel steering and drive, improving tracking accuracy and stability through joint optimization of steering angle and drive torque [17]. Other studies target joint optimization of the future path and speed profile, for example via coupled lateral-longitudinal trajectory-tracking MPC schemes that treat vehicle motion as a single optimization problem [19].

In parallel, the literature contains a strong line of hierarchical structures, where a higher-level module plans a global or local trajectory and lower-level lateral and longitudinal controllers track it [18]. The advantages of the hierarchical approach include transparency, modularity, and the possibility of developing and replacing controllers with partial independence. Integrated MPC solutions, however, often deliver better performance near operating limits, where the coupling between steering and acceleration can no longer be neglected [17], [19].

The architecture applied in this paper belongs to the hierarchical category. On the lateral side, it uses a TEB-based local planner and a geometric Pure Pursuit steering controller, while on the longitudinal side, an MPC-based ACC computes the acceleration command. This structure can be positioned between established hierarchical and integrated approaches: the separation between planning and control is retained, while the ACC controller already applies model predictive principles to handle longitudinal constraints and comfort criteria, thereby partially approaching integrated MPC-based solutions.

3. Methodology and Simulation Environment

The study was conducted in MATLAB and Simulink, relying on the Automated Driving Toolbox and the Driving Scenario Designer. The Driving Scenario Designer was used to define the road environment, lane geometry, and the motion of surrounding vehicles. Within each scenario, lane markings, road curvature geometry, and the ego vehicle's reference trajectory can be specified parametrically, and the simulation model uses these signals as inputs to the TEB-based local trajectory planner.

The Simulink model follows a hierarchical architecture. At the top level, the Driving Scenario Designer generates position and velocity data that are provided to the ego-vehicle and surrounding-vehicle blocks. Building on these signals, the framework integrates the TEB trajectory planner, a Pure Pursuit based lateral controller, and an MPC-based ACC longitudinal controller. The vehicle-kinematics subsystem encapsulates both the kinematic bicycle model and the longitudinal motion model, while the feedback states are updated at every sampling instant.

The investigated scenarios can be categorized into three main groups:

- lane keeping on a curved road, where the ego vehicle autonomously tracks the lane centerline,
- straight-line car-following, where the ego vehicle regulates its speed and following distance relative to a preceding vehicle,
- a complex multi-vehicle case featuring multiple lanes, lane changes, and overtaking maneuvers, where the ego vehicle must adapt to varying traffic situations.

Identical baseline vehicle parameters and the same sampling time were used in all cases, enabling a direct comparison of the architecture's behavior across different situations.

3.1 Vehicle Model

A kinematic bicycle model is used to describe lateral motion. The vehicle is represented by a single front and a single rear wheel in a coordinate system defined along the vehicle's longitudinal axis. The state vector comprises the global position (x, y) and the vehicle orientation (θ), augmented by the longitudinal speed (v). The model inputs are the steering angle (δ) and the longitudinal acceleration (a). Together with the geometric parameters, most importantly the wheelbase (b), the kinematic bicycle model ensures that the trajectory generated by the TEB planner remains physically feasible for the ego vehicle.

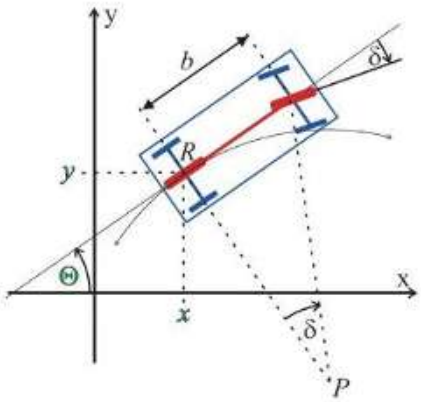


Figure 1: Car-like vehicle [20].

Kinematic model:

$$\dot{\boldsymbol{q}} = \begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\theta} \\ \dot{v} \end{bmatrix} = \begin{bmatrix} v \cdot \cos\theta \\ v \cdot \sin\theta \\ v \cdot \frac{\tan\delta}{b} \\ a \end{bmatrix} \tag{1}$$

Constraints that are relevant due to vehicle geometry and the control task are enforced within the model as well. The steering angle is limited in magnitude by a maximum value consistent with the steering geometry of a car-like vehicle, set to 40°. The longitudinal acceleration is bounded by lower and upper limits representing braking and acceleration capabilities; these bounds are also chosen to remain realistic with respect

to passenger comfort and tire-road adhesion. In this work, the acceleration limits are set to -8 and 5 m/s^2.

3.2. TEB-Based Lateral Trajectory Planning

Timed Elastic Band (TEB) [21] is a modern, dynamic local planning algorithm widely used in robotics and autonomous vehicles for motion planning and navigation. Its primary objective is to enable the vehicle to progress safely and efficiently along a planned route in dynamic environments, including moving obstacles and rapidly changing conditions.

TEB represents the motion to be executed along the roadway or during a lane-change maneuver by a discrete sequence of trajectory points with an associated temporal parameterization. A fixed number of geometric path points (n) is initialized along a reference curve. This initial "band" is then iteratively deformed by an optimizer while keeping the start state fixed. Figure 2 illustrates the resulting TEB band.

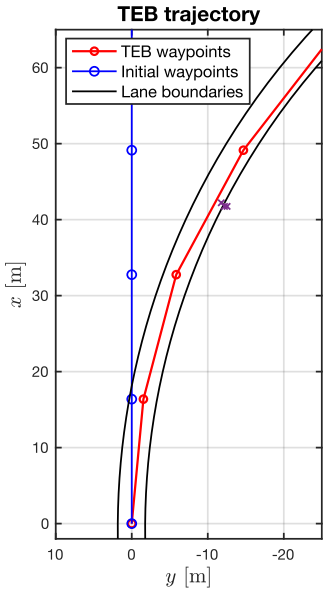


Figure 2: Formulation of the TEB points.

The band is defined by two coupled structures. First, a set of trajectory points

$$Q = \{P_i\}_{i=1\ldots n} \tag{2}$$

describes the ego vehicle position via

$$P_i = (x_i, y_i). \tag{3}$$

Second, a set of time intervals associated with consecutive points

$$\tau = \{\Delta T_i\}_{i=1\ldots n-1} \tag{4}$$

is introduced. Together, these two sets capture both the geometric shape of the path and its temporal parameterization; therefore, the TEB can be interpreted as the pair

$$B := (Q, \tau). \tag{5}$$

The planner operates in a receding-horizon manner: in each control cycle, the current ego-vehicle state becomes the new start point of the band, and the planning horizon is shifted forward along the lane.

The optimal TEB band is obtained by minimizing a cost function. The objective formulation allows the inclusion of parameters that constrain vehicle motion, such as obstacle avoidance and lane keeping. The overall cost is expressed as the weighted sum of all objective terms:

$$f(B) = \sum_k w_k \ \Gamma_k(B) \tag{6}$$

where Γ_k denotes the objective term encoding a specific motion constraint and w_k is its weight relative to the others. The optimal trajectory B^* is then obtained as

$$B^* = var \min_B f(B) \tag{7}$$

3.2.1. Objective Functions and Constraint Terms

The optimal trajectory is collision-free while exhibiting the smallest possible lateral accelerations; that is, it corresponds to the smoothest feasible collision-avoiding path available to the vehicle. Collision avoidance can be expressed through constraint terms that exclude any configuration in which the vehicle would collide with an obstacle or cross lane boundaries. For gradient-based optimization methods, a smooth, continuously differentiable penalty function is particularly advantageous because it provides well-behaved derivatives with respect to the trajectory states.

A generalized limit function can be formulated, for example, in the following form:

$$f_{limit}(z, z_m, \epsilon, S, n) = \begin{cases} 0 & for\ z \le (z_m - \epsilon) \\ \left(\frac{z-(z_m-\epsilon)}{S}\right)^n & for\ z > (z_m - \epsilon) \end{cases} \tag{8}$$

where z is a scalar "distance-like" quantity (for instance, the perpendicular distance to an obstacle or the lateral deviation from the lane centerline), z_m is a critical threshold, ϵ is a small safety margin, and S and n are parameters that control the scale and steepness of the penalty.

Using the generalized limit function above, the obstacle-avoidance objective term is defined as

$$\Gamma_{o,\text{limit}} = f_{\text{limit}}(-d_0, -d_{\text{limit}}, \epsilon_o, S_o, n_o) \tag{9}$$

where d_0 denotes the perpendicular distance between two TEB trajectory points and an obstacle, and d_{limit} specifies the minimum allowable clearance from the obstacle.

Lane keeping can be enforced in an analogous manner using limit functions. Let y be the lateral deviation of a TEB waypoint from the lane centerline and let y_{min} and y_{max} denote the lateral coordinates of the right and left lane boundaries, respectively. The corresponding lane-related objective terms are:

$$\Gamma_{Ll,limit} = f_{limit}(y, y_{max}, \epsilon_L, S_L, n_L) \tag{10}$$

$$\Gamma_{Lr,limit} = f_{limit}(-y, -y_{min}, \epsilon_L, S_L, n_L) \tag{11}$$

Together, $\Gamma_{o,\text{limit}}$, $\Gamma_{Ll,\text{limit}}$, and $\Gamma_{Lr,\text{limit}}$ provide a compact representation of obstacle-clearance and lane-boundary requirements within the TEB optimization. The aggregated constraint objective can therefore be written as:

$$f(B) = w_o \cdot \Gamma_{o,limit}(B) + w_L \cdot [(\Gamma_{Ll,limit}(B) + \Gamma_{Lr,limit}(B)] \quad (12)$$

where w_o and w_L are weighting factors.

The hyperparameters must be selected such that the vehicle follows the lane centerline with minimal tracking error while maintaining collision-free motion, and such that excessive steering intervention is avoided for passenger comfort. Based on testing, the following parameter values were found to provide satisfactory performance:

$$\epsilon_o = 0.154, \quad S_o = 0.96, \quad n_o = 2.8, \quad w_o = 1.5$$
$$\epsilon_L = 0.088, \quad S_L = 1.20, \quad n_L = 1.2, \quad w_L = 5$$

3.3. Pure Pursuit Based Angle Generation

In the implemented TEB algorithm, the local path at each time instant is represented by a fixed number of five waypoints expressed in the ego-vehicle coordinate frame. The first point always coincides with the current vehicle position, which corresponds to [0,0] in the ego frame, while the remaining four points are placed ahead along the vehicle's longitudinal axis. Since the TEB is regenerated at every sampling step around the current pose, the vehicle effectively needs to align with the next point in the sequence, that is, the second TEB waypoint. Therefore, the reference heading is determined from the direction between the first and the second points. The corresponding direction angle can be computed using the $atan2$ function:

$$\theta = atan2(y_2 - y_1,\ x_2 - x_1) \quad (13)$$

where $(x_1, y_1) = (0,0)$ is the current ego position, and (x_2, y_2) are the coordinates of the second TEB point. This provides a reference heading angle θ for the vehicle. However, tracking this heading angle alone is not sufficient. The steering command must be computed such that, taking the kinematic bicycle model geometry and the wheelbase into account, the vehicle reaches the desired waypoint within a specified look-ahead distance. In practice, this task is handled by the Pure Pursuit algorithm, which is a geometric path-tracking method.

The core idea of Pure Pursuit [3] is that the vehicle tracks a predefined target point (look-ahead point) located on the path at a fixed distance ahead. From the current position, the vehicle attempts to reach this target as if it were traveling along a circular arc. Accordingly, the steering angle is chosen such that the vehicle would follow a circle whose arc intersects the target point. In the vehicle coordinate frame, the target point is given by (x, y), and the look-ahead distance is $L_d = \sqrt{x^2 + y^2}$. Using the angular deviation θ relative to the vehicle's heading, the desired curvature can be computed as:

$$\kappa = \frac{2 \cdot sin(\theta)}{L_d} \quad (14)$$

The steering angle δ is then obtained as:

$$\delta = arctan(b \cdot \kappa) \quad (15)$$

where b denotes the wheelbase. The computed steering command, optionally scaled by a gain factor, is subsequently saturated according to the allowable steering limits. Figure 3 illustrates the geometric construction underlying the Pure Pursuit method.

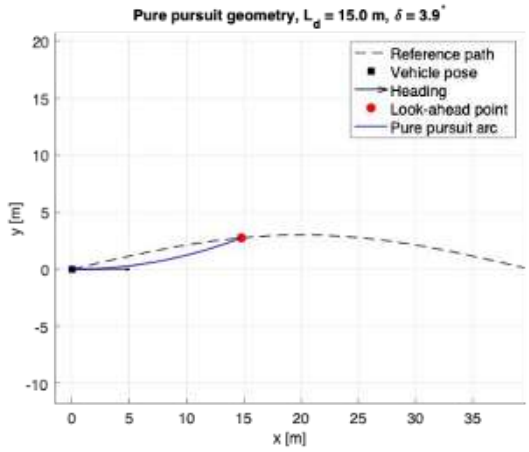


Figure 3: Pure Pursuit geometry.

3.4 MPC-Based Adaptive Cruise Control

Model Predictive Control (MPC) [12] is an advanced control method that computes the control input in a predictive manner using a dynamic model, such that future outputs track reference values while respecting constraints. The core principle of MPC is that, at every sampling instant, it solves a finite-horizon optimization problem based on the system model. Over a predefined prediction horizon, an optimal sequence of control inputs is computed by minimizing a cost function subject to operational constraints. Within this receding-horizon strategy, only the first control input of the optimized sequence is applied to the system; at the next sampling instant, the entire procedure is repeated using the updated current state. As a result, MPC can anticipate the system's behavior and respond to predicted disturbances or reference changes before they occur, unlike conventional PID controllers.

The MPC-based adaptive speed and distance control algorithm aims to regulate both the ego vehicle speed and its headway to a preceding vehicle:

Following (ACC) mode: If a preceding vehicle (lead vehicle) is present, the MPC controls the ego-vehicle acceleration to maintain a safe following distance. The desired spacing is defined using a time-gap policy with headway time T_h and a minimum standstill distance d_0. The reference distance is $d_{\text{ref}} = d_0 + T_h v_{\text{ego}}$, where v_{ego} denotes the current speed of the ego vehicle.

Free (Cruise) mode: If there is no slower vehicle ahead of the ego vehicle, the controller maintains a driver-defined target speed (v_{set}). In this mode, the MPC is responsible for reaching and sustaining the desired speed while respecting the vehicle's dynamic constraints.

In the implementation, the MPC optimization problem is formulated and solved at each time step using YALMIP [22]. YALMIP is a MATLAB-based modeling environment that enables a declarative specification of the decision variables, objective function, and constraints of an optimization problem, and then automatically converts the formulation into a solver-compatible numerical form. The outcome of the optimization

is the acceleration command (a_{cmd}) to be applied immediately, which determines the throttle and braking actuation of the vehicle.

Accurate MPC computation requires several components to be defined precisely. First, a discrete-time state-space model is needed, built around a state vector that captures the following distance and the vehicle speed. This is paired with a quadratic cost function that penalizes following-distance error, speed deviation, and control effort. In addition, constraints must be specified to represent the physical acceleration limits of the vehicle and the minimum permissible following distance. Finally, selecting the prediction horizon N and the sampling time T_s completes the control problem specification. The following subsections detail these elements: the state-space model formulation, the structure of the cost function and the constraints, and how these components are integrated into the YALMIP-based MPC formulation.

3.4.1 Dynamic Model and State Variable Definition

For the car-following mode, three states are defined:

1. gap: the distance between the ego vehicle and the preceding (lead) vehicle, that is, the longitudinal spacing. This is computed from the difference between the vehicle positions while accounting for vehicle geometry, corresponding to the actual distance between the front of the ego vehicle and the rear of the lead vehicle.
2. v: the longitudinal speed of the ego vehicle.
3. z: an integrator state used to compensate for offset (steady-state error). This allows the system to maintain the target following distance or speed reference accurately over time by eliminating residual error.

The longitudinal motion of the ego vehicle and the spacing dynamics are approximated by an affine discrete-time state-space model with sampling time Δt. In following (ACC) mode, the model can be written in the form:

$$x_{k+1} = Ax_k + Ba_k + c \tag{16}$$

where the state vector is $x := [gap \quad v \quad z]^T$, the control input a_k is the ego-vehicle longitudinal acceleration (positive for acceleration and negative for braking), and c is an exogenous term capturing the influence of the lead vehicle speed. The corresponding matrices are:

$$A = \begin{pmatrix} 1 & -\Delta t & 0 \\ 0 & 1 & 0 \\ \Delta t & -T_h\,\Delta t & 1 \end{pmatrix}, \qquad B = \begin{pmatrix} 0 \\ \Delta t \\ 0 \end{pmatrix}, \qquad c = \begin{pmatrix} \Delta t\, v_{\text{lead}} \\ 0 \\ 0 \end{pmatrix} \tag{17}$$

Component-wise interpretation:

Spacing dynamics (gap): The first row of the state update, together with the term c, updates the spacing state:

$$gap_{k+1} = gap_k + \Delta t(v_{\text{lead}} - v_k) \tag{18}$$

Here, v_{lead} is the speed of the lead vehicle, and v_k is the current ego speed. The equation expresses that the gap increases when the lead vehicle moves faster than the ego vehicle and decreases when the ego vehicle moves faster. Accordingly, the $-\Delta t$ coefficient in

the first-row models the effect of ego speed, while the $\Delta t v_{\text{lead}}$ term in c adds the contribution of the lead vehicle speed.

Speed dynamics (v): The second row of the model captures the ego-vehicle speed evolution:

$$v_{k+1} = v_k + \Delta t\, a_k \tag{19}$$

where a_k is the acceleration commanded by the controller. This indicates that the new speed equals the previous speed plus the change induced by acceleration integrated over the sampling interval.

Integrator dynamics (z): The third row updates the integrator state as:

$$z_{k+1} = z_k + \Delta t\,(gap_k - T_h\, v_k) \tag{20}$$

This shows that z integrates over time the difference between the actual spacing and the speed-proportional spacing term ($T_h\, v_k$). The purpose is offset-free tracking: z is effectively the integral of the dynamic spacing error. For example, if the ego vehicle is too close (the actual gap is smaller than $T_h v$), the integrator evolves accordingly, encouraging the controller to reduce acceleration or apply braking. It is important to note that the constant standstill distance term d_0 is not embedded directly in the integrator dynamics. Instead, d_0 appears as part of the reference distance. This is necessary because directly integrating a constant (nonzero) error contribution would introduce an undesirable drift in the integrator state. As formulated, z integrates only the speed-dependent component of the spacing error, ensuring that no persistent error remains in following distance under dynamic conditions.

In summary, the matrices A, B, c define the predictive model used to forecast the evolution of spacing and speed over the next N steps for a given sequence of acceleration inputs. Model parameters include the time headway T_h (default value 3 s) and the discrete step Δt (100 ms), both of which directly affect the state-transition matrix A.

Free (No-Lead) Mode Model: When no lead vehicle is present, the spacing state and its dynamics are no longer meaningful, because the ego vehicle can accelerate freely up to the set speed. In this case, the model reduces to a two-state system:

$$x_f = [v \quad z_v]^T \tag{21}$$

that is, only the ego speed and an integrator state for the speed error are retained. The discrete-time state-space model for free-driving mode is:

$$A_f = \begin{pmatrix} 1 & 0 \\ \Delta t & 1 \end{pmatrix}, \qquad B_f = \begin{pmatrix} \Delta t \\ 0 \end{pmatrix}, \qquad c_f = \begin{pmatrix} 0 \\ -\Delta t\, v_{ref} \end{pmatrix} \tag{22}$$

where c_f injects the reference speed into the integrator dynamics. Since v_{ref} is a constant desired value, its discrete integral appears as $-\Delta t\, v_{ref}$). In component form, the free-mode update equations are:

$$v_{k+1} = v_k + \Delta t\, a_k \tag{23}$$

$$z_{v,k+1} = z_{v,k} + \Delta t\,(v_k - v_{ref}) \tag{24}$$

Here v_{ref} is the desired speed (the driver-defined v_{set}). The integrator state z_v accumulates the speed error (current speed minus reference), ensuring that the cruise-

control behavior maintains the set speed accurately in steady state, without residual speed error.

3.4.2 MPC Cost Function

At each time step, the MPC controller solves an optimization problem that minimizes a predefined cost function. This cost function numerically encodes the desired system objectives and penalizes undesired behavior. In the present case, the cost consists of multiple terms, each weighting a specific aspect: following-distance error, speed error, the integrator state, the magnitude of the control input, and the variability of the control input.

The stage cost summed over the horizon steps $k = 1 \dots N$ includes the following components:

Following-distance error (weight: Q_{gap}):

$$Q_{gap}\left(gap_k - (d_0 + T_h\, v_k)\right)^2 \tag{25}$$

This term penalizes deviations of the instantaneous following distance gap_k from the reference distance $d_0 + T_h v_k$. A larger Q_{gap} forces the optimizer to prioritize maintaining the desired spacing.

Speed error (weight: Q_v):

$$Q_v\left(v_k - v_{\text{ref},k}\right)^2 \tag{26}$$

This term measures the deviation of vehicle speed from a reference speed v_{ref}. The interpretation of the reference depends on whether a lead vehicle is present:

Following mode: $v_{ref,k} = v_{lead}$, the speed of the lead vehicle. In this case, the cost penalizes relative speed, that is, situations where the ego vehicle is moving too fast or too slow compared to the lead vehicle. In practice, the reference speed is also bounded by the set cruise speed: if $v_{lead} > v_{set}$, the vehicle does not attempt to match the lead vehicle speed but instead tracks the user-defined set speed.

Free mode: $v_{ref} = v_{set}$, the predefined desired speed. The cost then represents speed-tracking error, and the controller minimizes it to drive v_k toward v_{set}.

Integrator state penalty (weight: Q_I):

$$Q_I\, z_k^2 \tag{27}$$

In free mode, the corresponding term is $Q_I\, z_{v,k}^2$. This term penalizes the squared integrator state. Here, z_k is the integrated (accumulated) dynamic spacing error, while $z_{v,k}$ is the integral of the speed error. The role of this penalty is to encourage the integrator state to converge toward zero, thereby removing steady-state error. In this work, the same Q_I weight is applied to the integrator state in both following and free modes, ensuring comparable steady-state error suppression across operating conditions.

Acceleration command magnitude (weight: R):

$$R\, a_k^2 \tag{28}$$

This regularization discourages unnecessarily large acceleration commands. Physically, it leads to more comfortable actuation by avoiding overly aggressive throttle or braking

when it is not required. If R is too small, the MPC may issue very large accelerations for short intervals to reduce other errors. If R is too large, the controller can become overly conservative and respond insufficiently to spacing or speed errors.

Jerk penalty, i.e., change in acceleration (weight: S_{jerk}):

$$S_{\text{jerk}}\,(a_k - a_{k-1})^2 \tag{29}$$

applied for each $k > 1$. This term penalizes variability in the acceleration command and promotes smooth actuation. By penalizing jerk, the MPC avoids abrupt switching between acceleration and braking, which improves both ride comfort and closed-loop stability. If S_{jerk} is large, the controller tends to select a more gradual acceleration profile, even if that implies slower correction of other errors.

Terminal integrator penalty (weight: Q_{IN}):

$$Q_{IN}\,z_N^2 \tag{30}$$

In free mode, the corresponding term is $Q_{IN}\,z_{v,N}^2$. This penalizes the integrator state at the final horizon step. Its purpose is to encourage the MPC to plan toward zero integrated error by the end of the horizon. The terminal weight enforces the zero steady-state error requirement without forcing an excessively large integrator penalty at earlier steps. The same terminal weight Q_{IN} is used in both following and free modes, so the end-of-horizon zero-error requirement is enforced with comparable strength in both cases.

The full-horizon MPC cost function can therefore be written as:

$$J_{MPC} = \sum_{k=1}^{N} \Big[Q_{\text{gap}} \left(gap_k - (d_0 + T_h v_k) \right)^2 + Q_v \left(v_k - v_{ref,k} \right)^2 + \\ + Q_I\, z_k^2 + R\, a_k^2 + S_{\text{jerk}}\,(a_k - a_{k-1})^2 \Big] + Q_{IN}\, z_N^2 \tag{31}$$

The effect of the MPC weighting factors was analyzed through a targeted parameter study. Starting from a baseline configuration, the weights Q_{gap}, Q_v, R, and S_{jerk} were varied systematically. The integrator-related weights were kept constant in all cases, specifically $Q_I = 0.1$and $Q_{IN} = 10$.

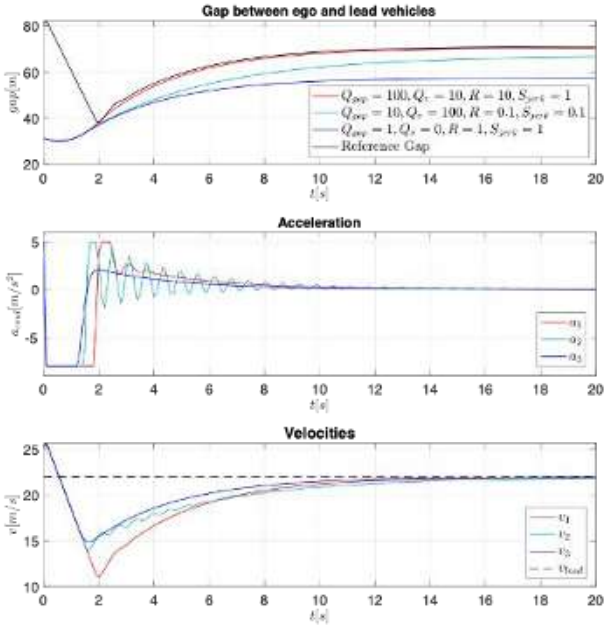


Figure 4: MPC testing under different parameter settings.

Figure 4 illustrates MPC behavior under different parameter settings. The figure was generated in a simulation in which the ego vehicle had to follow a slower vehicle on a straight road at a safe distance, with overtaking prohibited. In the upper plot, the ideal following distance as a function of ego speed is shown by the black curve. The simulation with tuned parameters corresponds to the red curves, where the vehicle reaches the desired following distance after approximately 15 seconds. The dark-blue case represents a configuration with very small weights, where the controller becomes overly sluggish and does not optimize sufficiently to achieve the required following distance; in contrast, it still tracks the lead vehicle speed (black dashed line). The green-shaded case shows a configuration in which jerk is hardly penalized, leading to oscillations in both acceleration and vehicle speed.

For the final ACC settings used in this paper, the weight vector corresponding to the red curves in Figure 4 was selected:

$$Q_{\text{gap}} = 100, \quad Q_v = 10, \quad R = 10, \quad S_{\text{jerk}} = 1, \quad Q_I = 0{,}1, \quad Q_{IN} = 10.$$

This combination provided a practical trade-off: the following distance approaches the reference curve quickly without overshoot, the speed profile matches the lead vehicle well, and the acceleration signal does not exhibit persistent large-amplitude oscillations, making the maneuver acceptable from a passenger-comfort perspective.

3.4.3 Constraints and Safety Conditions in the MPC

In real-world operation, vehicle dynamics and safety requirements impose constraints on the controller that must be respected within the MPC optimization. The following linear constraints are included.

Acceleration bounds: For each time step, lower and upper limits are imposed on the acceleration command:

$$a_{min} \leq a_k \leq a_{max}, \quad \forall k = 0 \dots N-1 \tag{32}$$

The default values are $a_{min} = -8\ {}^{m}/_{s^2}$ and $a_{max} = 5\ {}^{m}/_{s^2}$. The key point is that the controller must remain within this range and cannot request stronger braking or acceleration than permitted by these bounds. This constraint models the system's physical limitations (maximum engine force, maximum braking force, tire-road adhesion, etc.). Also, it supports safety and comfort, since excessive deceleration or acceleration can be unsafe or uncomfortable for passengers.

Minimum following distance (collision avoidance): For every k, the spacing is constrained such that

$$\text{gap}_k \geq d_0 - \delta \tag{33}$$

where d_0 is the minimum safety distance (default value 5 m), and δ is an optional slack allowance. For example, if $\delta = 0.5$ the condition becomes $\text{gap}_k \geq 4.5$ m. By default, $\delta = 0$ meaning a hard constraint is enforced. This constraint ensures that the MPC cannot plan a trajectory that would lead to a collision; that is, the ego vehicle cannot approach the lead vehicle closer than the minimum safety distance.

At each sampling instant, the controller checks whether a valid lead vehicle exists ahead of the ego vehicle. If an object is detected in front of the ego vehicle within the lane and within the relevant range, the MPC switches to following mode. If no such lead vehicle exists (no detection, or the previously tracked lead vehicle leaves the defined range), the controller switches to free mode.

Based on the model and cost function above, the MPC optimization problem can be formulated as a quadratic program: the objective is quadratic, while the dynamics and constraints are linear. Using the YALMIP framework, the required control input can be computed at each time step.

4. Simulation Results

The objective of this chapter is to experimentally validate the behavior of the integrated system in controlled, reproducible simulations. The simulation environment is introduced, alongside the investigated case types: pure lane keeping, multi-lane overtaking, and longitudinal car-following under varying traffic conditions.

In the simulations, the proposed TEB + Pure Pursuit + MPC-ACC architecture and the Path Following Control System (PFCS) reference model were executed using identical road geometry and the same lead-vehicle trajectory. This setup enables a direct comparison of lateral path-following performance and longitudinal following behavior. The simulations were run on an Apple MacBook Pro M3 Pro laptop, and the runtime was also evaluated. Here, runtime refers to the total wall-clock time of a simulation run, including scenario initialization and execution of the control algorithms, but excluding model compilation time.

4.1 Lane Keeping

The purpose of this experiment is to evaluate lane-keeping performance on a curved road segment. The track is a closed loop with varying curvature. The vehicle operates in its own coordinate frame, and all sensor and planner-module signals are interpreted in ego coordinates. During the simulation, the ego vehicle traveled at a constant speed of 100 km/h (27.78 m/s).

Trajectory planning was performed using the Timed Elastic Band approach. As an initial guess, a small set of seed points is placed along a straight line; the TEB cost function then deforms these points to match the actual lane geometry while accounting for lane-boundary constraints and smoothness requirements.

Lane-keeping quality is characterized by the lateral deviation and its root-mean-square (RMS) error. The lane width is 3.6 m; subtracting the ego vehicle footprint yields the admissible lateral bounds within which the vehicle must remain when treated as a point for this evaluation. In this case, the lateral deviation was required to stay within $[-0.9, 0.9]$ m. The safe lane boundaries are therefore indicated by the ± 0.9 m limits, as shown in the "Lateral Deviation" plot.

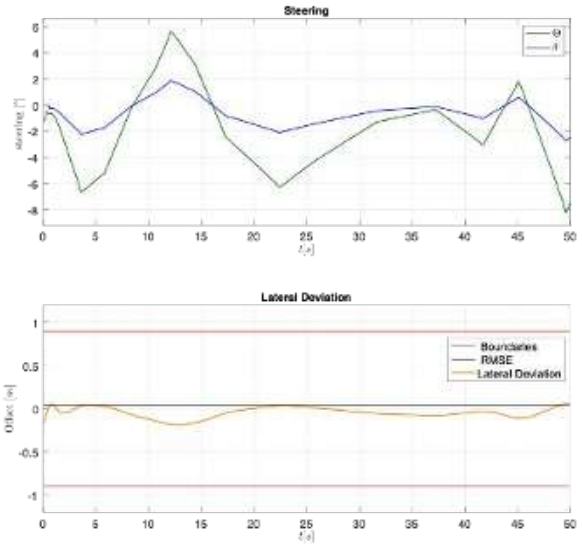


Figure 5: Steering angle and lateral deviation response.

Figure 5 presents the simulation results. The upper panel shows the evolution of the steering angle over time. The Pure Pursuit controller effectively aligns the steering command with the TEB waypoints, and the vehicle remains within the lane boundaries throughout the simulation. The lower panel shows the lateral deviation, which remains within geometrically admissible bounds, with a slight maximum deviation from the lane centerline (19 cm).

4.2 Testing the Adaptive Cruise Control

To evaluate the performance of the adaptive cruise control (ACC), a simulation environment was constructed in which the ego vehicle travels along a long, straight road

segment with strictly in-lane motion. The test road features continuous solid lines on both sides; therefore, lane changes are prohibited throughout the simulation. This setup eliminates lateral maneuvers, allowing the assessment to focus exclusively on longitudinal control quality. The MPC-based ACC controls the ego vehicle described earlier, incorporating a 3-second headway policy and the vehicle's dynamic acceleration and braking limits.

The traffic scenario includes a single preceding vehicle (lead vehicle) following a predefined speed profile. Initially, the lead vehicle travels more slowly than the ego vehicle. It then decelerates and accelerates in multiple phases, finally settling at a moderate speed. This creates realistic, continuously changing conditions for evaluating the spacing response. During the simulation, the ACC must maintain the desired time-gap distance by adapting to the lead vehicle's instantaneous speed and acceleration, avoiding excessive acceleration and braking, and ensuring collision-free motion.

The results can be summarized through three key characteristics. Figure 6 shows the evolution of the actual inter-vehicle distance together with the reference following distance targeted by the MPC. After the transient phase, the controller maintains the gap close to the reference. During acceleration and deceleration intervals, the spacing does not enter a critical range, and no sustained under-following occurs. The middle plot shows the speed profiles of the ego and lead vehicles and illustrates that the ACC gradually aligns the ego speed with the lead vehicle's speed while avoiding abrupt speed changes. The bottom panel shows the acceleration command generated by the MPC; after the initial settling phase, the actuation remains predominantly continuous with a small amplitude, supporting comfortable, physically realistic behavior.

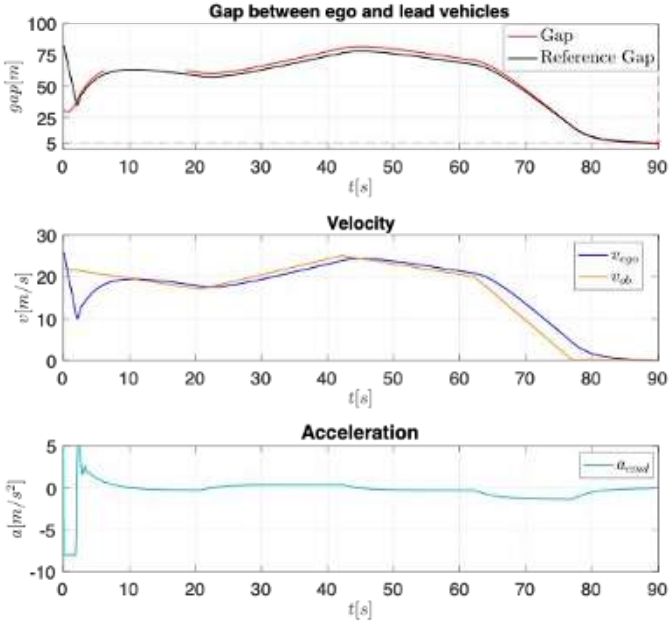


Figure 6: ACC simulation results.

The most critical segment of the simulation is the final emergency-braking maneuver, in which the lead vehicle decelerates to zero in a short time. In this situation, the MPC-based ACC applies progressively stronger braking as required, and the ego vehicle comes to a stop while maintaining an inter-vehicle distance of approximately 5 m. This indicates that, even under the imposed dynamic constraints, the controller can ensure a safe stop without collision while maintaining spacing within the defined safety envelope throughout the maneuver.

4.3 Lane Following in the Presence of Obstacles

This experiment considers a two-lane curved road segment. The ego vehicle travels in the outer lane while multiple vehicles appear ahead with different speed profiles. In certain sections, the lane markings are dashed; therefore, overtaking is permitted in principle. The ego vehicle follows the waypoints generated by the TEB-based planner, while longitudinal motion is governed by the MPC controller, which applies the 3-second time-headway policy.

4.3.1 Simulation Procedure

1. A slower vehicle moves into the ego vehicle's path in the outer lane. In the overtaking lane, a car approaches from behind at high speed and passes the ego vehicle, therefore a lane change cannot be initiated yet.
2. Once the higher-speed vehicle in the inner lane has passed the ego vehicle and reached a safe distance ahead, the lane change is initiated.
3. Traffic in the left lane is locally faster, therefore the MPC transitions to the set-speed target, since the lead vehicle is significantly quicker and outside the relevant following-distance range.
4. The speed of the lead vehicle in the inner lane decreases, so the ego vehicle merges back into the original outer lane.
5. Near the end of the segment, the lead vehicle performs an emergency braking maneuver and comes to a complete stop. The ACC applies the kinematic braking limit, and the ego vehicle stops safely within the targeted standstill spacing. During the emergency stop at the end of the segment, the TEB-based planner does not generate an evasive maneuver because the scenario provides no adjacent lane into which the vehicle could legally and safely move; therefore, the only admissible solution is a safe stop. If a situation arose in which the ego vehicle could not stop in time even when respecting the braking limit, the TEB optimization would, through the cost function, search for an alternative laterally shifted path and attempt to find a collision-minimizing trajectory, provided that lane geometry and traffic rules allow such a maneuver.

4.3.2 Simulation Evaluation

Gap between ego and lead vehicles: The upper part of Figure 7 shows the time evolution of the measured gap and the reference gap. In the final segment, when the

lead vehicle comes to a stop, the gap decreases monotonically while tracking the reference curve.

Steering: The steering-related plots indicate that, during fast lane-change transitions, the TEB-generated path induces larger and more abrupt lateral commands (θ), which are then smoothed by the Pure Pursuit controller (δ). After the maneuver is completed, the controller returns to a small-amplitude, damped behavior.

Acceleration: The lower plot shows the acceleration response. The signal reaches saturation at multiple points where the MPC enforces the braking constraint, which would be perceived as a strong jerk by passengers in a real vehicle. These large amplitudes and high jerk values result from a weight selection in the cost function that prioritizes safety and spacing accuracy over comfort. In the final segment, the acceleration remains negative, resulting in braking to a complete stop.

Lateral deviation: The lateral deviation remains within the lane boundaries throughout the scenario, showing brief peaks during lane-change transitions before settling back close to the lane centerline.

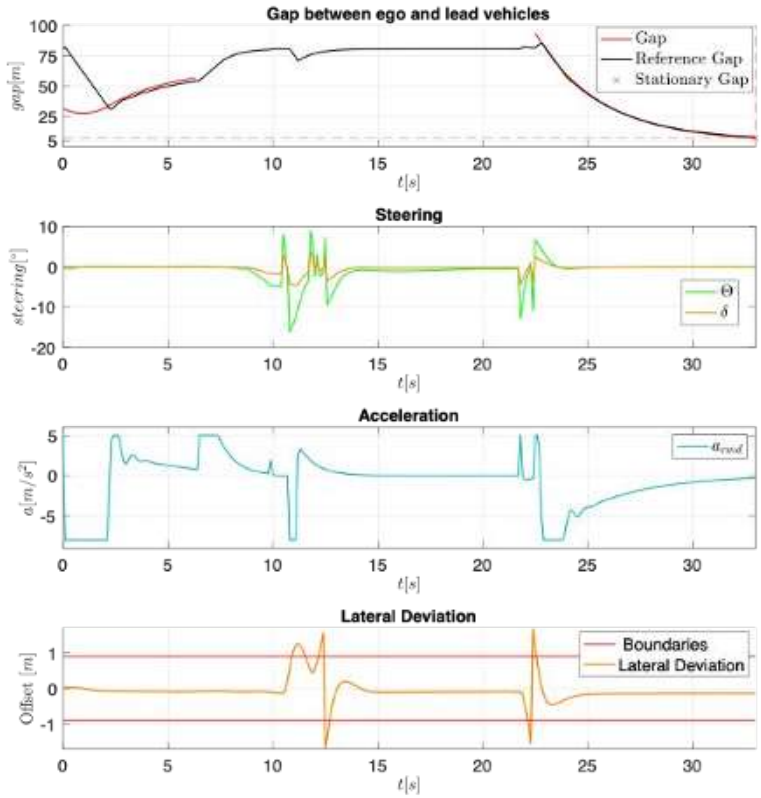


Figure 7: Simulation results in a complex environment.

4.3.3 Summary of Results

At all times, the ego vehicle selected a trajectory that remained compliant with lane-admissibility constraints. The ACC maintained the 3-second time-headway policy throughout the scenario. In the final segment, when the lead vehicle came to a complete

stop, the ego vehicle safely decelerated to a standstill, reaching a final standstill spacing of approximately 5 m.

4.3.4 Interpretation

The presented case illustrates the interaction between the TEB-based planner and the ACC. The TEB searches for lane-change opportunities with comparatively aggressive lateral intent, while the longitudinal dynamics ultimately remain constrained by the ACC limits. Together, this yields a conservative maneuvering behavior that primarily preserves safe following.

4.4 Comparison of TEB+MPC and the Path Following Control System

The Path Following Control System (PFCS) is a MATLAB/Simulink reference model that provides integrated lateral and longitudinal control for a car-like vehicle. The block follows a predefined reference path, typically the lane centerline, and uses nonlinear MPC to compute steering-angle and longitudinal-acceleration commands while ensuring the desired speed tracking and maintaining the headway to a lead vehicle. However, PFCS does not perform independent obstacle-avoidance planning or plan lane-change maneuvers; it focuses exclusively on motion along the prescribed path and on car-following behavior.

The two control architectures were compared on the same scenario using five runs, based on average runtime and lane-keeping accuracy. The proposed TEB+MPC system achieved an average runtime of 10.193 s, whereas PFCS required 13.355 s. Thus, the TEB+MPC approach reduced simulation runtime by approximately 24%. This difference indicates that combining TEB-based local planning with a separate MPC-ACC longitudinal controller imposes a lower computational burden than the fully integrated PFCS solution in this setup.

Lateral tracking accuracy was compared using RMSE relative to the lane centerline. For TEB+MPC, the lateral RMSE was 0.026 m, while for PFCS it was 0.021 m. This indicates that PFCS kept the lane centerline slightly more accurately; however, the difference is on the order of millimeters and is negligible in practical terms. A key distinction is that PFCS is limited to lane-center tracking and car-following and does not perform lane changes for obstacle avoidance. In contrast, the TEB+MPC architecture can execute lane-change maneuvers, although with a marginally higher lateral error. Overall, the TEB+MPC solution provides near-identical lane-keeping accuracy at lower runtime while enabling more functionally complex maneuvers.

5. Safety Rationale and Potential Benefits for African Road Contexts

The proposed TEB + Pure Pursuit + MPC-ACC stack improves safety primarily by making constraints explicit and by separating safety-critical functions into modules that can be validated and tuned independently.

Constraint-aware motion generation reduces collision risk. The TEB planner optimizes a short-horizon trajectory while directly penalizing proximity to obstacles and violations of lane boundaries. This produces trajectories that maintain clearance and remain within the drivable corridor, rather than relying solely on geometric tracking of a fixed reference line. In safety terms, the planner encodes keep-out regions and lane admissibility into the optimization objective, which reduces the likelihood of generating an infeasible or unsafe lateral plan when the environment changes.

Predictive longitudinal control maintains a safety distance under disturbances. The MPC-based ACC uses a predictive model to regulate speed and headway. Minimum following distance and acceleration limits are handled as explicit constraints, ensuring that the controller does not request physically impossible or unsafe braking or acceleration. The time-headway policy provides a speed-scaled safety buffer, which is robust to typical lead-vehicle speed fluctuations.

Conservative fallback behavior in constrained situations. When lateral options are not available (for example, no legal adjacent lane), the architecture naturally defaults to longitudinal safety: the ACC can decelerate to maintain a minimum gap and, if necessary, stop safely. This is safety-relevant because it prevents "planning into a dead end" where the vehicle commits to a lateral maneuver that cannot be completed without violating lane or clearance constraints.

Reduced computational load supports timely reactions. The measured runtime advantage versus PFCS indicates that, in this implementation, the modular planner-controller stack can be computationally lighter than an integrated nonlinear MPC reference model while maintaining comparable lateral accuracy. Lower compute load helps preserve real-time feasibility, a safety prerequisite for timely responses to traffic changes.

5.1 Potential Benefits for African Road Context

Road traffic injury remains a major public-health and development burden in Africa, with the region carrying a disproportionate share (19%) of global road deaths and persistent structural gaps in road-safety management and enforcement capacity [23-25]. Systematic reviews also highlight the scale and under-measurement of crash outcomes in many settings, reinforcing the need for interventions that are robust to imperfect infrastructure and heterogeneous road users [26-28], [29].

The proposed TEB + Pure Pursuit + MPC-ACC methodology aligns with these needs because it encodes safety requirements directly into the motion-generation and control loop rather than assuming ideal lane structure or entirely predictable traffic. The TEB layer can explicitly penalize lane-boundary violation and low-clearance proximity, which is relevant when hazards are localized and appear with limited warning. The MPC-ACC layer enforces a time-headway policy and actuator bounds as constraints, which support rear-end crash prevention by maintaining a speed-scaled safety buffer and ensuring braking commands remain physically feasible under emergency

deceleration scenarios. These design choices target common, high-severity crash modes emphasized in global and Africa-focused road-safety reporting, particularly loss-of-control on curves and collision risk in car-following and stop scenarios [23], [25].

From a deployment perspective, African AV discussions emphasize readiness constraints such as infrastructure variability, governance, and public acceptance, alongside the potential for safety gains if the technology is implemented responsibly [33]. Empirical work from Ghana shows that user perception and intention to adopt AV-related technologies are nontrivial and context-dependent, suggesting that incremental, safety-centered driver-assistance functions may be a practical pathway before full autonomy [30], [31]. In parallel, legal and governance analyses argue that regulation must account for local societal considerations and responsible adoption frameworks, which favor architectures with transparent safety rules and auditable constraints rather than opaque behavior [32].

Practically, the methodology supports a staged introduction: first as advanced driver-assistance functions (lane keeping, headway control, emergency braking behavior under constraints), then as higher automation where the environment permits. This incremental strategy is consistent with the need to strengthen institutional road-safety capacity and governance mechanisms highlighted in Africa-wide assessments [25].

6. Conclusions and Summary

Based on simulation studies, it can be concluded that the TEB-based local planner, combined with the Pure Pursuit geometric steering controller, is well-suited for lateral control of a car-like vehicle. In the lane-keeping tests on the curved track, the ego vehicle remained within the lane boundaries throughout the simulation, with a maximum lateral deviation of approximately 0.19 m, which is negligible relative to the lane width. The steering signal follows the TEB-generated waypoints, while Pure Pursuit, accounting for the kinematic bicycle model, produces steering commands that correspond to maneuvers feasible for real vehicles.

For longitudinal motion, the MPC-based ACC controller enforced the 3-second time-headway policy while respecting acceleration limits and comfort-related criteria. On a straight road, with a lead vehicle that alternated between deceleration and acceleration, the following distance stabilized around the reference after the transient response, the speed profile matched the lead vehicle's dynamics, and saturation occurred only where required by safety constraints. In the emergency-braking scenario, the ego vehicle stopped without collision, maintaining a final standstill spacing of approximately 5 m. This confirms that, under the selected parameterization, the MPC can generate a safe braking command that satisfies the physical constraints.

In the complex multi-lane scenario, the integrated architecture exhibited conservative but consistent behavior. Laterally, the TEB sought overtaking opportunities with relatively aggressive intent; however, the longitudinal MPC-ACC limited ego speed in multiple instances due to spacing and acceleration constraints. Overall, the TEB + Pure

Pursuit + MPC-ACC combination provided stable, collision-free behavior consistent with the defined safety requirements across the investigated scenarios.

6.1 Contribution to the Literature

The presented architecture aligns with hierarchical solutions commonly reported in the literature, while implementing a less frequently discussed combination in its specific form: TEB-based local trajectory planning is coupled with a geometric Pure Pursuit steering controller and an MPC-based ACC longitudinal controller within a unified Simulink environment. One contribution of the paper is that it details how TEB can be integrated as a local, lane- and obstacle-aware planner specifically for a car-like vehicle, while keeping lateral control simple and interpretable through a well-established geometric tracking method.

A second contribution is the ACC formulation, which explicitly incorporates relative distance, relative speed, and an integrator state, and augments the objective with a jerk penalty. The results demonstrate how the selection of weighting factors shapes the trade-off between spacing accuracy, speed tracking, and passenger comfort. The final weight vector identified through the parameter study provides a configuration that balances tracking performance and comfort while maintaining the imposed safety constraints.

By evaluating the integrated simulation of the lateral and longitudinal modules across multiple scenarios of increasing complexity, the study shows that a hierarchical architecture, while only partially optimization-based, can approach behaviors typically associated with fully integrated MPC solutions while retaining the transparency of a modular structure. The obtained results, therefore, provide a bridge between purely geometric control approaches and fully unified, joint-optimization control schemes.

Compared to the PFCS reference model, the TEB+MPC architecture achieved roughly a 25% reduction in simulation runtime, while the lane-keeping RMSE was only a few millimeters higher than the PFCS value. Given that PFCS is limited to lane-center tracking, whereas the TEB-based approach also supports lane-change maneuvers and explicit obstacle avoidance, the results indicate that the proposed structure offers a favorable trade-off between computational demand, tracking accuracy, and functional complexity.

6.2 Future Research Directions

Several directions for further development emerge from this work. One key extension is the explicit temporal enrichment of the TEB formulation, in which trajectory points are associated with time parameters, and the objective includes penalties on longitudinal acceleration and jerk. This would bring lateral planning and longitudinal motion closer together, allowing the TEB optimization to address lane boundaries, obstacles, and dynamic constraints in a more unified manner.

A second direction is a fully integrated lateral-longitudinal MPC formulation, where steering angle and acceleration are computed within a single optimization problem. This could be particularly beneficial for emergency avoidance maneuvers and high-utilization situations near adhesion limits, where the conservative behavior of the current hierarchical structure may excessively restrict maneuverability.

Finally, the next step beyond simulation is experimental validation on real vehicles or small-scale test platforms in a hardware-in-the-loop setup. Such experiments would enable the assessment of sensor acquisition, delays, and model mismatch, and would support automatic tuning of TEB and MPC parameters, for instance, using Bayesian optimization. In the long term, this could enable robust deployment of the proposed architecture in real road environments.

Conflict of Interest

The authors hereby declare that they have no financial interest in this manuscript.

Notes on Contributor

Alex Kádár is a PhD student in the Doctoral School of Electrical Engineering at the Budapest University of Technology and Economics, Faculty of Electrical Engineering and Informatics, Department of Control Engineering and Information Technology. His research focuses on local trajectory planning and predictive control for car-like autonomous robots, including Timed Elastic Band-based path planning and model predictive control.

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Figure captions

Figure 1: Car-like vehicle [20] 51
Figure 2: Formulation of the TEB points 52
Figure 3: Pure Pursuit geometry 55
Figure 4: MPC testing under different parameter settings 60
Figure 5: Steering angle and lateral deviation response 62
Figure 6: ACC simulation results 63
Figure 7: Simulation results in a complex environment 65

Afrocentric Intelligence Studies: Resolving the Challenges of Domains of Intelligence Pedagogy in African Non-Military Universities[1]

Ngboawaji Daniel Nte[2]

Abstract:

The realities of global insecurity in recent years have led to the liberalisation of security intelligence management and the establishment of intelligence studies in non-military universities across the world. This trajectory has been progressively sustained and driven by various philosophical and pedagogical templates in the West. While the USA and other Western nations preferred the political analytical model, the UK and other European nations preferred historical and case study analytics to drive this nascent discipline. At the centre of these seemingly divergent approaches is the issue of appropriate domiciliation of intelligence studies academic programmes. Relying extensively on historicist content analysis, this study found justifications in the aforementioned approaches for the USA as a post-Second World War undisputed global power and Europe including the UK because of their imperial past and inclinations. However, for Africa, the study found that due to lack of global political dominance and global historical imperial history, these departments may not appropriately house intelligence studies on the continent. In the search for the most appropriate department to house intelligence studies, the author posits that due to the broadness of socio-anthropological enquiries in content and the lack of real political power in the continent, the department of Sociology and Social Anthropology seems the best department to accommodate and drive intelligence studies in Africa. This proposition is predicated on the complex institutionalisation of African society. This does not in any way prejudice, in the view of the author, the already existing intelligence studies programmes on the continent but is a cautious endeavour to respond to the nagging question of the most suitable academic department to host intelligence studies in the global south and more importantly in Africa where global power hegemony is obviously lacking. The study recommends the integration of indigenous knowledge systems into intelligence curricula and the establishment of partnerships between African universities and regional security bodies to ensure contextual relevance and practical effectiveness.

Keywords:

Afrocentric; Intelligence Studies; Pedagogy; Non-Military Universities; Decolonization.

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1. Introduction

In a world where security dynamics have become highly complex, intelligence studies has become a critical school of thought in universities all around the world. Out of its military background, intelligence studies has expanded its boundaries to other fields of study and pedagogical systems, cutting across various academic fields. This development has experienced unique approaches to philosophy and methodology established in various areas and influencing the intelligence education terrain. Whereas a political analytical model has been mostly adopted in the United States with a focus on strategic analysis and policy development, European nations like the United Kingdom have preferred historical and case study analytics, focusing on how and what intelligence has done in the past (Nte, 2025). This intelligence pedagogical diversification is not restricted to philosophical nuances but also to the institutional residences of these programmes.

The location of intelligence studies in a given academic department is not only a reflection of the disciplinary traditions but also the conceptualizations of the nature and scope of the area of inquiry in general. In the United States and South Africa, among others, the subject of intelligence tends to be placed in the same department of Politics and International Relations, which is geopolitical in nature and scope of these programmes. In contrast, the UK and other European nations have done so through History and International Studies departments, which focus on historical contextualization and interdisciplinary approaches to the teaching of intelligence (Higgs, 2016). But, in the middle of these conflicting practices, there is one burning question: which is the best academic department to accommodate the study of intelligence in Africa? This is not just an academic exercise but it has great implications on how intelligence education can be developed and applied in the African context.

The African context, with its rich sociocultural tapestry and its peculiar geopolitical issues, offers a special range of considerations in the development of intelligence pedagogy. The move to have intelligence studies in African universities housed in appropriate academic institutions deserves special scrutiny and consideration. The current paper aims to answer this burning question by discussing the complexity of the issue of intelligence pedagogy in the African context and suggesting an appropriate academic department where it can be accommodated. Based on the existing literature, empirical research, and opinion leaders, this paper seeks to add to the current debate on the subject of intelligence education within the global South and more specifically Africa.

The key point of this discussion is the fact that sociological inquiries are comprehensive and the structural realities of African society. The Department of Sociology and Social Anthropology becomes an interesting option to locate intelligence studies in Africa as it has an intrinsic interest in social phenomena, culture, and interdisciplinary views. Through the placement of intelligence education in this department, African universities have the opportunity to use the already existing knowledge in sociological studies to deepen the study of intelligence and place it in the context of the entire society of the continent. In addition, this proposal is not meant to belittle or demean the already established intelligence programs in Africa but simply to

provide a realistic and contextually specific view of streamlining the academic infrastructure to intelligence education. It is a humble effort to find a way through the maze of intelligence pedagogy in Africa and to forge dialogue and cooperation between the stakeholders in academic circles, government, and civil societies.

2. Literature Review

2.1 The Evolution of Intelligence Studies in Western Academia

The field of intelligence studies has traditionally been centred on military and national security contexts, but recent global security realities have necessitated its introduction in civilian academic settings worldwide (Gill, 2018). The American model is largely based on a political analytical perspective with an emphasis on the analysis of political events, the implications of policy and the strategic application of intelligence to statecraft. This model is strongly rooted in the cultures of political science and international relations, which is the pragmatic and policy-centered American academia. The intelligence studies in the U.S. are generally located in the departments of politics and international relations where the focus is on the analytical skills needed to aid in making decisions regarding national security and national policies (Lowenthal, 2020). Conversely, the European approach especially in the UK and other regions in Europe is more inclined towards the historical and case study analytic model. The approach lays a heavy stress on the historical context of intelligence activities, the development of intelligence agencies, and the effects of the past on modern intelligence practices (Andrew, 2021). The European model is more introspective and usually found within history departments or interdisciplinary programs that integrate history and international studies.

2.2 Intelligence Studies in the African Context

In Africa, the setting for intelligence studies presents unique challenges and opportunities. With the continent's diverse sociocultural landscape and historical experiences, determining the most suitable departmental home for intelligence studies becomes crucial (Nte, 2025). While some African universities have opted to place intelligence studies within departments of Politics and International Relations, others have explored alternative settings such as Sociology and Social Anthropology. This choice reflects the recognition of the sociological dimensions of intelligence, particularly in the context of African societies characterized by complex social structures and dynamics (Ogbuagu, 2021). Statetism, statecraft and security intelligence management are key ingredients of national security, peace and stability in post-modern societies of the west where nation building process has crystallised. The same cannot be said of African countries that are still grappling with challenges of nation building (Isah & Nte, 2024).

2.3 African Educational Realities and Challenges

The educational systems in Africa have a special set of challenges and opportunities, which influence the implementation of specialized disciplines like intelligence studies. There are high levels of inequality in access, quality and resources within the education

sector in the continent. Although certain nations have quite well-developed higher education systems, others have a hard time with the lack of funding, lack of adequate infrastructure, and unqualified faculty (Teferra & Altbach, 2021). The lack of academic resources is one of the most acute problems. Most universities in Africa are run on a tight budget, a factor that impedes their capacity to attract and retain talented teachers and researchers. This shortage of resources is especially acute in specialized areas in which a large amount of funds is required to be invested in research and training facilities, such as intelligence studies (Zeleza, 2022). The colonial past still impacts educational policy and practice in Africa, in many cases giving rise to systems that fail to adequately meet the needs of the continent. Nevertheless, more and more attention and initiative is being paid to decolonizing education and making it more relevant to the needs of African communities.

2.4 The Nature and Scope of Intelligence Studies

As an academic field of study, intelligence studies involves a complex study of intelligence processes, activities and institutions both at home and abroad. It is the study of information collection, analysis, distribution, and decision-making in different contexts, including national security and business intelligence. The discipline is informed by varied fields of knowledge, such as political science, history, sociology, psychology, and law in order to comprehend the phenomena of intelligence complexities (Warner, 2021). One of the defining characteristics of intelligence studies is its interdisciplinary nature. As Michael Warner, a prominent scholar in the field, notes, intelligence "is not a discipline but an activity" (Warner, 2021). This activity involves the collection, analysis, and interpretation of information to support decision-making processes. Within intelligence studies, several theoretical frameworks inform the analysis of intelligence phenomena. One such framework is the intelligence cycle, which conceptualizes the process of intelligence gathering and analysis as a cyclical sequence of activities, including planning, collection, processing, analysis, dissemination, and feedback (Lowenthal, 2020).

2.5 Intelligence Studies as Imperialism

Intelligence studies, as a burgeoning academic discipline, has been increasingly integrated into the curricula of universities worldwide. However, the adoption and propagation of intelligence studies often bear the hallmarks of neo-imperialism, reflecting the geopolitical interests and ideological biases of dominant global powers (Nte, 2025). This phenomenon is evident in the ways that Western models of intelligence are exported to and imposed upon universities in the Global South, particularly in Africa. The implementation of intelligence studies in African universities frequently mirrors Western paradigms that prioritize political and military frameworks. During the colonial era, intelligence was a tool of domination, used by colonial powers to control and suppress indigenous populations (Mafeje, 2020). This legacy continues to influence how intelligence is perceived and implemented in post-colonial African states. The transplantation of Western intelligence models can thus be seen as a continuation of

colonial practices, perpetuating dependency and undermining the development of autonomous African intelligence methodologies.

2.6 The Role of Sociology and Social Anthropology

The Department of Sociology and Social Anthropology offers the tools and methodologies to explore the sociocultural aspects of African societies in-depth. This department has the potential to provide knowledge on social behaviours, conflict resolution, and the role of traditional systems in present-day governance, which are crucial in intelligence work in Africa (Ndlovu, 2021). African societies are characterized by diverse social systems, communal living, and intricate cultural practices. Understanding these social fabrics is essential for effective intelligence gathering and analysis (Tettey, 2021). The multidisciplinary approach is also associated with the importance of integrating intelligence studies into the Sociology and Social Anthropology departments. The work of intelligence cannot be performed without the knowledge of political, economic, social, and cultural aspects, which is why the multidisciplinary framework is needed (Zeleza, 2022). Such an approach is inherent to these departments, which offer a complete educational experience preparing students for the multifaceted character of intelligence work.

2.7 Sacred Institutions in African Societies

Africa, commonly discussed as a land of rich cultural tapestry and a variety of different societal organizations, is home to a great number of sacred institutions, which are extremely important to the lives of African people. These are institutions that are deeply embedded in the history and traditions of the continent and they are religious organizations, chieftaincies and family systems, which play an important part in the social and cultural life of African communities (Nte, 2025). African religious institutions are some of the most powerful institutions, which affect not only the spiritual life of people but also their social and political relations. The two major religions, Christianity and Islam exist along with a multiplicity of indigenous belief systems that are diverse throughout the continent (Falola & Heaton, 2021). In most African cultures, chieftaincies and traditional leaderships are also sacred. Chiefs and traditional leaders are not just political leaders but the guardians of custom, traditions and values. They are important in resolving conflicts, land distribution and in maintaining cultural practices (Ray & Reddy, 2020). The family unit is the cornerstone of African society, characterized by an extended family system that fosters strong kinship ties and collective responsibility (Nsamenang, 2021).

3. Methodology

This study employs a qualitative research design, specifically utilizing historicist content analysis as its primary methodological framework. The choice of this approach is informed by the need to understand intelligence studies pedagogy within its historical and socio-political contexts, particularly as it relates to the African continent. The historicist approach allows for an examination of how intelligence studies has evolved differently across various geopolitical contexts, with particular attention to the

philosophical and pedagogical traditions that have shaped the discipline in the United States, Europe, and Africa (Nte, 2025). This method is appropriate for understanding the institutional and intellectual genealogies that inform current debates about the disciplinary home of intelligence studies.

The corpus for this study comprises peer-reviewed journal articles and book chapters on intelligence studies pedagogy published between 2020 and 2025, institutional documents and curricula from African universities offering intelligence studies programmes, policy documents and reports from African regional bodies such as the African Union and ECOWAS relating to security and intelligence training, and foundational texts in intelligence studies theory from Western scholarship. Texts were selected based on three criteria: relevance to intelligence studies pedagogy or curriculum design, geographical representation covering Western and African contexts, and scholarly or institutional authority of the source. Priority was given to sources that explicitly address the relationship between academic discipline and intelligence training.

The analysis proceeded through three stages. First, a thematic coding framework was developed to identify recurring arguments and assumptions regarding disciplinary location. Second, comparative analysis was conducted to contrast Western and African approaches, with particular attention to the historical and political factors that shaped disciplinary choices. Third, the analysis synthesized these findings to develop a coherent argument for the most appropriate disciplinary home for intelligence studies in African universities. This systematic approach ensures that the findings are grounded in a rigorous examination of the available evidence and scholarly discourse.

4. Results and Discussion of Findings

4.1 Comparative Analysis of Departments for Housing Intelligence Studies

Criteria	Politics and International Relations	History and International Studies	Sociology and Social Anthropology
Focus	Political analytical models	Historical and case study analytics	Sociological and anthropological perspectives
Relevance to African Context	Moderate: Focuses on political structures and theories	Moderate: Emphasizes historical context and case studies	High: Addresses societal complexities and cultural dynamics
Existing Academic Infrastructure	Well-established but limited to political sciences	Well-established in historical and archival research	Extensive: Covers a wide range of social research
Interdisciplinary Potential	Moderate: Integrates politics,	Moderate: Integrates history,	High: Integrates sociology, anthropology, politics,

	economics, and law	politics, and cultural studies	psychology, and economics
Availability of Expertise	Limited in intelligence-specific areas	Limited in contemporary intelligence issues	High: Strong presence of social researchers and academics
Comprehensive Framework	Focuses on political dynamics	Focuses on historical precedents	Broad: Focuses on social behaviour, cultural norms, and community dynamics

Figure 1: Comparative Analysis of Potential Departments for Housing Intelligence Studies in African Universities. Source: Author's compilation (2025).

The figure above presents a comparative analysis of three potential departments for housing intelligence studies in African universities. The analysis reveals that the Department of Sociology and Social Anthropology offers the most comprehensive framework for intelligence studies in the African context. Its high relevance to the African context, extensive academic infrastructure, and strong interdisciplinary potential make it particularly well-suited for addressing the complex sociocultural dynamics that characterize African societies (Nte, 2025). While Politics and International Relations and History and International Studies have their strengths, they are more limited in their ability to address the multifaceted nature of intelligence in Africa. The sociological and anthropological perspectives provide a holistic approach that is essential for understanding the underlying factors that influence security and intelligence issues in African societies (Comaroff & Comaroff, 2020).

4.2 Euro-Americo Models: Between History and Politics

Aspect	American Model	European Model
Philosophical Approach	Political analytical	Historical and case study analytics
Academic Housing	Departments of Politics and International Relations	History departments or interdisciplinary programs combining history and international studies
Curriculum Focus	Analysis of political events, policy implications, and strategic use of intelligence	Understanding historical context, evolution of intelligence agencies, and impact of historical events on contemporary intelligence practices
Pedagogical Emphasis	Pragmatic and policy-oriented	Reflective and theoretical, emphasizing long-term implications and historical contexts
Strengths	Relevant to immediate policy and security needs	Provides a deeper understanding of intelligence as a historical continuum

Weaknesses	May lack broader historical context	May lack immediate policy relevance

Figure 2: Comparison of American and European Models of Intelligence Studies. Source: Author's compilation (2025).

The figure above clearly indicates the major distinctions between the American and European models of intelligence studies. The American paradigm mainly locates the study of intelligence in the departments of Politics and International Relations, which is a political analytical approach to the field. This model is concerned with analysis of political events, policy implications, and how intelligence is strategically applied in statecraft (Lowenthal, 2020). Conversely, the European model tends to locate intelligence studies in history departments or in interdisciplinary programs that involve history and international studies (Andrew, 2021). In this case, one is interested in the historical context of intelligence operations, development of intelligence agencies and the role of historical events in modern intelligence activities. The two philosophies of education differ in the philosophical differences of the two models. The political analytical approach that is American is determined by practical needs of a nation that is highly involved in world politics (Warner, 2021). The European model that includes its historical and case study analytics offers a more general and theoretical concept of intelligence (Jeffery, 2022).

4.3 Intelligence Studies with Differentiated Settings

Region	Academic Housing	Philosophical Approach	Pedagogical Emphasis
United States	Departments of Political Science or International Relations	Political analytical	Pragmatic and policy-oriented
United Kingdom/Europe	Departments of History or International Studies	Historical and case study analytics	Reflective and theoretical
Africa	Departments of Sociology and Social Anthropology (proposed)	Sociological and anthropological	Holistic and contextually relevant

Figure 3: Intelligence Studies in Different Global Settings. Source: Author's compilation (2025).

The figure above illustrates the differentiated settings for intelligence studies across various regions. In the United States, intelligence studies tend to be housed in departments of Political Science or International Relations, reflecting the American emphasis on the political and strategic aspects of intelligence (Lowenthal, 2020). In the United Kingdom and other European countries, intelligence studies are frequently housed within departments of History or International Studies, emphasizing the

importance of context and precedent in understanding intelligence activities (Andrew, 2021). In Africa, the setting for intelligence studies presents unique challenges and opportunities. With the continent's diverse sociocultural landscape and historical experiences, determining the most suitable departmental home for intelligence studies becomes crucial. The proposed model for Africa places intelligence studies within departments of Sociology and Social Anthropology, reflecting the recognition of the sociological dimensions of intelligence in the context of African societies (Ogbuagu, 2021). This differentiated setting has implications for pedagogy and curriculum development, with African universities prioritizing interdisciplinary perspectives and empirical research methods.

4.4 Sacred Institutions and Their Relevance to Intelligence Studies

Sacred Institution	Description	Relevance to Intelligence Studies
Religious Institutions	Spiritual centres providing moral guidance and social cohesion	Understanding community dynamics, trust networks, and information flow
Chieftaincies and Traditional Leadership	Historical continuity and cultural heritage; conflict resolution	Local governance structures, traditional intelligence networks, and community trust
Family Systems	Extended family system fostering kinship ties and collective responsibility	Social organization, value transmission, and community intelligence gathering

Figure 4: Sacred Institutions in African Societies and Their Relevance to Intelligence Studies. Source: Author's compilation (2025).

The figure above presents the sacred institutions in African societies and their relevance to intelligence studies. African religious institutions are some of the most powerful institutions, which affect not only the spiritual life of people but also their social and political relations (Falola & Heaton, 2021). These institutions serve as centres of community life, moral guidance, social support, and a sense of identity. Chieftaincies and traditional leadership structures are integral to many African societies, symbolizing historical continuity and cultural heritage (Ray & Reddy, 2020). Chiefs and traditional leaders wield political and spiritual authority, facilitating conflict resolution and the preservation of customs and traditions. The family unit is the cornerstone of African society, characterized by an extended family system that fosters strong kinship ties and collective responsibility (Nsamenang, 2021). Understanding these sacred institutions is essential for effective intelligence gathering and analysis in African societies. They provide insights into social behaviours, conflict resolution, and the role of traditional systems in present-day governance (Ndlovu, 2021). By drawing on insights from sociology, anthropology, and related disciplines, students are equipped with the analytical tools to critically examine the intersection of intelligence and society in Africa.

4.5 Comparison of Intelligence Studies Frameworks and Their Impact on African Universities

Aspect	Western Model (USA/Europe)	Impact on African Universities	Proposed Afrocentric Model
Philosophical Approach	Political analytical (USA); historical and case study analytics (Europe)	Imposition of Western-centric perspectives; misalignment with local needs	Sociological and anthropological approach
Academic Housing	Departments of Politics and International Relations; History	Reflects Western academic structures; limited relevance to African contexts	Departments of Sociology and Social Anthropology
Historical Context	Intelligence as a tool of national security and geopolitical strategy	Continuation of colonial practices; perpetuation of dependency	Emphasis on indigenous knowledge systems and local intelligence traditions
Pedagogical Focus	Emphasis on national security, political analysis, and historical cases	May not address specific intelligence needs of African states	Holistic and contextually relevant curriculum
Ethical Concerns	Potential misuse for maintaining external interests and status quo	Risk of intelligence being used to suppress dissent	Aligns with socio-cultural values and ethical considerations
Interdisciplinary Needs	Less emphasis on social dynamics and cultural contexts	Overlooked complexity of African societies	Integration of social, cultural and anthropological dimensions
Colonial Legacy	Extension of colonial-era intelligence practices	Echoes coercive tactics of colonial period	Focus on decolonization and academic autonomy

Figure 5: Comparison of Western and Afrocentric Intelligence Studies Frameworks. Source: Author's compilation (2025).

The table above gives a comparative idea of the Western model of intelligence studies and its influence in African universities against a proposed Afrocentric model. The

Western models, namely those of the USA and Europe, are interested in political analytical and historical/case study analytics respectively (Lowenthal, 2020; Andrew, 2021). Such models tend to apply Western-centric views and these might not translate to the unique needs and realities of African countries. Conversely, the Afrocentric model promotes a sociological and anthropological model, which considers social structure and cultural backgrounds of African communities (Nte, 2025). The teaching of intelligence studies in Western universities is usually located in departments of Politics and International Relations or History. This framework is of Western academic origins and might not fit African settings, where an approach that is more integrated is required (Isah & Nte, 2024). The Afrocentric model proposes that intelligence studies be placed in departments of Sociology and Social Anthropology that are better placed to respond to the holistic approach of sociological questions that pertain to African societies. The history of Western powers' use of intelligence especially in colonial times was directed towards control and oppression. The effects of this heritage are still evident in the way intelligence is practiced in African states and tend to create dependency and destroy local intelligence practices (Mafeje, 2020). The Afrocentric model gives more emphasis to the significance of indigenous knowledge systems and aims to create intelligence methodologies which are independent and contextually applicable.

4.6 African Security Intelligence Studies

The complicated nature of African society, with its various ethnicities, cultures, and social interactions, demands a more complex approach to intelligence that is not limited to the traditional political and historical paradigm of the West (O'Brien, 2022). These complexities can be well understood through the sociological and anthropological approach. These fields offer useful information on the underlying factors that determine security and intelligence issues in African societies since they are concerned with social behaviour, cultural norms and community dynamics (Comaroff & Comaroff, 2020). In addition, the lack of scholars in the field of intelligence studies in the continent makes it necessary to capitalize on the expertise available in the universities in Africa. Sociology and Social Anthropology departments are usually well established and have scholars who have been in the field of social research making them the best to develop and deliver intelligence studies programs (Mafeje, 2020). Another aspect is the interdisciplinary nature of intelligence that is compatible with the idea of integrating intelligence studies into Sociology and Social Anthropology departments. Intelligence studies are disciplines that by virtue need to have knowledge of other fields such as politics, history, psychology and economics (Hutchinson, 2021). The holism of sociological and anthropological research facilitates integration of these multiple viewpoints and leads to a better and more holistic intelligence education.

4.7 Intelligence Studies as Imperialism

The dominance of Western frameworks in intelligence studies also raises ethical concerns about the potential misuse of intelligence education. Training programs that are heavily influenced by Western doctrines may inadvertently equip African states with tools that serve external rather than internal interests (Nte, 2025). This can lead to scenarios where

intelligence is used to maintain the status quo or suppress dissent, echoing the coercive tactics of the colonial period (Comaroff & Comaroff, 2020). Therefore, it is crucial to critically assess and adapt intelligence curricula to ensure they are aligned with the needs and values of African societies. While the integration of intelligence studies into African universities offers potential benefits for national security and academic development, it also poses significant risks of intellectual and cultural imperialism. To mitigate these risks, it is essential to develop intelligence studies programs that are rooted in the socio-cultural contexts of African nations, fostering indigenous knowledge and promoting genuine academic autonomy (Nte, 2025). This approach not only enhances the relevance and effectiveness of intelligence education but also contributes to the decolonization of African higher education.

5. Conclusion

This study explored an alternative narrative with regards to the optimal academic housing for intelligence studies within African universities, taking into account the continent's unique sociological and anthropological contexts. The need for a well-suited department arises from the growing global emphasis on intelligence studies and the necessity for such programs to address local and regional security challenges effectively. The analytical trajectory favoured the department of Sociology and Social Anthropology as it provides a comprehensive framework that aligns well with the intricate historical, social and cultural dynamics of African societies (Nte, 2025). This alignment is crucial for fostering a robust and contextually relevant intelligence curriculum that can produce graduates equipped with the necessary analytical and practical skills needed for continental intelligence studies in line with global benchmarks. Moreover, the interdisciplinary nature of sociology and social anthropology provides a holistic perspective that is essential for understanding and addressing the multifaceted issues related to intelligence and security issues in Africa that differ markedly from Western realities and templates (Ogbuagu, 2021). This approach is not only academic but also practical, as it prepares students to tackle real-world challenges through a well-rounded understanding of societal dynamics. While this recommendation does not disregard the value of existing intelligence programs housed in departments of politics, international relations, or history, it proposes a model that may offer a more integrated and contextually pertinent framework for African universities (Isah & Nte, 2024). The successful implementation of this model will require collaborative efforts among academic institutions, government agencies, and international partners to ensure that the programs are well-resourced and aligned with contemporary security needs. Positioning intelligence studies within the Department of Sociology and Social Anthropology in African universities promises to enhance the discipline's relevance and effectiveness in addressing the continent's unique security challenges.

6. Recommendations

Based on the analysis presented in this paper, the following recommendations are offered. African universities should develop intelligence studies curricula that integrate sociological and anthropological perspectives, emphasizing local contexts, cultural

dynamics, and community-based approaches to security. Institutions should invest in training existing faculty in Sociology and Social Anthropology departments to deliver intelligence studies courses, leveraging their expertise in social research methodologies. Universities should establish partnerships with intelligence agencies, security practitioners, and regional bodies such as the African Union to ensure that academic programs remain relevant to practical security needs. Intelligence studies programs should actively incorporate indigenous knowledge systems, African philosophical traditions, and local intelligence practices into their curricula (Nte, 2025). Future research should focus on developing African-grounded intelligence theories, evaluating the effectiveness of the proposed model, and exploring innovative pedagogical strategies. Additionally, African universities should prioritize the recruitment and retention of faculty with expertise in both intelligence studies and African social systems to ensure the sustainability and growth of these programs.

Conflict of Interest

The authors hereby declare that they have no financial interest in this manuscript.

Notes on Contributor

Professor Nte holds degrees and diplomas in Social Work, Sociology, Security Studies, Journalism, Business and Police Science. He is widely published with over a hundred articles in refereed national and international journals besides book chapters. He has four books to his credit and spoken in over three hundred conferences, workshops and seminars. His expertise include social work, intelligence and security management and public safety management.

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Rewriting Democracy from the Margins: Hybrid Political Orders, Gendered Exclusion, and the Limits of the Liberal Template in Post-Conflict Africa[1]

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Abstract:

A renewed debate questions whether the liberal democratic template fits the conditions in which it now operates. Recent commentary attributes the strain on democracy to rigidity and to the neglect of local language, memory, and political culture. This article argues that the diagnosis is necessary but incomplete. Drawing on hybrid political orders scholarship, feminist institutionalism, and applied experience from electoral cycles in Liberia, Somalia, Somaliland, and Zimbabwe, it argues that the template's fragility lies less in its inflexibility than in its political ontology, an assumption of the consolidated liberal state that does not describe most post-conflict African polities. The article also contests the populist-conservative variant of the local turn, which can rehabilitate patriarchal and clientelist orders under the language of authenticity. Building on the concept of patriarchal hybridity (Hamandishe & Ewusi, 2025), and on prior work on state fragility in the Sahel (Ziso & Hamandishe, 2024), it proposes a reorientation of democracy assistance from template export toward the co-production of context-grounded democratic practice, with gendered political settlements as a central axis of analysis.

Keywords:

Hybrid Political Orders; Feminist Institutionalism; Democratic Backsliding; Post-Conflict Elections; Africa; Democracy Assistance; Decolonial Knowledge Production.

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1. Introduction

The argument that liberal democracy promotion has failed not because its ideals are wrong but because its implementation has been too rigid and too detached from the political culture of recipient societies has moved from heterodox commentary into mainstream policy debate (Carothers, 2002). The diagnosis identifies something real. After three decades in which constitutional engineering, election cycles, and donor-driven institutional design have served as the dominant grammar of democracy promotion, the gap between liberal templates and the political life of recipient societies has become difficult to ignore. Sub-Saharan Africa is one terrain on which this gap has been particularly visible, and in many respects the most demanding one on which the argument plays out.

The article contributes to this debate but pushes it in two specific directions. It accepts the diagnosis that liberal templates have travelled badly, but argues that the mainstream rewrite-the-playbook argument is incomplete in two respects. First, it locates the deficiency in implementation rather than in theory. The implicit reference of liberal democracy promotion remains the consolidated Weberian state in which elections, parties, and constitutional norms operate on a stabilised institutional terrain. Across most post-conflict polities, that polity does not exist. Second, the cultural turn it proposes leaves underexplored which 'local' is to be honoured, on whose authority, and at what cost. From the vantage point of post-conflict African contexts, this question is decisive. The same arguments that dignify cultural specificity have, in the recent history of the continent, been used to defer gender equality, to legitimate patrimonial bargains, and to consolidate the very orders that conflict transitions were meant to displace (Hamandishe & Ewusi, 2025; Tripp, 2015).

The argument advanced here proceeds along three lines. First, the strain on liberal templates reflects a mistaken political ontology, not merely rigid implementation. Second, the analytic apparatus developed within hybrid political orders scholarship and feminist institutionalism offers a more honest reading of the polities in which democracy assistance now operates than the standard transitions paradigm. Third, a credible reorientation of democracy support requires gendered political settlements at the centre of analysis and Global South knowledge production as constitutive rather than illustrative (Ake, 1996; Mkandawire, 2015).

The article extends two strands of the author's prior research. The first is the analysis of state fragility, ungoverned spaces, and the exploitation of governance vacuums by armed actors in the central Sahel (Ziso & Hamandishe, 2024). The second is the empirical analysis of patriarchal hybridity in post-conflict Somalia, in which formal and informal political institutions merge to sustain women's exclusion despite progressive constitutional commitments (Hamandishe & Ewusi, 2025). The present article works at a higher level of abstraction, asking what these case-grounded findings imply for the way the international community theorises and supports democratic practice in fragile and post-conflict polities. It contributes to the scholarly project of treating African

political experience as constitutive of democratic theory rather than as case material for theories produced elsewhere (Mkandawire, 2015).

The article is structured as follows. Section 2 sets out the methodological approach. Section 3 develops the theoretical framework, drawing together hybrid political orders scholarship, feminist institutionalism, and decolonial perspectives on knowledge production. Section 4 addresses the diagnostic problem, contrasting the rigidity argument with the ontology argument. Section 5 presents three empirical illustrations from Somalia, Liberia, and Zimbabwe. Section 6 examines the gender problem in the cultural turn. Section 7 discusses the analytical and policy implications. Section 8 concludes.

2. Materials and Methods

This article is a conceptual and analytical contribution rather than an empirical study based on new primary data. It applies a qualitative descriptive approach (Sandelowski, 2000) that integrates three sources: theoretical scholarship in comparative politics, hybrid political orders, and feminist institutionalism; the author's prior published empirical work on Somalia (Hamandishe & Ewusi, 2025) and on the Sahel (Ziso & Hamandishe, 2024); and observations drawn from the author's professional engagement with electoral cycles and democracy assistance in Liberia, Somalia, Somaliland, and Zimbabwe between 2010 and 2026.

The reasoning strategy is interpretive synthesis (Sandelowski, 2000). The article identifies a debate within mainstream commentary on democratic fragility, locates a theoretical gap in the dominant framing, and works through that gap by reading the debate against three bodies of scholarship and against context-specific empirical material. Where empirical claims about Somalia, Liberia, or Zimbabwe are advanced, they are anchored in published scholarly sources, in the author's prior peer-reviewed work, or in observations from professional practice that are appropriately disclosed. No new interview, survey, or archival data are presented in this article. Readers seeking primary empirical evidence on the Somalia case are directed to Hamandishe and Ewusi (2025), which reports on twenty-five semi-structured interviews with female parliamentarians, civil society actors, and clan elders, and on policy archaeology of the 2012 Provisional Constitution and the 2016 National Gender Policy.

The three empirical illustrations were selected on three criteria. First, each has undergone a formal transition from a preceding period of violent conflict, authoritarian rule, or contested constitutional order, and each holds regular multi-party elections. Somalia's federal state emerged from the Djibouti and Mbagathi peace processes and the 2012 Provisional Constitution; Liberia's Second Republic emerged from the 2003 Accra Comprehensive Peace Agreement; Zimbabwe's post-2013 constitutional order emerged from the 2008 Global Political Agreement and was reshaped by the 2017 political transition. While Zimbabwe is not post-conflict in the narrow interstate sense, its constitutional trajectory tracks the same analytic questions this article examines. Second, each has adopted formal gender-inclusion architecture whose implementation

gap makes visible the analytic point about the interaction between formal and informal institutions: the Somali 30 per cent constitutional quota, the Liberian voluntary Memorandum of Understanding for the 2023 cycle, and the Zimbabwean reserved-seat system. Third, each is a context in which the author has worked professionally, which supports the observation-informed dimension of the analysis without substituting for the peer-reviewed empirical sources on which specific claims rest. Somaliland is not analysed as a case in this article; the earlier reference to the author's professional engagement with Somaliland indicates only the geographic scope of practice from which broader observations are drawn.

Three analytical dimensions structure the reading of each case. The first is the interaction between formal electoral architecture and informal institutions of authority: clan, party, customary, and religious. The second is the gap between descriptive women's representation, measured through seat counts, and substantive women's political authority, measured through influence over agenda-setting, committee assignment, party leadership, and constitutional review. The third is the mechanism by which cultural-authenticity discourse legitimates gendered exclusion despite formal constitutional commitments to inclusion. Each empirical illustration in Section 5 illustrates a different configuration of these three dimensions.

3. Theoretical Framework

Three bodies of scholarship inform the analysis. They are read together rather than separately because their combined analytic yield is the description that the standard democracy promotion playbook cannot accommodate without revision. The standard playbook, as used throughout this article, refers to the operational model of democracy promotion that emerged in the third wave of democratisation and now dominates donor practice: constitutional engineering, electoral cycles, party system development, and civil society support, calibrated to a consolidated liberal state of the kind described by Carothers (2002) as the transitions paradigm.

The first is the literature on hybrid political orders, developed in part as a corrective to the 'fragile states' frame that dominated international policy discourse in the early 2000s. Boege, Brown, Clements, and Nolan (2009) argued that what international actors classify as state fragility is, in many cases, the empirical condition of polities in which customary, religious, and statutory authorities coexist, compete, and produce political order through their interaction. Hagmann and Péclard (2010) extended this insight by reconceptualising African statehood as an ongoing process of negotiation among heterogeneous actors, rather than as an outcome to be approximated against the Weberian ideal. These authors do not romanticise customary authority. They argue, more modestly, that the analytic move of treating non-state authority as residual, transitional, or merely cultural produces poor description and poorer policy. Menkhaus's (2007) work on Somalia, in which governance without government emerged through clan structures, business networks, and Islamic institutions during the long period of central state collapse, illustrates the empirical claim. The Sahel literature

on state fragility further demonstrates how hybrid political orders coexist with, and are sometimes deepened by, the rise of armed non-state actors and the erosion of state authority through coups (Ziso & Hamandishe, 2024).

The second body of work is feminist institutionalism. Mackay, Kenny, and Chappell (2010) synthesised the field's foundational claim that institutions are gendered through and through, and that any account of institutional change which does not specify how gender is produced and reproduced within rules, norms, and practices will misread the politics it studies. Krook (2009, 2016) demonstrated that formal architecture, including constitutionalised quotas and reserved seats, interacts with informal institutions in ways that can either entrench or unsettle patriarchal political settlements depending on configuration. Goetz and Hassim (2003), writing on African contexts specifically, mapped the sectoral differentiation of women's political access and showed how representation in the legislature does not automatically translate into substantive influence over budgeting, security, or constitutional politics. Htun and Weldon (2012) further established that mobilisation by autonomous feminist movements, rather than the simple presence of women in office, is the most consistent predictor of policy change on violence against women, providing additional empirical foundation for the substantive-versus-descriptive representation distinction. The combined contribution is methodological. It insists that the political cannot be specified without specifying its gender architecture.

This account converges with the analytical frame of the Women, Peace and Security agenda, established by United Nations Security Council Resolution 1325 (2000) and developed through the subsequent resolutions that constitute the WPS architecture. The participation pillar of the agenda identifies meaningful women's participation in peace and security decision-making as a foundational commitment, not as a quantitative benchmark. The gap between the participation commitment and its implementation across post-conflict polities has been widely documented through national action plans and donor programming, and it provides an operational reference point for the descriptive-versus-substantive representation distinction elaborated above (Goetz & Hassim, 2003; United Nations Security Council, 2000).

The third body of work concerns knowledge production. Ake's (1996) argument that democracy in Africa cannot be analysed through frameworks treating African polities as deviant cases of an external norm remains foundational. Mkandawire (2015) extended the methodological critique by reassessing the concept of neopatrimonialism, showing that it had been deployed in ways that erased African economic agency and political reasoning. What unites these contributions is not a rejection of comparative theory but a refusal of the asymmetry whereby concepts travel from the Global North into African settings while African scholarship is treated as ethnographic detail rather than as theory. These three literatures, read together, generate a description of post-conflict African polities as hybrid, gendered, and theoretically autonomous. That description is the foundation of the argument that follows.

4. The Diagnostic Problem: Rigidity or Ontology?

Mainstream critiques of democracy promotion locate the difficulty of the field in design and sequencing. Templates are said to fail because they are imposed too quickly, with insufficient attention to local political culture, or with inadequate calibration to context (Carothers, 2002). The implicit referent in this critique remains the consolidated liberal state, with elections, parties, and constitutional norms operating on a stabilised institutional terrain. Refinement, on this account, would mean better adaptation of broadly correct instruments to broadly stable political environments.

African post-conflict experience has long unsettled the assumption embedded in this account. Bratton and van de Walle (1997), writing in the immediate aftermath of the third wave of African democratisation, demonstrated that African transitions inherited neopatrimonial structures which elections alone could not dissolve. Carothers (2002) argued that the transitions paradigm took as definitional what was in fact contingent: that polities undergoing political change were on a coherent path toward consolidated liberal democracy, and that the principal task of analysis was to track their progress along that path. When polities did not consolidate, scholarship and practice tended to read the failure as a deficiency of the polity rather than as a problem with the framework. Mamdani's (1996) analysis pushed deeper, showing that the bifurcated colonial state produced a citizen-subject divide that postcolonial constitutionalism reproduces rather than resolves. His point was not that constitutions are useless. It was that constitutional reform alone could not undo a political ontology built into the architecture of the state itself.

If these scholars are taken seriously, the diagnostic problem is not that liberal templates are insufficiently flexible. It is that they presuppose a polity which does not exist in most of the contexts to which they are exported. The template's difficulty is that the polity it addresses in its default implementation, with elections, parties, and a unified citizenry mediated through a Weberian state, differs from the polity it typically encounters. Hybrid political orders scholarship has documented this gap for some time, but the gap has been slow to reshape the operational assumptions of democracy promotion. What the template encounters instead is an arrangement in which clan, lineage, faith community, customary authority, and party machine coexist with formal state institutions and produce political order through their interaction. The Boege group's core claim, that hybridity is the political reality of much of the world rather than a residual to be cleared, is the claim that the standard playbook cannot absorb without revising its theoretical foundations (Boege et al., 2009; Hagmann & Péclard, 2010).

The recent wave of military coups across West Africa and the Sahel reinforces the analytic point. Ziso and Hamandishe (2024) show that the conditions enabling the rise of juntas in Niger, Burkina Faso, and Mali cannot be reduced to a failure of formal democratic institutions. They emerge from a longer-running interaction between weak state authority, ungoverned territory, climatic and economic stressors, and the persistence of armed non-state actors who operate within and against hybrid political orders. The transitions paradigm reads such cases as backsliding from democracy. The

hybrid orders frame reads them as the predictable consequence of treating fragile polities as if they were consolidated ones.

The distinction between rigidity and ontology is not academic. It carries direct policy implications. A diagnosis of rigidity prescribes more cultural sensitivity, better local consultation, longer timelines, and more responsive sequencing. These adjustments are useful but do not address the deeper problem. A diagnosis of mistaken ontology prescribes a different kind of analysis altogether: one that maps the actual loci of authority in a given polity, identifies how those loci interact, and asks what democratic practice within hybrid orders looks like before it asks what reforms should be funded. The remainder of the article works through the implications of this second diagnosis.

5. Empirical Illustrations: Somalia, Liberia, and Zimbabwe

Three brief illustrations from post-conflict and politically constrained African settings ground the theoretical claims advanced above. They are presented not as case studies in the technical sense but as analytic vignettes drawing on prior published work and on the author's professional engagement with electoral cycles and democracy assistance. Each illustrates a different dimension of the analytic gap between the standard playbook and the polities it claims to address.

5.1. Somalia: Patriarchal Hybridity in the Indirect Electoral Process

The Somali indirect electoral process must be read against a longer history of clan-based political ordering in the absence of central state authority. Menkhaus (2007) documented how, during the long period following the 1991 state collapse, governance in southern Somalia was produced through the interaction of clan structures, Islamic courts, business networks, and diaspora remittance flows, generating a functional political order without a functional central state. The federal architecture established through the 2004 Transitional Federal Government and the 2012 Provisional Constitution was layered onto this pre-existing hybrid order rather than displacing it. The 2021 to 2022 electoral process therefore combined federal-level electoral competition with clan-level negotiation over representation, and both operated within a broader settlement in which women's political participation was formally guaranteed by constitutional quota but substantively mediated by clan authority and by the four-point-five formula that structures the distribution of political access across Somalia's major clan families.

Somalia's 2021 to 2022 indirect electoral process illustrates the descriptive failure of templates that read electoral politics as a process unfolding within a unified state. The contest was simultaneously a competition for federal seats, a negotiation over clan equilibria across the four-point-five formula and the federal member states, and a struggle over the constitutional 30 per cent quota for women's representation. International support oriented to electoral mechanics treated the second and third dimensions as background noise. They were, in fact, the substance. The federal seats

whose contest international support sought to support were allocated through a process that depended on clan negotiation for legitimacy, on Federal Member State approval for delivery, and on the Provisional Constitution for legal authority. Each of these tracks operated through different rules-in-use, and the women's quota functioned across all three simultaneously, producing variable outcomes by Member State (Hamandishe & Ewusi, 2025).

Hamandishe and Ewusi (2025) document this dynamic through the concept of patriarchal hybridity, in which formal constitutional commitments and clan-based informal institutions merge to sustain women's political exclusion despite progressive legal architecture. Women's representation in the Federal Parliament moved from approximately 14 per cent in 2012, to 24 per cent in 2016, and back to 20 per cent in 2021–2022. This trajectory does not describe a polity in which formal architecture is gradually enabling substantive representation. It describes a polity in which gains achieved through international pressure are reversed once that pressure recedes, and in which clan elders exercise effective veto over candidate selection by reclassifying reserved seats and negotiating women's presence in exchange for political concessions. The 2020 Electoral Law, which had been expected to institutionalise the quota, was negotiated in ways that removed the binding language during closed-door consultations with elders (Hamandishe & Ewusi, 2025).

A democracy assistance architecture designed for an electorate-state model could fund the ballot but could not analyse the political settlement within which the ballot was nested. The result was an electoral outcome that satisfied formal procedural minima while leaving the underlying gender settlement substantially unchanged. The Somalia case is therefore not an illustration of an unusual or aberrant polity. It is a precise empirical instance of what hybrid political orders look like when liberal electoral templates are applied to them without analytic adjustment.

5.2. Liberia: Procedural Stability and Upstream Exclusion

Liberia's 2023 electoral cycle offers a different illustration. Two decades after the formal end of civil war, the country has institutionalised competitive multiparty politics, alternation in power, and a stable electoral commission. By the metrics the standard playbook tracks, Liberia performs well. Yet the cycle exposed how thinly distributed the gains of formal democratisation can be when informal institutions of campaign finance, candidate selection, and political party loyalty remain stratified by gender, ethnicity, and county. The leadership pipeline for women aspirants, which sustained donor investment had developed over the preceding decade, intersected with party financing structures that systematically advantaged incumbents and male candidates with access to informal networks (Tripp, 2015). Civic education programming and election observation registered the procedural conduct of the elections accurately. They could not, by design, document the upstream selection processes that determined which candidates entered the formal arena in the first place. This is precisely the kind of analytic

gap a feminist institutionalist reading is built to address (Mackay et al., 2010; Krook, 2009).

Liberia's case also illustrates a longer-term concern. The post-conflict moment of the early 2000s opened a window in which women's political participation increased measurably, in part because patriarchal settlements were temporarily destabilised by transition (Tripp, 2015). The narrowing of that window in subsequent cycles indicates that without sustained contestation of informal institutions, formal architecture by itself does not protect early gains. The trajectory is striking when traced numerically. Women constituted approximately 24 per cent of candidates in 2005, the year of the country's first post-war election held under the Comprehensive Peace Agreement. By 2017, women candidates for the House of Representatives had fallen to 15.8 per cent, and by 2023 to roughly 15 per cent of the candidate pool, with the proportion of women elected to the Legislature descending in parallel from 16 per cent in 2006 to 8 per cent in 2023 (Bauer, 2009; Tripp, 2015). This is not the gradual incremental progress that liberal democratic theory predicts. It is a sustained reversal under conditions of formal institutional stability, and it is precisely the kind of trajectory that purely procedural metrics cannot diagnose.

What lies beneath the descent is a layered system of gatekeeping that operates upstream of the ballot itself. Three mechanisms warrant particular attention. First, traditional authority structures, especially in counties such as Lofa where decisions on representative candidatures are taken in the *traditional men's house* from which women are excluded by custom, deny women candidates entry into the deliberative space in which the political opportunity structure is set. Second, godfather politics structure access to party slates and campaign resources through patron–client relationships that, even when individually facilitative for particular women candidates, reproduce a male-dominated grooming pipeline epitomised by the University of Liberia's Student Unification Party and its political mentorship circuits. Third, the strategic logic of party nomination treats women candidates as instruments for satisfying voluntary quota commitments in unwinnable districts while preserving competitive seats for male incumbents, a calculation that surfaced sharply in the 2023 cycle when the National Elections Commission's 30 per cent Memorandum of Understanding produced only fifteen per cent women on candidate lists. The 2023 pre-electoral coalition negotiated among the Unity Party, Liberty Party, and Movement for Democracy and Reconstruction extended the same logic, with women candidates withdrawn to accommodate male nominees from coalition partners. The cumulative effect is what Beresford (2015) describes as the use of authority to control access to political opportunity, and what feminist institutionalist analysis identifies as informal institutions reproducing themselves beneath formally egalitarian rules (Krook, 2016; Mackay et al., 2010). The Liberia case is therefore not a story about a polity failing to progress along the standard transition path. It is a precise instance of how hybrid political orders absorb formal democratic architecture without surrendering the gendered settlements that organise authority in practice.

The county-level texture of these dynamics, examined through the author's fieldwork in Montserrado, Lofa, and Nimba, demonstrates that gatekeeping is not a uniform phenomenon to be addressed through a single instrument. Each of the three counties is governed by a distinct institutional configuration, and each configuration produces a different relationship between formal architecture and women's actual political access. In Montserrado, the urban network organised around the University of Liberia's Student Unification Party functions as a long-running training pipeline for political aspirants whose membership is approximately 90 per cent male and whose evening sessions are scheduled at hours that effectively exclude women bound by gendered domestic roles. The exclusion is enacted not through any written rule but through the social composition of the space and the timing of access, which is the precise mechanism feminist institutionalism instructs us to identify and analyse (Mackay et al., 2010). In Lofa, the configuration shifts toward customary authority, with pre-selection of candidates for House of Representatives seats negotiated in spaces that customary norms close to women, with the consequence that the consequential decision is taken before the formal nomination process begins. In Nimba, the configuration shifts again, toward what local political vocabulary identifies as the kingmaker dynamic, in which endorsement by a senior political patron determines viability; the Movement for Democracy and Reconstruction fielded no female candidates for House of Representatives seats in the 2023 cycle, an outcome that any analysis confined to formal procedures cannot explain (Albaugh, 2022; Kayuni & Chikadza, 2016). The three counties, read together, demonstrate that the same national architecture produces different patterns of women's political access depending on the informal institutions operating beneath it. The implication for democracy assistance is that interventions calibrated at the national level will systematically miss the level at which gatekeeping is actually exercised.

The financial architecture of the 2023 cycle merits separate analytical treatment because it operates as a screening device that precedes the gatekeeping moves discussed above. Candidate financial returns indicate average direct campaign expenditure of approximately 9,281 United States dollars for a House of Representatives race, a figure that excludes nomination filing fees, asset declarations at the Liberian Revenue Authority, insurance bonds, document notarisation, party membership dues, and the transactional costs of voter mobilisation. For aspirants without family wealth or established patronage networks, both of which are gendered in their distribution, the monetary threshold pre-empts entry to the formal candidate selection process altogether. Beresford's (2015) account of southern African patronage politics as a system in which authority is exercised through control of access to opportunity reads as a descriptively accurate analysis of the Liberian electoral economy. The voluntary 30 per cent gender quota produced women as 15 per cent of the candidate pool, a shortfall parties rationalised through reference to candidate viability, which functions in practice as a coded reference to fundraising capacity. Where female candidates were retained on lists, the empirical pattern indicates strategic placement in less competitive districts,

allowing parties to claim quota compliance while preserving electoral viability where seats were genuinely contested. Gatekeeping in Liberia is therefore not lodged in a single institution but distributed across financial, party-organisational, and inter-party levels in ways that mutually reinforce one another. Any intervention designed against one level alone will not displace the configuration. This is the diagnostic point that the rigidity-versus-ontology distinction developed in Section 4 is built to register, and that procedural-stability metrics of post-conflict democratisation systematically miss.

A further dimension of the gatekeeping configuration deserves notice because it bears on how women navigate exclusion when formal party channels fail them. Where party gatekeepers withhold endorsement, financing, or slate placement, the available alternative is to contest as an independent candidate (Conway, 2001). The Liberian record indicates that this option produces consistently weaker electoral results, not because independent women candidates lack political competence, but because the structural disadvantage operates at the level of resource access. Independent candidates carry the full financial burden of the campaign without the institutional infrastructure of a party machine, and they confront an electorate accustomed to evaluating viability through party affiliation. Afrobarometer Round 8 survey data indicate that 85.7 per cent of Liberian respondents accord traditional leaders some level of influence over how voters in their communities vote, with 30 per cent describing this influence as substantial (Afrobarometer, 2021). For an independent female candidate, the absence of party endorsement compounds the structural disadvantage of operating against this baseline of customary authority. The pattern is consistent with what the comparative literature describes as anti-competitive gatekeeping, in which the practice operates not by selecting against women in formal nomination contests but by withholding the resources that make contestation viable in the first place (Albaugh, 2022; Conway, 2001).

The Liberian record also clarifies what kinds of institutional arrangements have historically produced gains for women's political participation, and the answer is relevant for the broader argument of this article. The 24 per cent female candidate share recorded in 2005 was achieved under the Comprehensive Peace Agreement, which incorporated affirmative-action provisions enforced through an externally monitored transition framework (Bauer, 2009; Sims, 2012). Subsequent voluntary mechanisms, including the 30 per cent Memorandum of Understanding negotiated by the National Elections Commission for the 2023 cycle, have failed because the authority to enforce them was retained by the same actors whose preferences the mechanism was designed to constrain. A proposed legislative amendment to introduce a binding 30 per cent quota in advance of the 2023 elections was vetoed by the executive, leaving the voluntary arrangement as the only remaining instrument. This sequence is analytically instructive. It illustrates a generalisable point about democracy assistance in hybrid political orders: voluntary mechanisms placed in the hands of incumbent gatekeepers reproduce the configuration they were intended to displace, while binding mechanisms with external enforcement architecture can generate temporary openings during transitional moments. The implication for the rewrite-the-playbook argument is direct.

The question is not whether to demand stronger formal architecture, but whether the architecture proposed contains enforcement provisions that the political settlement it confronts cannot quietly neutralise (Hamandishe & Ewusi, 2025).

5.3. Zimbabwe: Constitutional Architecture and Cultural Authenticity

Zimbabwe occupies a third position. It is not a post-conflict state in the conventional sense, but it shares with post-conflict polities the central analytic feature of consequence here: a gap between formal democratic architecture and the political settlement which operates beneath it. The country has held regular elections under a relatively detailed constitutional framework since 2013. It has also produced a sustained pattern of contestation over electoral integrity, candidate access, civic space, and the gendered distribution of political opportunity. The 2018 cycle, in which women's representation on party lists fell despite the constitutional commitment to gender equality, illustrated how rapidly gains made through formal architecture can be reversed when informal institutions of party financing, intra-party violence, and ruling-coalition discipline remain unaddressed (Tripp et al., 2009).

The Zimbabwean experience also illustrates the danger of the cultural-turn argument. Arguments invoking cultural authenticity, traditional values, and national rooting have been deployed by the ruling party with sufficient frequency to make the rhetorical move familiar. When deployed without internal critique, these arguments do not democratise the polity. They consolidate the bargain that already governs it. The current global vogue for nationally rooted, conservative carriers of democratic renewal will resonate uncomfortably for analysts familiar with how that argument has functioned in Zimbabwean political discourse over the past two decades.

The constitutional architecture itself rewards careful reading. The 2013 Constitution of Zimbabwe introduced two provisions that on paper should have produced a transformative shift in women's representation. Section 17 commits the state to gender balance in all institutions and agencies of government at every level. Section 124(1)(b) reserves sixty seats in the National Assembly for women, distributed among the ten provinces under a proportional-representation formula derived from the votes cast for political parties in the constituency elections. The combined effect was to lift women's parliamentary presence at one stroke. What the architecture left untouched, however, was the constituency contest itself. Of the 210 directly elected seats, women won 26 in 2013 and 25 in 2018, representing approximately 12 per cent in each cycle (United States Department of State, 2019; Zigomo, 2022). Removed from the reserved-seats column, the substantive participation of women in the competitive electoral arena did not move. The reserved-seats provision, intended as a transitional measure, was extended in 2021 for a further ten years through Constitution of Zimbabwe Amendment (No. 2) Act, an extension that quietly acknowledged the failure of the formal architecture to produce the substantive change the original drafters anticipated. This is the precise pattern that feminist institutionalism identifies (Krook, 2009; Mackay et al., 2010): a formal

innovation that satisfies descriptive representation while leaving the rules-in-use of constituency contests, party financing, and intra-party violence untouched.

The 2018 cycle exposed the underlying logic with unusual clarity. Despite the expectation that the post-Mugabe transition would open democratic space, women constituted approximately 14 per cent of National Assembly candidates, a figure that fell further to 11 per cent in 2023 (Zigomo, 2022; Al Jazeera, 2023). Of the eighty-one women who contested parliamentary seats in Harare in 2018, only five were elected (Zigomo, 2022). The mechanisms producing this outcome are well documented and operate beneath the visible procedural surface of the election. Zigomo's (2022) ethnographic work with eleven female candidates in the 2018 Harare contest identifies a configuration of intersecting barriers in which gender, age, marital status, class, and party identification operate together to constrain women's electoral viability. To these intersectional pressures must be added the structural ones documented across the comparative literature on the region: intra-party primaries in which women aspirants confront violence and intimidation calibrated to deter contestation, party financing structures that systematically advantage incumbents, and the prohibitive nomination fees that escalated sharply by 2023 (Bauer, 2012; Tripp et al., 2009). The ruling party's persistent invocation of cultural authenticity, *pungwe* imagery from the liberation war, and the figure of the disciplined revolutionary cadre operates as what Mamdani (1996) would identify as a discursive consolidation of the very settlement that constitutional reform was meant to displace. The Zimbabwean case is therefore not an outlier. It is a particularly transparent illustration of how a polity can produce a constitutional architecture that meets international benchmarks, perform the procedural rituals of competitive elections, and yet preserve a gendered political settlement in which the meaningful contest for power remains structured along long-established patriarchal lines. Any rewrite of the democratic playbook that does not engage with this pattern, and with the cultural-authenticity argument that legitimates it, will reproduce its analytic shortcomings.

The Zimbabwean trajectory is also legible through the regional comparative literature on women's political participation in the Southern African Development Community context. Mlambo and Kapingura (2019) identify a recurring pattern across the region in which constitutional and policy frameworks formally aligned with the 2008 SADC Protocol on Gender and Development coexist with the persistent under-representation of women in elected office, and in which the gap between formal commitment and substantive outcome is most pronounced where parties retain control over candidate selection without internal democratisation. The 2023 cycle in Zimbabwe extended this pattern with particular sharpness. Nomination fees for presidential candidates rose from approximately 1,000 United States dollars in 2018 to 20,000 dollars in 2023, a twenty-fold escalation that materially closes the political space to candidates outside the resourced political class, with disproportionate consequences for women whose access to capital is structurally constrained. Linda Masarira of the Labour Economists and African Democrats was disqualified for late payment of the fee, and Elisabeth Valerio of

the United Zimbabwe Alliance was admitted only after court intervention. The fee escalation operates as a class-gendered deterrent that pre-empts the substantive electoral contest, and it is a mechanism that no element of the formal electoral architecture is designed to address. Read alongside the documented use of intra-party violence and gendered intimidation as deterrence devices during nomination contests, the cumulative effect is a polity in which the financial and physical costs of female political contestation have been escalated to thresholds higher than those facing male aspirants of comparable political standing (Bauer, 2012; Mlambo & Kapingura, 2019).

A second dimension of the Zimbabwean case clarifies the limits of descriptive representation as a policy goal. Even when the reserved-seat quota lifts the headline figure of women's parliamentary presence to approximately 31 per cent, the substantive distribution of political authority remains heavily skewed. Women remain under-represented in cabinet, in the chairs of consequential parliamentary committees, in the leadership structures of major political parties, and in the electoral commission and constitutional review bodies whose decisions shape the rules-in-use of the political contest. The distinction between descriptive and substantive representation, developed in the African context by Goetz and Hassim (2003) and extended through cross-national analysis by Htun and Weldon (2012), is not a technical refinement of representational theory. It identifies the political work that numerical presence cannot perform on its own. The reserved-seat architecture in Zimbabwe has produced what feminist institutional scholarship characterises as performative compliance: the formal commitment to gender balance is satisfied at the level of headline numbers, while the substantive contest for political authority remains structured along the settlement that constitutional reform was nominally designed to transform. The cultural-authenticity discourse mobilised across electoral cycles, centred on motherhood, marital respectability, and the gendered iconography of the liberation struggle, is the discursive layer through which the settlement defends itself against feminist critique (Zigomo, 2022). The implication for the rewrite-the-playbook argument is direct. Any approval of cultural rooting that does not incorporate an internal critique of how the local is gendered will, in the Zimbabwean case, endorse the discursive architecture used to discipline female political contestants for the past two decades.

A comparative reading of the 2013, 2018, and 2023 electoral cycles in Zimbabwe sharpens the analytical point about constitutional architecture and informal containment. The 60 reserved seats introduced under the 2013 Constitution were intended as a transitional measure to address historical under-representation while political parties reformed their internal candidate selection processes. The empirical record indicates that the major political parties, including ZANU-PF and the MDC formations, treated the reserved seats as a substitute for inclusion in direct contests rather than as a complement to it. The Zimbabwe Election Support Network documented a systematic exclusion of women from direct candidate selection across political parties in 2013, with the explanation offered that women would be represented through the sixty seats reserved for them (ZESN, 2013). Scholarship on Zimbabwean gender politics has

characterised this as the zero-sum framing of the quota: the reserved seats absorb the political demand for women's representation while preserving the open contest as a male-dominated terrain (Hamandishe, 2018). The structural consequence is that the proportion of women directly elected to the National Assembly has remained at approximately 12 per cent across the three cycles, despite headline parliamentary figures of 31 to 34 per cent achieved through the quota. The architecture has produced descriptive representation; it has not produced substantive change in the gendered distribution of electoral opportunity (Hamandishe, 2018).

The local government tier provides an additional empirical window into the same dynamic. The Zimbabwean reserved-seat quota applies at the national parliamentary level only. At the local council tier, where a first-past-the-post system operates without quota provisions, women's representation has declined steadily from approximately 18 per cent in 2008, to 16 per cent in 2013, and to 14 per cent in 2018 (Hamandishe, 2018). The trajectory is significant for two reasons. First, it falsifies the assumption that parliamentary quotas generate pipeline effects for local-level gender inclusion, an assumption that has informed several donor strategies for women's political participation across the region. Second, it reveals what happens beneath the protective architecture of the reserved seats: the gendered settlement of electoral competition reasserts itself with each cycle, contracting rather than expanding women's political access at the tier of governance closest to citizens. The 2022 statutory amendment, which raised candidate registration fees to twenty thousand United States dollars for presidential candidates and one thousand dollars for National Assembly candidates, accelerated this contraction by introducing a class-gendered financial threshold that pre-empts entry. The cumulative pattern, traced across three electoral cycles and across both the parliamentary and local tiers, indicates that the constitutional architecture has not displaced the underlying political settlement. It has instead produced a stratified arrangement in which women's substantive political authority remains constrained at every level not protected by binding external requirements (Mlambo & Kapingura, 2019).

Three different polities, three different relationships to conflict and constitutional reform, three illustrations of the same analytic point. Templates calibrated to the consolidated liberal state miss the substance of political competition in hybrid orders. Generic cultural-turn arguments, which propose to remedy this by rooting democracy in local memory and identity, cannot adjudicate among competing claimants to 'the local,' and in practice frequently empower the loudest of them. The next section examines this problem in greater depth through the gender lens.

6. Whose Local? The Gender Problem in the Cultural Turn

The current case for rewriting the playbook welcomes nationally rooted, conservative figures as authentic carriers of democratic renewal. The rewrite argument treats vernacular fluency as a virtue, and some of its recent articulations use conservative political figures who have positioned themselves as nationally rooted carriers of

democratic renewal as illustrations. The point about vernacular is well taken. Democracy that does not articulate itself in the languages, idioms, and registers of the people it claims to serve will fail. The difficulty is what happens next, when the question shifts from whether to root democratic practice locally to which local voices are accorded democratic warrant.

In African contexts, the answer to this second question has historically been narrow. Tripp's (2015) comparative analysis of post-conflict trajectories in Liberia, Rwanda, Uganda, and Burundi documented how transitional moments destabilised patriarchal settlements and created openings for women's political participation that pre-conflict politics had foreclosed. Where the post-transitional period treated local rooting as a sufficient democratic warrant, those gains were among the first revisited. Goetz and Hassim's (2003) earlier work showed that the architecture of women's representation requires sustained contestation across legislative, executive, and party institutions to translate numerical presence into substantive influence. Numerical gains in legislatures, where they have occurred, have not generally been mirrored in cabinets, party leadership structures, electoral commissions, or constitutional review bodies.

The Somalia case develops this argument empirically. Hamandishe and Ewusi (2025) document how the formal architecture of gender quotas in post-2012 Somalia has functioned as what they describe as performative compliance: the formal commitment is satisfied at the level of seat counts, while the substantive distribution of authority remains unchanged. Female parliamentarians describe being systematically blocked from committee assignments, with seats reclassified to male candidates after quota allocation has formally been agreed. International donor pressure produces episodic increases in numerical representation, followed by reversals once attention moves elsewhere. The pattern is not anomalous. It is the predictable outcome of a political settlement in which liberal electoral architecture is layered over a clan-based decision system, with neither track able to discipline the other.

The risk in the current rewrite-the-playbook argument is therefore not that it values local political reality. The risk is that it treats the local as undifferentiated and accords democratic legitimacy to whoever speaks the local language with the loudest voice. In post-conflict Africa, that voice has rarely been a woman's, a youth's, or a minority's. A democratic theory which cannot adjudicate among competing claims to the local cedes its critical edge.

Feminist institutionalism offers the analytic apparatus to make this adjudication. Its key methodological move is to insist that the rules-in-use are themselves the object of analysis: not the formal institutional architecture alone, but the actual practices through which authority is exercised, contested, and reproduced (Mackay et al., 2010). Krook's (2009, 2016) comparative analysis of quota implementation showed that the same formal design produces different outcomes depending on the informal institutions which surround it. Mackay and colleagues' (2010) broader argument is that change is most likely where formal innovation, informal contestation, and discursive shift align. When this analytic apparatus is applied to the cultural-turn argument, the prescription which

emerges is more demanding than the original commentary suggests. It requires not only listening to local voices but specifying which voices, on what authority, and through what institutional configurations they are allowed to shape democratic practice. The cultural turn, in other words, must be a feminist institutional turn if it is to do the analytic work its proponents claim for it.

7. Discussion: Toward Co-Produced Democratic Practice

The argument advanced in the foregoing sections converges on a set of analytic and policy implications that diverge substantively from the dominant frame in democracy promotion. Three implications merit particular attention.

First, democracy assistance should fund analysis before it funds activity. Hybrid political orders demand a settlement-level reading of who actually governs in a given polity, on what authority, and through which informal institutions, before electoral cycles, civic education curricula, or institutional capacity-building programmes are funded as if they were the main game (Boege et al., 2009; Mkandawire, 2015). The standard programme cycle, in which a country assessment of three to six months precedes a multi-year intervention designed around standard pillars, builds the assumptions of the standard playbook into the architecture of assistance itself. A reoriented architecture would invest more in analytic capacity at the front end and treat programming as derivative of analysis rather than the reverse. The Sahel experience, in which a sustained pattern of military coups since 2020 has unfolded against the backdrop of long-running international democracy and security assistance, provides a sharp illustration of the cost of analytic shortcuts (Akinola & Makombe, 2024; Ziso & Hamandishe, 2024).

Second, gender analysis should be constitutive of political analysis, not appended to it. Feminist institutionalism provides the analytic tools to make this shift (Krook, 2009; Mackay et al., 2010). In professional practice, this means that observer methodologies, civic education curricula, candidate training programmes, and dispute-resolution frameworks should be designed as instruments through which the gendered political settlement of a polity becomes visible and contestable. The Somalia and Liberia experience suggests this is feasible. The campaign manuals, conflict-prevention frameworks, and methodological tools developed for those contexts produced more durable outcomes when gender was treated as a feature of political competition rather than as a sectoral concern. The institutional location of gender within democracy assistance organisations is part of the difficulty: where gender sits in a separate unit, it is a separate concern; where it is constitutive of political analysis, it shapes the design of programming itself (Goetz & Hassim, 2003; Htun & Weldon, 2012).

Third, knowledge production must shift. African scholars, women's movements, electoral commissions, and civil society organisations have generated a substantial body of context-grounded analysis on the questions raised here, much of which sits outside the canonical literature on democracy promotion. The continued treatment of African scholarship as ethnographic supplement to comparative theory developed in the Global

North is not merely an aesthetic complaint. It produces poor analysis. Mkandawire's (2015) reconstruction of neopatrimonialism, Ake's (1996) challenge to externally derived democratic theorising, and the long arc of African feminist political thought are not regional contributions to be integrated into a metropolitan core. They are the analytic frame through which the politics of African polities can be read accurately. Treating Global South knowledge as co-constitutive, rather than as case material, is a precondition for any honest rewrite of the democracy playbook.

These implications also connect to the journal's wider remit on analytical concerns shared between African and Central and Eastern European contexts. The analytic apparatus developed here, treating hybridity, gendered institutional configuration, and the politics of authenticity as constitutive rather than residual, transfers usefully to Central and Eastern European polities where hybrid political orders and contested constitutional settlements coexist with formal democratic architecture. What such comparison requires is analysis on each polity's own terms, rather than the flattening of distinct political ontologies into a generic democratic-backsliding narrative.

8. Conclusion

The case for rewriting the democracy playbook is well made. The case for rewriting it carefully is stronger still. Templates fail when they misread the political ontology of the societies they enter, and they fail again when 'the local' is invoked without internal critique. Rigidity is part of the problem, but only part. The deeper difficulty is that the standard playbook presupposes a polity which most of its target contexts do not exhibit, and the cultural-turn argument that seeks to repair the resulting damage cannot, on its own, distinguish a democratic local from an authoritarian one.

A more durable democratic practice begins where most post-conflict polities already are: in the negotiated, gendered, hybrid orders which liberal theory has long preferred to treat as residual. The path forward requires three commitments. The first is to political analysis grounded in the actual configuration of authority in a given polity. The second is to feminist analytic frames that take seriously the rules-in-use through which gendered political settlements are produced and contested. The third is to a knowledge architecture that treats Global South scholarship and practitioner knowledge as constitutive of theory rather than as evidence in support of theories produced elsewhere. None of these commitments is novel. The question is whether the architecture of democracy assistance is willing, at last, to take them seriously.

Future research should test these claims through case-grounded empirical work in additional post-conflict and politically constrained African settings, and should examine the analogous patterns in Central and Eastern European contexts where hybrid political orders also operate beneath formal democratic architecture. The agenda is large. It starts from the recognition that the polities to which democratic theory has long been applied have been theorising themselves all along.

Conflict of Interest

The authors hereby declare that they have no financial interest in this manuscript.

Notes on Contributor

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Investment Decisions and Firm Growth Among SMEs: The Moderating Role of CEO Duality in Ghana[1]

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Abstract:

Background: Small and medium-sized enterprises (SMEs) form the bulk of Ghana's private sector and are a major source of jobs, yet many of them grow slowly because scarce capital is committed to projects that do not pay off. How SME leaders take investment decisions, and who holds authority over those decisions, is therefore an economic question as much as a managerial one. Objectives and scope: The study examined the effect of investment decisions (ID) on firm growth (FG) among SMEs in the Accra and Tema metropolitan areas, the effect of CEO duality (CEOD), where one person serves as both chief executive officer (CEO) and board chair, on FG, and whether CEOD moderates the ID–FG relationship, with firm age, firm size and industry as control variables. Methodology: Agency Theory and the Resource-Based View (RBV) informed the framework. Survey data from 341 SME owners, managers and decision-makers were analysed with Partial Least Squares Structural Equation Modelling (PLS-SEM) in SmartPLS 4, supported by several robustness checks. Results: ID had a strong positive effect on FG ($\beta = 0.650$, $t = 12.768$, $p < 0.001$), and CEOD also had a positive effect on FG ($\beta = 0.283$, $t = 5.530$, $p < 0.001$). The ID × CEOD interaction was positive and significant ($\beta = 0.051$, $t = 2.166$, $p = 0.030$) and remained significant after the control variables were added ($\beta = 0.031$, $t = 2.583$). Firm age ($\beta = 0.371$), firm size ($\beta = 0.317$) and industry ($\beta = 0.206$) also had positive effects on FG, and the model explained 81.5% of the variance in FG ($R^2 = 0.815$). Conclusion: Investment decisions translate into stronger growth when decision authority is unified, which suggests that SME owners, investors and support agencies should treat investment planning and leadership structure as joint decisions.

Keywords: Investment Decisions; Firm Growth; CEO Duality; SMEs; Agency Theory; Resource-Based View; Ghana.

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1. Introduction

Small and medium-sized enterprises (SMEs) form the backbone of private economic activity in Ghana. They dominate trade, light manufacturing, construction, hospitality and services, absorb a large share of the urban workforce, and supply many of the goods and services consumed in cities such as Accra and Tema (Gherghina et al., 2020; Kerr & McDougall, 2026). Their growth therefore matters for national income, tax revenue and job creation, particularly as Ghana seeks broader private-sector expansion after the debt and inflation pressures of recent years (World Bank, 2025). Yet many Ghanaian SMEs remain small for long periods. Limited access to finance, high borrowing costs and weak management systems restrict the funds available for expansion, so the way scarce capital is committed to equipment, technology, stock, people and new markets largely determines which firms grow and which stagnate (Naradda Gamage et al., 2020; Nkansah-Sakyi, 2023).

In this paper, investment decisions (ID) refer to the choices SME leaders make about how much to invest, in what, when and with what level of risk, while firm growth (FG) refers to the expansion of sales, assets, employment, profit and market reach. CEO duality (CEOD) describes the situation in which the same person serves as Chief Executive Officer (CEO) and chair of the board. Firm age (FA), firm size (FS) and industry (IND) are used as control variables, and the analysis is carried out with Partial Least Squares Structural Equation Modelling (PLS-SEM). These abbreviations are used throughout the remainder of the paper.

Investment decisions are a central driver of firm growth, as they determine how resources are allocated to generate future returns and sustain competitiveness (Almansour et al., 2023; Mittal, 2022). While prior studies establish that effective investment decisions can enhance firm performance, empirical findings remain inconsistent, particularly within Small and Medium Enterprises (SMEs) operating in emerging economies. Some studies report positive growth outcomes from investments in productive assets, innovation, and market expansion (Chen et al., 2024; Farida & Setiawan, 2022), whereas others show weak or negative effects due to financial constraints, poor timing, or inefficient resource allocation (Ahmed et al., 2020; Yiu et al., 2020). These mixed results suggest that the investment–growth relationship is context-dependent and influenced by internal firm characteristics. To improve estimation accuracy, the study also controls for firm-specific characteristics such as firm size, firm age, and industry effects, as these factors may independently influence firm growth.

SMEs, which are central to employment creation and economic development, are particularly vulnerable to inefficiencies in investment decision-making due to structural and governance limitations (Naradda Gamage et al., 2020; OECD, 2019). These structural limitations include concentrated ownership, limited managerial expertise, weak internal controls, restricted access to finance, and informal organizational processes, all of which increase the likelihood of suboptimal investment decisions.

CEO duality where the same individual serves as both Chief Executive Officer and Board Chairperson is therefore common in such firms. While this structure may facilitate faster decision-making and strategic alignment, it can also alter the mechanism through which investment decisions influence growth. Specifically, CEO duality may strengthen or weaken this relationship. It strengthens the relationship when the dual role enables coherent strategic planning and swift execution of growth-oriented investments, ensuring effective resource deployment. Conversely, it weakens the relationship when concentrated power reduces oversight, encourages personal bias, or leads to resource misallocation.

This study addresses these gaps by examining the relationship between investment decisions and firm growth among SMEs in Ghana, with CEO duality explicitly modelled as a **moderating variable**. Drawing on Agency Theory and the Resource-Based View (RBV), the study provides a framework for understanding how governance structures influence the efficiency of resource allocation and strategic decision-making (Wijethilake & Ekanayake, 2020; Ferreira & Ferreira, 2025; Lubis, 2022). While RBV emphasizes the role of investments in leveraging valuable and rare resources for competitive advantage, Agency Theory highlights how governance mechanisms, such as CEO duality, affect managerial behaviour and decision outcomes.

The novelty of this study lies in incorporating CEO duality as a moderator in the investment–growth relationship, thereby moving beyond the dominant focus on direct effects in prior research (Suteja et al., 2023; Saif Ul Islam et al., 2022). By doing so, the study provides a theoretically grounded explanation for the inconsistent findings reported in the literature and responds to calls for incorporating contingent factors in empirical models (Rasoolimanesh et al., 2021; Hayes, 2017).

Empirically, the study contributes evidence from Ghana, where SMEs operate under conditions of financial constraints, regulatory uncertainty, and governance variability. The findings show that investment decisions significantly influence firm growth; however, this relationship is significantly moderated by CEO duality. Specifically, CEO duality strengthens the positive effect of investment decisions when it enables faster and more coherent strategic execution (Cambrea et al., 2025; Nuanpradit, 2024; La Rocca et al., 2024), but weakens the relationship when reduced oversight leads to inefficient or misaligned investments (Ali et al., 2022; Romano et al., 2020; Mubeen et al., 2020).

The study contributes to knowledge in three ways. On the theoretical side, it combines Agency Theory and the Resource-Based View (RBV) to show that the investment–growth relationship depends on how decision authority is structured, with CEO duality conditioning the effectiveness of investment decisions. On the empirical side, it provides evidence from Ghanaian SMEs on the direct and moderating effects of CEO duality, which helps to reconcile earlier inconsistent findings on the relationship between investment and growth. On the practical side, it shows that the returns from investment strategies depend on leadership structure as well as on resource allocation, which gives SME owners, investors and regulators a basis for designing governance arrangements that support growth.

Overall, this study advances the literature by demonstrating that investment decisions are not purely financial choices but governance-conditioned strategic actions, with CEO duality conditioning their effect on firm growth. By explicitly modelling CEO duality as a moderator and clarifying its channels of influence through both agency cost reduction and efficient resource deployment the study provides a clearer explanation of when, why, and how investment decisions translate into firm growth in SMEs. This approach not only reconciles prior inconsistencies in the literature but also offers practical guidance for SME owners, investors, and policymakers seeking to optimize governance structures for growth.

The aim of the study is to establish whether, and under what leadership arrangement, investment decisions raise the growth of Ghanaian SMEs. Three objectives follow from this aim: to examine the effect of ID on FG, to assess the effect of CEOD on FG, and to determine whether CEOD moderates the ID–FG relationship once FA, FS and IND are controlled. Accordingly, the study answers three research questions. RQ1: What is the effect of investment decisions on the growth of SMEs in Ghana? RQ2: What is the effect of CEO duality on the growth of SMEs in Ghana? RQ3: Does CEO duality change the strength of the relationship between investment decisions and SME growth when firm age, firm size and industry are held constant?

The remainder of the paper is organised as follows. Section 2 reviews Agency Theory, the RBV and the empirical literature and develops the hypotheses and the conceptual framework. Section 3 describes the research design, sampling, measurement, model specification and robustness checks. Section 4 presents the measurement and structural model results, Section 5 discusses the findings in relation to the Ghanaian economy and earlier studies, and Section 6 concludes with the implications, limitations and directions for further research.

2. Literature Review

2.1 Agency Theory and Investment Decisions

Agency Theory provides a foundational framework for understanding how investment decisions (ID) affect firm growth (FG). According to Jensen and Meckling (2019), conflicts of interest between managers (agents) and shareholders (principals) can lead to suboptimal investment decisions if managerial incentives are misaligned with owner objectives. Governance mechanisms, such as board oversight and incentive structures, are therefore critical in guiding managerial behavior toward decisions that maximize shareholder wealth. Empirical evidence shows that firms with effective governance structures are more likely to undertake investments that generate superior growth outcomes (Naz et al., 2022; Dong et al., 2021).

Within this framework, CEO duality where the CEO also serves as Board Chair moderates the ID–FG relationship by influencing both decision authority and monitoring. Firms with CEO duality may implement investment strategies more rapidly, aligning managerial actions with firm objectives. However, concentrated executive power can reduce independent oversight, increasing the risk of inefficient or self-serving

investment decisions (Alves, 2023; Le et al., 2023; Alves, 2020). Hence, the effectiveness of investment decisions is contingent upon the balance between authority concentration and governance oversight.

Agency Theory was developed mainly for firms in which ownership and control are separated, so its use in a study of SMEs requires justification. The theory is applied here to SMEs that have a board in which the CEO and chair positions can be held either by the same person or by different persons; in the sample, 172 firms (50.4%) combined the two positions and 169 firms (49.6%) separated them. In such SMEs, agency conflicts do not arise between dispersed shareholders and professional managers, as in large listed companies, but between owner-managers and minority or non-managing owners, between family and non-family shareholders, and between owners and lenders who finance expansion (Abor & Biekpe, 2007; Teixeira & Carvalho, 2024). Evidence from Chinese SMEs and from new ventures shows that board leadership structure affects performance in smaller firms (Li et al., 2022; Gan & Erikson, 2022), and a recent systematic review confirms that the consequences of CEO duality depend on firm size and ownership context (Mehmood et al., 2025). Agency Theory is therefore used together with the RBV, which explains how the resources of small firms are deployed, rather than on its own.

2.2 Resource-Based View (RBV) and Firm Growth

The Resource-Based View (RBV) complements Agency Theory by emphasizing how firms achieve growth through the strategic deployment of valuable, rare, inimitable, and non-substitutable (VRIN) resources (Ferreira & Ferreira, 2025). Investment decisions are the primary vehicle through which these resources—such as financial capital, human expertise, and technological assets—are mobilized to create competitive advantage. Firms that align their investment choices with their resource endowments tend to experience superior growth outcomes (Lubis, 2022; Beamish & Chakravarty, 2021).

In this theoretical context, CEO duality functions as a moderator that shapes the efficiency of resource allocation. Unified leadership under CEO duality allows for coordinated deployment of resources, reducing delays and ensuring that investments leverage the firm's unique capabilities effectively. Conversely, weak oversight associated with duality can lead to inefficient resource use, limiting growth potential (Curea et al., 2022; Nguyen et al., 2021; Madhani, 2017). This highlights that investment effectiveness depends not only on the availability of resources but also on how governance structures facilitate their strategic use.

2.3 Integration of Agency Theory and RBV

Integrating Agency Theory and the RBV provides a robust framework for understanding how investment decisions drive SME growth and why CEO duality serves as a critical moderator. From the Agency Theory perspective, CEO duality can reduce agency costs by aligning managerial incentives with owner objectives, centralizing decision-making, and accelerating approval of growth-oriented investments. From the RBV perspective,

duality enhances resource allocation efficiency by enabling coordinated deployment of firm-specific resources to high-value projects.

CEO duality positively moderates the ID–FG relationship because it simultaneously reduces agency costs and improves resource deployment. By centralizing authority, it ensures that managerial actions are aligned with ownership goals, minimizing conflicts that could delay or distort investment decisions. At the same time, unified leadership allows for the rapid and coordinated allocation of financial capital, human expertise, and technological resources, enhancing the effectiveness of investment decisions and ensuring that resources are used optimally to drive firm growth.

In Ghanaian SMEs, this integration is particularly relevant. These firms often face resource scarcity, informal governance, and limited monitoring mechanisms, which amplify the importance of leadership structures that can manage agency challenges and deploy resources efficiently. By centralizing authority, CEO duality mitigates agency problems and ensures that scarce resources are strategically mobilized, providing a theoretical justification for its positive moderating role in the ID–FG link.

The conceptual framework in Section 2.9 (Figure 1) reflects this relationship, showing investment decisions influencing firm growth, moderated by CEO duality via agency cost reduction (from Agency Theory) and resource allocation efficiency (from RBV), with contextual factors such as informal governance and resource constraints in Ghanaian SMEs shaping the overall effect. This integrated framework provides a distinct theoretical basis for explaining why similar investment decisions may yield different growth outcomes across SMEs and highlighting the conditional yet positive effect of CEO duality on translating investments into growth.

2.4 Investment Decisions

Investment decisions refer to the processes through which firms allocate financial resources to projects, assets, or activities expected to generate future returns (Rashid & Saeed, 2017). These decisions are shaped by several key indicators. Allocation reflects how firms distribute resources across potential investment opportunities to maximise long-term benefits (Baker & Ricciardi, 2014). Diversification involves selecting a combination of assets or projects to reduce exposure to risk while enhancing performance potential (Fabozzi et al., 2008). Timing represents managerial judgement regarding when to initiate investments, based on expected market or operational conditions (Graham & Harvey, 2001). Risk captures the level of uncertainty associated with investment outcomes and the firm's willingness to engage in projects with varying levels of volatility (Sharpe, 1964). Evaluation involves assessing the financial feasibility, expected returns, and strategic relevance of potential investments before committing resources (Brigham & Ehrhardt, 2013). Together, these indicators define investment decisions as deliberate actions aimed at supporting sustainable organisational development.

2.5 Firm Growth

Firm growth refers to the expansion of a firm's operations, capabilities, and performance over time (Sterk et al., 2021). Growth is reflected through several measurable indicators. Sales growth represents the firm's ability to increase revenue generation over successive periods (Delmar et al., 2003). Assets growth captures the accumulation of physical and intangible resources that support production and service delivery (Penrose, 2009). Employees represent the expansion of the workforce, reflecting greater operational capacity and organisational development (Wiklund & Shepherd, 2003). Profit indicates the firm's ability to generate higher returns relative to costs, signifying improved financial performance (Delmar et al., 2003). Market growth reflects an increase in market share or customer reach, demonstrating competitive strength and strategic progress (Davidsson & Wiklund, 2017). Through these indicators, firm growth represents the measurable advancement of organisational performance and capacity.

2.6 SME Growth

SME growth refers to the expansion of small and medium enterprises in terms of operational capacity, market reach, and financial performance over time (Serrasqueiro et al., 2021). Growth in SMEs is shaped by both internal firm characteristics and external environmental conditions that influence their ability to compete and scale (Tsuruta, 2020). Unlike large firms, SME growth is often nonlinear and highly constrained by resource limitations, managerial capacity, and governance structures (Lim et al., 2020). Growth in SMEs can be assessed through several indicators. Revenue growth reflects increased sales performance and enhanced market demand for the firm's products or services (Saridakis et al., 2018). Employment growth shows expansion in the workforce, signalling increased production capacity and organisational development (Varum & Rocha, 2013). Market expansion represents the ability of SMEs to penetrate new customer segments or geographical areas, demonstrating improved competitive positioning (Storey, 2016). Asset growth indicates the accumulation of productive resources such as machinery, technology, and intellectual capital that support long-term development (Širec & Crnogaj, 2010). Profit growth measures the improvement in financial returns and operational efficiency over time (Foreman-Peck et al., 2006).

SME growth is strongly influenced by the effectiveness of strategic decision-making processes, particularly those related to investments. Due to structural constraints such as limited capital access, managerial deficiencies, and inadequate governance mechanisms, SMEs often struggle to make optimal investment choices that support sustainable growth (Ermawati, 2025; Teirlinck, 2017). As a result, leadership structure especially the presence or absence of role separation plays a significant role in determining how investment decisions translate into SME growth outcomes (Kindström et al., 2024).

2.7 CEO Duality

CEO duality refers to a governance structure in which the same individual occupies both the position of Chief Executive Officer and Chairperson of the Board. This structure influences decision-making authority and oversight within the firm (Alves, 2023). CEO duality concentrates authority in the hands of the CEO, which can limit the board of directors' ability to provide effective oversight (Yu,2023; Dalton & Dalton, 2011). This structure can foster stronger and more decisive leadership (Lin et al., 2023). However, the concentration of power also creates the potential for CEOs to pursue personal interests that may conflict with the company's overall objectives (Li et al., 2022). Power reflects the consolidation of strategic control in the hands of the CEO, shaping how decisions are directed across organisational levels (Finkelstein & D'Aveni, 1994). Control refers to the CEO's influence over board activities and monitoring processes, affecting the level of accountability applied to managerial actions (Daily & Dalton, 1997). Authority captures the formal decision-making rights associated with holding both executive and board leadership roles (Brickley et al., 1997). Influence represents the CEO's capacity to shape board discussions, strategic priorities, and organisational direction (Boyd, 1995). Governance reflects how CEO duality affects the firm's internal oversight structure and the balance between managerial independence and board supervision (Daily & Dalton, 1997). These indicators define CEO duality as a structural feature that shapes leadership decision processes and organisational control.

2.8 Empirical Review and Hypotheses

2.8.1 Investment Decisions (ID) and SME Growth (FG)

Investment decisions are critical for firm growth because they determine how financial and non-financial resources are allocated to generate future returns (Almansour et al., 2023; Mittal, 2022). Prior studies indicate that investments in productive assets, innovation, market expansion, and advanced capital-budgeting techniques enhance SME growth by increasing operational capacity, competitiveness, and profitability (Gichuru et al., 2024; Nicolas, 2022; Ali et al., 2024; Darmansyah, 2025; Shields et al., 2024; Anipa et al., 2025; Ahmed et al., 2023). However, these effects are context-dependent and may vary due to financial constraints, managerial capabilities, and governance structures.

Theoretically, the **Resource-Based View (RBV)** suggests that strategic allocation of valuable and rare resources through investment decisions enables SMEs to develop unique capabilities and sustain growth (Ferreira & Ferreira, 2025; Lubis, 2022). **Agency Theory** highlights that managerial decision-making efficiency affects whether investments translate into firm performance, particularly in firms with limited oversight (Mehmood et al., 2025; Wijethilake & Ekanayake, 2020).

Building on these theoretical perspectives, we reason that in the context of Ghanaian SMEs, **well-structured investment decisions are likely to positively influence growth**. This is because when SMEs strategically allocate scarce financial and human resources, they

can enhance operational capacity, exploit market opportunities, and strengthen competitive advantages. Moreover, under effective governance, managers are more likely to align investment actions with firm objectives, further supporting growth.

H1: Investment Decisions have a significant positive effect on SME Firm Growth in Ghana.

2.8.2 CEO Duality and SME Firm Growth

Evidence on CEO duality's effect on firm performance is mixed. Some studies suggest that combining the roles of CEO and Board Chair can facilitate faster decision-making, strategic alignment, and implementation of growth initiatives (Abor & Biekpe, 2007; Dixit et al., 2024; Li et al., 2022). Conversely, concentrated power may reduce oversight, increase managerial opportunism, and weaken performance (Mubeen, 2021; Owusu, 2021; Din et al., 2024).

From a theoretical perspective, **Agency Theory** predicts that CEO duality can either mitigate or exacerbate principal–agent conflicts depending on the firm's governance environment. In SMEs, where formal monitoring mechanisms are often weak, duality may significantly shape managerial decision-making and the translation of investments into growth outcomes (Yahaya, 2025; Yu, 2023). Thus, we anticipate that CEO duality has a meaningful influence on growth, but the direction and magnitude depend on the quality of governance and oversight.

H2: CEO Duality has a significant positive effect on SME Firm Growth.

2.8.3 Firm-Specific Characteristics (Firm Age, Firm Size, and Industry) and SME Firm Growth

Firm-specific characteristics such as firm age, firm size, and industry structure have repeatedly been identified as important determinants of SME growth, although the magnitude and direction of their effects often depend on internal capabilities and external operating conditions. Recent empirical studies indicate that firm age contributes to growth through accumulated operational experience, improved managerial routines, and strengthened stakeholder relationships, which together support performance stability and expansion over time (Erdogan, 2023; Angelidou et al., 2022). Older SMEs are often able to refine processes and strengthen market positioning, which enhances their ability to convert resources into sustained growth, although some evidence shows that very mature firms may experience slower expansion due to reduced flexibility in responding to environmental changes (Garcia-Martinez et al., 2023; Coad et al., 2018). Firm size has also been widely associated with SME growth outcomes, as it reflects access to financial capital, workforce capacity, and operational scale advantages that support expansion in output, employment, and profitability. Empirical evidence from developing economies, including Ghana and other African contexts, suggests that larger SMEs tend to perform better in terms of financial growth because they can spread fixed costs, attract external financing more easily, and invest in productive resources more

effectively (Ahinful et al., 2023; Kerr & McDougall, 2026; Ayambila, 2023; Gupta et al., 2013). Smaller enterprises, however, may face greater resource limitations that restrict expansion, even though they sometimes demonstrate adaptive responses to market changes that support short-term performance improvements (Beck et al., 2005; Erdogan, 2023).

Industry classification further explains differences in SME growth patterns because firms operate under varying competitive pressures, regulatory frameworks, and demand conditions across sectors. Studies focusing on Ghanaian SMEs show that firms in manufacturing, trade, and services exhibit different growth trajectories due to differences in capital intensity, innovation requirements, and market accessibility (Essel et al., 2019; Toku et al., 2020; Ayambila, 2023). Sectoral conditions therefore shape how firms convert internal resources into growth outcomes, making industry an important control variable in SME performance models, particularly in developing economies where structural differences across sectors remain pronounced (Oppong et al., 2014; Kerr & McDougall, 2026). From a theoretical standpoint, the Resource-Based View explains firm age and size as proxies for accumulated resources and capabilities that can be deployed to improve growth performance (Barney, 1991), while Agency Theory suggests that managerial effectiveness influences how efficiently these resources are utilized for expansion (Jensen & Meckling, 2019). Industry structure further conditions these relationships by shaping competitive intensity and resource requirements across sectors. In the Ghanaian SME environment, firms with greater operational experience, larger resource bases, and favourable industry positioning are more likely to record stronger growth outcomes when managerial decisions are aligned with strategic objectives and market opportunities. Thus, we anticipate that firm age, firm size, and industry structure have a meaningful influence on SME firm growth, while the direction and magnitude of these effects depend on resource availability, managerial capacity, and sector-specific conditions.

H3a: Firm Age has a significant positive effect on SME Firm Growth.
H3b: Firm Size has a significant positive effect on SME Firm Growth.
H3c: Industry has a significant positive effect on SME Firm Growth.

2.8.4 CEO Duality as a Moderator between Investment Decisions and SME Growth

While prior research confirms that both investment decisions and CEO duality influence performance independently, few studies examine how duality conditions the effectiveness of investments. Conceptually, CEO duality can accelerate or hinder growth depending on how it affects the translation of investments into strategic outcomes. Duality may strengthen the effect of investments when it enables swift decision-making, coherent strategic execution, and coordinated deployment of firm-specific resources (Cambrea et al., 2025; Nuanpradit, 2024; La Rocca et al., 2024). Conversely, duality can weaken the effect when reduced oversight allows misaligned investments or

personal biases to dominate decision-making (Ali et al., 2022; Romano et al., 2020; Mubeen et al., 2020).

By integrating **RBV and Agency Theory**, we argue that CEO duality moderates the investment–growth relationship by influencing the efficiency and alignment of resource deployment. Specifically, in Ghanaian SMEs—where governance is often informal and resources are constrained dual leadership may ensure that scarce financial, human, and technological resources are effectively mobilized to generate growth, while poor oversight could undermine the returns from investments. Empirical evidence from governance studies supports the plausibility of this moderation, even if not yet fully tested in the SME context (Pham & Pham, 2020; Arosa et al., 2013; Dakhlallh et al., 2019; Ronoh, 2025).

H4: CEO Duality positively moderates the relationship between investment decisions and SME Firm Growth, such that the positive effect of investment decisions is stronger under effective CEO duality and weaker under reduced oversight.

2.9 Conceptual Framework

The conceptual framework of this study examines three primary constructs: Investment Decisions (ID) as the independent variable, SME Firm Growth (FG) as the dependent variable, Firm Size (FS), Firm Age (FA), Industry (IND) as Control Variables and CEO Duality (CEOD) as the moderating variable. The identification and refinement of these constructs are informed by evidence and theoretical perspectives from the literature review, as presented in **Figure 1**.

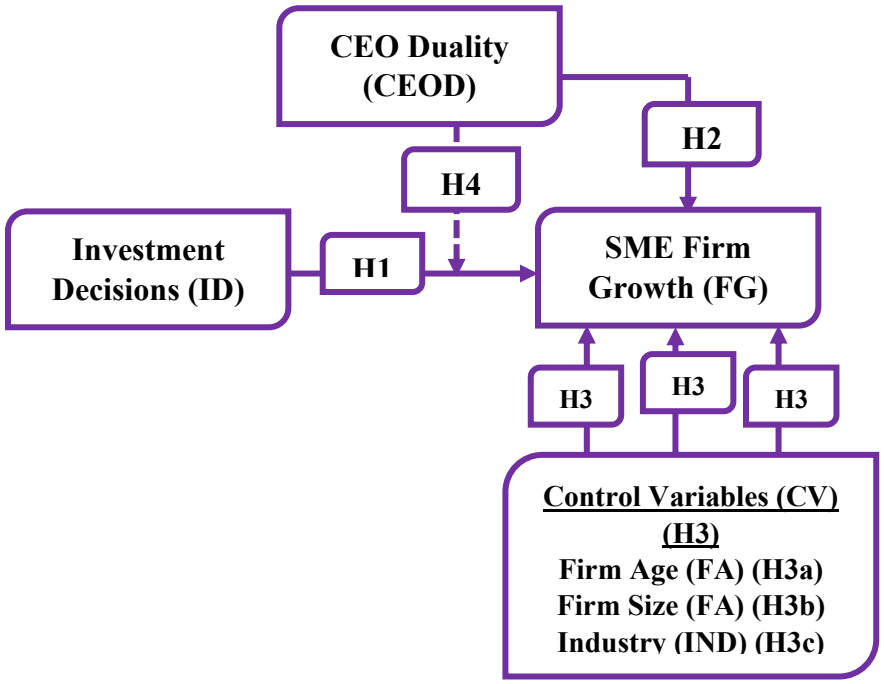


Figure 1: Conceptual framework diagram. Source: Authors' conceptual framework 2026

In Figure 1, the solid arrows show the direct paths tested in H1 (ID → FG), H2 (CEOD → FG) and H3a to H3c (FA, FS and IND → FG), while the dashed arrow from CEOD

to the ID–FG path shows the moderating effect tested in H4. The labels on the arrows identify the hypotheses and do not represent estimated coefficients.

2.10 Conceptualization and Operationalization of Variables

The study utilized defined constructs and their associated measurement indicators, based on previously validated scales, as presented in **Figure 2**.

Constructs	Indicators	Source	Code
Investment Decisions (ID)	Allocation	(Baker & Ricciardi, 2014)	ID1
	Diversification	(Fabozzi et al., 2008)	ID2
	Timing	(Graham & Harvey, 2001)	ID3
	Risk	(Sharpe, 1964)	ID4
	Evaluation	(Brigham & Ehrhardt, 2013)	ID5
SME Firm Growth (FG)	Sales	(Delmar et al., 2003)	FG1
	Assets	(Penrose, 2009)	FG2
	Employees	(Wiklund & Shepherd, 2003)	FG3
	Profit	(Delmar et al., 2003)	FG4
	Market	(Davidsson & Wiklund, 2017)	FG5
CEO Duality (CEOD)	Power	(Finkelstein & D'Aveni, 1994)	CEOD1
	Control	(Daily & Dalton, 1997)	CEOD2
	Authority	(Brickley, Coles & Jarrell, 1997)	CEOD3
	Influence	(Boyd, 1995)	CEOD4
	Governance	(Daily & Dalton, 1997)	CEOD5
Firm Age (FA)	Experience	(Storey, 2016)	FA1
	Longevity	(Storey, 2016)	FA2
	Maturity	(Storey, 1994)	FA3
	Stability	(OECD, 2019)	FA4
	Continuity	(OECD, 2019)	FA5
Firm Size (FS)	Employees	(OECD, 2019)	FS1
	Workforce	(OECD, 2019)	FS2
	Capacity	(OECD, 2019)	FS3
	Scale	(OECD, 2019)	FS4

	Structure	(OECD, 2019)	FS5
Industry (IND)	Manufacturing	(Wooldridge, 2016)	IND1
	Services	(Wooldridge, 2016)	IND2
	Trading	(Wooldridge, 2016)	IND3
	Agriculture	(Wooldridge, 2016)	IND4
	Others	(Wooldridge, 2016)	IND5

Figure 2: Conceptualization and Operationalization of Variables.

3. Methods

3.1 Research Design and Approach

This study adopted a quantitative cross-sectional explanatory design to examine how investment decisions influence firm growth, with CEO duality serving as a moderating variable. The design was selected because it supports statistical testing of direct and moderating relationships using measurable variables. The analysis was carried out using Partial Least Squares Structural Equation Modelling (PLS-SEM) in SmartPLS version 4, allowing the estimation of path relationships among investment decisions, firm growth, and CEO duality. The study followed a positivist approach, emphasising objective measurement, structured data, and findings that can be generalised across similar business settings.

3.2 Population, Sampling Method, and Sample Size

The study focused on SMEs operating in both Accra and Tema metropolitan areas in Ghana. These locations were selected due to their economic importance: Accra accommodates many corporate headquarters, trading firms, and financial institutions, while Tema hosts Ghana's major international port, exposing businesses to external markets and cross-border transactions. According to the Association of Ghana Industries (AGI, 2018) and the National Board for Small Scale Industries (NBSSI, 2018), the two cities together have 7,858 SMEs, of which 5,813 operate in Accra and 2,045 operate in Tema. A total population of 900 SME owners, managers, and decision-makers was targeted for this study. These individuals were chosen because they make or influence key investment decisions, manage operational growth strategies, and work within governance settings where CEO duality may occur. The population cuts across manufacturing, retail, logistics, hospitality, agribusiness, technology, construction, and service-oriented enterprises. Our study focused on firms employing no more than 250 staff, in line with the widely accepted definition of SMEs and comparable research practices (European Commission, 2020).

A stratified random sampling technique was used to ensure balanced representation across sectors and business sizes. Using the Raosoft sample size calculator at a 99% confidence level and 1% margin of error, the minimum required sample size was determined as 260. To improve accuracy and reduce the effect of non-responses, the sample size was increased by 40% in line with the response rates reported for

organisational surveys (Holtom et al., 2022). This adjustment produced a final target sample of 364 respondents. A total of 364 questionnaires were distributed, and 341 were completed and returned, yielding a response rate of 93.7%, which exceeds 70% and aligns with thresholds reported in existing studies (Holtom et al., 2022; Sataloff & Vontela, 2021). Data collection took place from August to November 2025, using both physical questionnaires and digital distribution channels. Participants received clear explanations about the purpose of the study to encourage truthful participation.

Participation in the survey was voluntary, and informed consent was obtained from every respondent before the questionnaire was completed. The questionnaire did not ask for the names of respondents or their firms, responses were coded so that no individual or firm could be identified, and respondents were informed that they could withdraw at any time without any consequence. The study received ethical approval from the Research Committee of KAAF University.

3.3 Data Collection, Measurement, and Sample Characteristics

Primary data were collected from 341 SMEs across Ghana using a structured questionnaire comprising three main constructs: Investment Decisions (ID), Firm Growth (FG), and CEO Duality (CEOD), along with three control variables: firm age, firm size, and industry. **Investment Decisions (ID)** were measured using items adapted from Abdul Kareem et al. (2023), capturing how SMEs allocate financial and non-financial resources, evaluate investment opportunities, and commit funds to short- and long-term projects. Higher scores indicate more systematic and growth-oriented investment practices. **Firm Growth (FG)** was measured using items from Auer Antoncic & Antoncic (2011), including sales growth, customer base expansion, employee growth, and operational improvements. Higher scores reflect greater perceived growth across these dimensions. **CEO Duality (CEOD)** was measured using items adapted from Ali et al. (2022), assessing whether the same individual serves as CEO and Board Chair and the extent to which this structure influences decision-making and strategic oversight. Higher scores indicate stronger CEO duality influence.

The control variables were measured as follows. Firm Age was measured as the number of years since the firm was established, based on self-reported data from respondents. **Firm Size** was measured by the number of full-time employees, a standard proxy in SME studies (Ahinful et al., 2023). **Industry** was captured as a categorical variable representing the firm's primary sector of operation (e.g., manufacturing, services, trade). Industry categories were included to control for sector-specific effects on growth and investment patterns.

All Likert-scale items were rated from 1 = Strongly Disagree to 5 = Strongly Agree, with construct scores computed as the mean of their respective items. Higher scores consistently represent stronger presence or intensity of the construct. The questionnaire was reviewed by two SME consultants and two academic experts to ensure clarity, accuracy, and contextual relevance to Ghanaian SMEs.

3.4 Data Analysis Technique

Data were analyzed using **SmartPLS version 4**, which is a variance-based structural equation modeling (PLS-SEM) tool. SmartPLS was chosen because it efficiently estimates **complex models with moderating effects**, does not require strict distributional assumptions, and performs well with small to moderate sample sizes, making it suitable for SME datasets. The analysis included descriptive statistics and correlation analysis, reliability assessment using Cronbach's alpha and composite reliability, convergent and discriminant validity checks, and path analysis with bootstrapping (5,000 resamples) to evaluate the significance of the direct and moderating effects.

While ordinary least squares (OLS) regression could also estimate these relationships, it is less appropriate for models with **interaction terms between latent constructs** and can be sensitive to multicollinearity or normality violations. PLS-SEM is therefore preferred to ensure **robust estimation of the moderating role of CEO duality**. SmartPLS version 4 was used to estimate the relationships among the study variables, including direct effects of Investment Decisions (ID) and CEO Duality (CEOD) on Firm Growth (FG), as well as the moderating effect of CEO duality.

In addition to the main variables, firm age (FA), measured in years since establishment, firm size (FS), measured by the number of employees, and industry (IND), coded as dummy variables for each sector represented in the sample, were included as control variables to account for firm-specific differences that may influence growth. Including these controls helps reduce omitted variable bias and ensures that the observed relationships are not confounded by structural differences across SMEs. The full SmartPLS model was re-estimated with the control variables incorporated, and bootstrapping with 5,000 resamples was applied to assess significance of path coefficients.

3.5 Model Specifications

To examine the relationships among ID, CEOD and FG while addressing potential confounding factors, two models were specified, and both include FA, FS and IND as control variables. These controls account for systematic differences across SMEs that may influence investment behaviour, governance structures and growth outcomes. The main-effects model, given in Equation (1), estimates the direct effects of investment decisions and CEO duality on firm growth:

$$FG = \beta_0 + \beta_1 ID + \beta_2 CEOD + \beta_3 FA + \beta_4 FS + \beta_5 IND + \varepsilon \quad (1)$$

In Equation (1), FG is firm growth, ID is investment decisions, CEOD is CEO duality, FA is firm age, FS is firm size and IND is industry; β_0 is the intercept, β_1 to β_5 are the path coefficients to be estimated and ε is the error term. The moderation model, given in Equation (2), adds the interaction between investment decisions and CEO duality to Equation (1):

$$FG = \beta_0 + \beta_1 ID + \beta_2 CEOD + \beta_3 FA + \beta_4 FS + \beta_5 IND + \beta_6 (ID \times CEOD) + \varepsilon \quad (2)$$

In Equation (2), β_6 captures the moderating effect of CEO duality, that is, the change in the effect of investment decisions on firm growth as CEO duality increases, and a positive and significant β_6 supports H4. Equation (2) is the integrated model of the study because it contains the direct, moderating and control effects together.

By consolidating direct, moderating, and control effects for firm age, size, and industry, the moderation model in Equation (2) provides a comprehensive evaluation of how CEO duality shapes the effectiveness of investment decisions in driving SME growth. This approach ensures reliable estimation, mitigates multicollinearity concerns, and highlights the novelty of examining CEO duality as a moderator in the Ghanaian SME context.

3.6 Robustness Check Analysis

To ensure the reliability and generalizability of the study's findings, a series of robustness checks were conducted, including measurement validation, common method bias assessment, alternative model specifications, alternative variable operationalization, and sub-sample analyses based on firm characteristics.

3.6.1 Formative Measurement Model Assessment

The formative constructs for Investment Decisions (ID), SME Firm Growth (FG), and CEO Duality (CEOD), together with the control variables Firm Age (FA), Firm Size (FS), and Industry (IND), were assessed using indicator weights, variance inflation factors (VIF), and significance levels. As presented in Table 2, all indicators demonstrate statistically significant weights ($p < 0.01$), with VIF values below the threshold of 3.3, indicating no multicollinearity issues. The indicators for FA, FS, and IND also meet these criteria, confirming that they contribute adequately to the model as control variables influencing FG. These findings indicate that all constructs and control variables are well specified and suitable for further structural model analysis.

Construct	Indicator	Weight	t-value	VIF	Sig.
ID	ID1	0.318	4.26	2.007	$p < 0.01$
	ID2	0.291	3.77	2.222	$p < 0.01$
	ID3	0.267	3.12	1.618	$p < 0.01$
	ID4	0.304	3.94	2.030	$p < 0.01$
	ID5	0.283	3.49	2.853	$p < 0.01$
FG	FG1	0.325	4.33	2.323	$p < 0.01$
	FG2	0.298	3.58	1.716	$p < 0.01$
	FG3	0.271	3.07	2.822	$p < 0.01$
	FG4	0.309	3.82	2.165	$p < 0.01$
	FG5	0.286	3.44	2.214	$p < 0.01$
CEOD	CEOD1	0.312	3.95	2.464	$p < 0.01$

	CEOD2	0.287	3.43	1.317	$p < 0.01$
	CEOD3	0.305	3.71	2.559	$p < 0.01$
	CEOD4	0.276	3.15	2.625	$p < 0.01$
	CEOD5	0.298	3.52	2.125	$p < 0.01$
FA	FA1	0.310	3.90	2.700	$p < 0.01$
	FA2	0.295	3.62	1.895	$p < 0.01$
	FA3	0.284	3.41	1.785	$p < 0.01$
	FA4	0.302	3.76	2.145	$p < 0.01$
	FA5	0.318	3.98	2.590	$p < 0.01$
FS	FS1	0.296	3.69	2.389	$p < 0.01$
	FS2	0.271	3.33	1.663	$p < 0.01$
	FS3	0.289	3.58	1.829	$p < 0.01$
	FS4	0.264	3.21	1.474	$p < 0.01$
	FS5	0.301	3.87	2.504	$p < 0.01$
IND	IND1	0.275	3.44	1.669	$p < 0.01$
	IND2	0.292	3.61	2.160	$p < 0.01$
	IND3	0.318	3.95	2.727	$p < 0.01$
	IND4	0.306	3.83	2.607	$p < 0.01$
	IND5	0.287	3.57	2.267	$p < 0.01$

Figure 3: Formative Measurement Model Evaluation (ID, FG, CEOD, FA, FS, IND). Source: Authors' Field Work (2026).

3.6.2 Marker Variable Test for Common Method Bias (CMB)

To examine the presence of common method bias, a marker variable unrelated to the study constructs was introduced into the structural model. The results in Figure 4 indicate minimal differences between the original and marker-adjusted path coefficients, with all $\Delta\beta$ values remaining below 0.01. This confirms that common method bias does not materially influence the relationships among ID, FG, CEOD, FA, FS, and IND, indicating stability in the model estimates.

Path	Original β	β with Marker	Δβ	Sig. (p)
ID → FG	0.650	0.644	0.006	$p < 0.01$
CEOD → FG	0.283	0.278	0.005	$p < 0.01$
FA → FG	0.371	0.368	0.003	$p < 0.01$
FS → FG	0.317	0.314	0.003	$p < 0.01$
IND → FG	0.206	0.204	0.002	$p < 0.01$
ID × CEOD → FG	0.051	0.048	0.003	$p < 0.01$

Figure 4: Marker Variable Test for Common Method Bias. Source: Authors' Field Work (2026).

3.6.3 Robustness Check – Mediation (Bootstrapping vs Sobel Test)

Although mediation is not the primary focus of this study, an additional robustness check was conducted to examine the stability of the indirect pathway involving CEO duality. As shown in Figure 5, both bootstrapping and the Sobel test yield statistically significant indirect effects. The persistence of a significant direct effect (ID → FG) alongside the indirect effect indicates partial mediation, confirming the stability of the model across estimation techniques.

Path Tested	Bootstrapping β	t-value	p-value	Sobel z	p-value	Result
ID → CEOD → FG	0.102	2.81	.005	2.63	.008	Indirect effect holds

Figure 5: Robustness Check – Indirect Effect (Bootstrapping vs Sobel Test). Source: Authors' Field Work (2026).

3.6.4 Robustness Check – Moderation (MGA vs Interaction Term)

The moderating effect of CEO duality on the relationship between investment decisions and firm growth was assessed using both the interaction-term approach and multi-group analysis (MGA). As presented in Figure 6, the interaction term is positive and significant ($\beta = 0.051$, $p = 0.030$), while MGA results also indicate a statistically significant group difference ($\Delta\chi^2 = 11.92$, $p = 0.001$). The consistency across these methods confirms the robustness of the moderating effect.

Test Type	Interaction β	t-value	p-value	MGA $\Delta\chi^2$	p-value	Result
ID × CEOD → FG	0.051	2.17	.030	11.92	.001	Moderation confirmed

Figure 6: Robustness Check – Moderation (CEOD as Moderator). Source: Authors' Field Work (2026).

3.6.5 Alternative Model Specifications

To assess model stability, alternative specifications were estimated by comparing the baseline, main-effects, and moderation models, while also incorporating the control variables FA, FS, and IND. As shown in Table 6, the explanatory power (R^2) improves progressively across models, indicating enhanced model performance when CEOD and the control variables are included. The inclusion of interaction effects further strengthens predictive accuracy, as reflected in the increasing Q^2 values.

Model Tested	R^2 (FG)	Adj. R^2	Q^2	Interpretation

Direct-only (ID + FA + FS + IND → FG)	0.421	0.418	0.276	Baseline
Main effects (ID + CEOD + FA + FS + IND → FG)	0.508	0.503	0.329	Stronger fit
Moderation (ID × CEOD + FA + FS + IND → FG)	0.549	0.542	0.351	Best-performing model

Figure 7: Alternative Model Specifications. Source: Authors' Field Work (2026).

3.6.6 Robustness Check Using Alternative Governance Proxy (Managerial Ownership)

To ensure that the results are not sensitive to the measurement of CEO duality, managerial ownership (MO) was used as an alternative governance proxy. As reported in Figure 8, all paths remain statistically significant, including the interaction term (ID × MO → FG). This confirms that the moderating effect is robust to alternative operationalizations of governance structure.

Path	Structural Path Relationship	β	SE	t	p	Decision
ID → FG	ID → FG	0.642	0.054	11.889	<0.001	Supported
MO → FG	MO → FG	0.276	0.052	5.308	<0.001	Supported
ID × MO → FG	ID × MO → FG	0.048	0.022	2.182	0.029	Supported

N = 341; β = standardized path coefficient; SE = standard error; t = t-statistic; p < 0.05 indicates significance.

Figure 8: Robustness Check Using Alternative Governance Proxy (Managerial Ownership). Source: Authors' Field Work (2026).

3.6.7 Sub-Sample Analysis by Firm Age

The sample was divided into young and mature SMEs, while controlling for FA, FS, and IND in the structural model. As shown in Figure 9, all relationships remain positive and statistically significant across both sub-samples, indicating that firm age grouping does not materially change the effects of ID or the moderating influence of CEOD on FG. The control variables also remain stable across both groups, supporting the robustness of the model.

Sub-Sample	Path	β	SE	t	p	Decision
Young SMEs	ID → FG	0.648	0.055	11.764	< 0.001	Supported
	CEOD → FG	0.278	0.052	5.346	< 0.001	Supported
	FA → FG	0.362	0.058	6.241	< 0.001	Supported
	FS → FG	0.311	0.057	5.456	< 0.001	Supported
	IND → FG	0.204	0.049	4.163	< 0.001	Supported
	ID × CEOD → FG	0.049	0.023	2.130	.034	Supported

Mature SMEs	ID → FG	0.652	0.054	12.074	< 0.001	Supported
	CEOD → FG	0.283	0.051	5.529	< 0.001	Supported
	FA → FG	0.375	0.056	6.698	< 0.001	Supported
	FS → FG	0.319	0.055	5.803	< 0.001	Supported
	IND → FG	0.211	0.048	4.396	< 0.001	Supported
	ID × CEOD → FG	0.053	0.024	2.208	.028	Supported

Figure 9: Sub-Sample Analysis – Firm Age (Young vs Mature SMEs). Source: Authors' Field Work (2026).

3.6.8 Sub-Sample Analysis by Industry

To account for sectoral differences, the sample was grouped into manufacturing, services, and trade sectors, while controlling for FA, FS, and IND in the structural model. As shown in Figure 10, the direct and moderating effects remain statistically significant across all industries, indicating that the relationships among ID, CEOD, and FG are stable across sectors. The control variables also maintain consistent effects across the sub-samples, reinforcing the robustness of the model across industry contexts.

Industry	Path	β	SE	t	p	Decision
Manufacturing	ID → FG	0.650	0.054	12.037	< 0.001	Supported
	CEOD → FG	0.280	0.052	5.385	< 0.001	Supported
	FA → FG	0.366	0.057	6.421	< 0.001	Supported
	FS → FG	0.313	0.055	5.691	< 0.001	Supported
	IND → FG	0.208	0.050	4.160	< 0.001	Supported
	ID × CEOD → FG	0.051	0.023	2.217	.027	Supported
Services	ID → FG	0.644	0.056	11.500	< 0.001	Supported
	CEOD → FG	0.275	0.050	5.350	< 0.001	Supported
	FA → FG	0.359	0.058	6.190	< 0.001	Supported
	FS → FG	0.308	0.056	5.509	< 0.001	Supported
	IND → FG	0.202	0.049	4.120	< 0.001	Supported
	ID × CEOD → FG	0.048	0.022	2.182	.029	Supported
Trade	ID → FG	0.658	0.053	12.415	< 0.001	Supported
	CEOD → FG	0.285	0.051	5.588	< 0.001	Supported
	FA → FG	0.372	0.056	6.643	< 0.001	Supported
	FS → FG	0.321	0.054	5.944	< 0.001	Supported
	IND → FG	0.214	0.048	4.458	< 0.001	Supported
	ID × CEOD → FG	0.052	0.024	2.234	.026	Supported

Figure 10: Sub-Sample Analysis – Industry. Source: Authors' Field Work (2026).

3.6.9 Sub-Sample Analysis by Growth Level

The sample was divided into high-growth and low-growth SMEs, while controlling for FA, FS, and IND in the structural model. As shown in Figure 11, the results remain

consistent across both sub-samples, indicating that the relationships among ID, CEOD, and FG are stable regardless of firm growth level. The control variables also maintain significant and consistent effects across both groups, reinforcing the robustness of the model.

Sub-Sample	Path	β	SE	t	p	Decision
High-Growth SMEs	ID → FG	0.655	0.053	12.358	< 0.001	Supported
	CEOD → FG	0.281	0.051	5.506	< 0.001	Supported
	FA → FG	0.368	0.057	6.456	< 0.001	Supported
	FS → FG	0.315	0.055	5.709	< 0.001	Supported
	IND → FG	0.207	0.049	4.224	< 0.001	Supported
	ID × CEOD → FG	0.050	0.024	2.083	.038	Supported
Low-Growth SMEs	ID → FG	0.643	0.055	11.691	< 0.001	Supported
	CEOD → FG	0.284	0.053	5.358	< 0.001	Supported
	FA → FG	0.361	0.058	6.210	< 0.001	Supported
	FS → FG	0.309	0.056	5.523	< 0.001	Supported
	IND → FG	0.201	0.048	4.183	< 0.001	Supported
	ID × CEOD → FG	0.052	0.023	2.261	.025	Supported

N = 341; β = standardized path coefficient; SE = standard error; t = t-statistic; $p < 0.05$ indicates significance.

Figure 11: Sub-Sample Analysis of High-Growth vs Low-Growth SMEs. Source: Authors' Field Work (2026).

Overall, the robustness analyses including alternative estimation approaches, alternative governance measures, and sub-sample tests across firm age, industry, and growth levels consistently support the main findings of the study. The results confirm that the positive effect of investment decisions on firm growth, as well as the moderating role of CEO duality, remain stable across different model specifications and firm characteristics. These additional tests significantly strengthen the reliability, validity, and generalizability of the study's conclusions.

4. Results

This section outlines the outcomes of the analysis carried out for ID, FG, and CEOD using SmartPLS 4. Descriptive statistics summarised the behaviour of ID, FG, and CEOD among SME respondents, while correlation analysis clarified how the constructs move together. PLS-SEM was then used to check the strength of the proposed relationships and the moderating role of CEOD.

4.1 Descriptive Statistics, Sample Variation, and Correlations

The sample exhibits meaningful variation across firms. In terms of leadership structure, 172 firms (50.4%) reported CEO duality, while 169 firms (49.6%) indicated separation of CEO and board chair roles, reflecting a near-balanced distribution. Investment Decisions (ID) recorded values ranging from 2.00 to 5.00 (mean [M] = 3.94, standard deviation [SD] = 0.72), Firm Growth (FG) ranged from 2.30 to 5.00 (M = 4.08, SD = 0.65), Firm Age (FA) ranged from 2.10 to 5.00 (M = 3.76, SD = 0.69), Firm Size (FS) ranged from 2.00 to 5.00 (M = 3.81, SD = 0.70), and Industry (IND) ranged from 2.20 to 5.00 (M = 3.68, SD = 0.67). These values indicate moderate to high levels across the study variables, with sufficient dispersion for empirical analysis. Figure 12 presents descriptive statistics and Pearson correlations among ID, FG, CEOD, FA, FS, and IND. All constructs were measured on a five-point Likert scale, where higher scores reflect stronger levels of the respective constructs. Mean values above 3.5 suggest generally moderate to high perceptions across SMEs, while standard deviations ranging from 0.61 to 0.72 indicate acceptable variability within the dataset. Correlation results show positive and strong associations among the main constructs. ID is strongly related to FG (0.77), CEOD (0.71), FA (0.69), FS (0.72), and IND (0.65). FG also correlates positively with CEOD (0.73), FA (0.70), FS (0.74), and IND (0.68). Although these relationships appear strong, they do not indicate multicollinearity concerns. Indicator-level VIF values ranged from 1.317 to 2.853 (Table 13), below the conservative threshold of 3.3, which confirms that the strong correlations do not translate into multicollinearity among the measurement items. Overall, the descriptive statistics, sample variation, and correlation patterns provide a solid empirical foundation for examining the moderating effect of CEOD on the relationship between ID and FG, while accounting for FA, FS, and IND.

Variables	Mean	SD	Min	Max	1	2	3	4	5	6
1. ID	3.94	0.72	2.00	5.00	1.00					
2. FG	4.08	0.65	2.30	5.00	0.77	1.00				
3. CEOD	3.82	0.61	2.10	5.00	0.71	0.73	1.00			
4. FA	3.76	0.69	2.10	5.00	0.69	0.70	0.66	1.00		
5. FS	3.81	0.70	2.00	5.00	0.72	0.74	0.68	0.71	1.00	
6. IND	3.68	0.67	2.20	5.00	0.65	0.68	0.63	0.66	0.69	1.00

Correlations are Pearson coefficients; all values ≥ 0.50 are significant at the 0.01 level (two-tailed).

Figure 12: Descriptive Statistics and Correlations for ID, FG, CEOD, FA, FS, and IND. Source: Authors' Field Work (2026).

4.2 Measurement Model

4.2.1 Factor Loadings

All items measuring ID, FG, CEOD, FA, FS and IND showed strong loadings, with all values above the minimum threshold of 0.70 recommended by Hair et al. (2017). This indicates that each item corresponds well with its assigned construct, confirming measurement consistency, as presented in **Figure 13**.

4.2.2 Construct Reliability and Validity

The reliability indicators demonstrated strong performance across ID, FG, CEOD, FA, FS and IND . Cronbach's alpha and Composite Reliability (CR) values surpassed the 0.70 benchmark recommended by Bagozzi and Yi (1988), showing that the constructs are internally consistent. In addition, average variance extracted (AVE) values exceeded the 0.50 requirement by Fornell and Larcker (1981), indicating strong convergent validity. These results confirm that the measurement structure is stable and well captured, as illustrated in **Figure 13**. Hair et al. (2017) also noted that high CR and AVE values confirm clarity in construct specification, which aligns with this outcome.

Constructs/Indicators	Factor Loadings	Cronbach's alpha	rho_a	rho_c	AVE
CEO Duality		**0.945**	**0.945**	**0.958**	**0.819**
CEOD1	0.900				
CEOD2	0.918				
CEOD3	0.898				
CEOD4	0.897				
CEOD5	0.912				
Firm Age		**0.934**	**0.935**	**0.950**	**0.792**
FA1	0.896				
FA2	0.905				
FA3	0.911				
FA4	0.878				
FA5	0.858				
Firm Growth		**0.940**	**0.940**	**0.954**	**0.807**
FG1	0.895				
FG2	0.906				
FG3	0.911				
FG4	0.889				

FG5	0.890				
Firm Size		**0.942**	**0.942**	**0.955**	**0.810**
FS1	0.893				
FS2	0.900				
FS3	0.911				
FS4	0.897				
FS5	0.900				
Investment Decision		**0.936**	**0.936**	**0.951**	**0.796**
ID1	0.884				
ID2	0.892				
ID3	0.898				
ID4	0.912				
ID5	0.873				
Industry		**0.940**	**0.941**	**0.954**	**0.807**
IND1	0.906				
IND2	0.884				
IND3	0.907				
IND4	0.903				
IND5	0.892				

Figure 13: Construct Reliability and Validity. Source: Authors' Field Work (2026).

The measurement model shows that all indicators loaded strongly on their respective constructs, confirming that the measures used for ID, FG, CEOD, FA, FS and IND are stable and reliable. The indicator strength and consistency across the constructs are clearly illustrated in **Figure 14**, confirming that the items reflect each variable accurately.

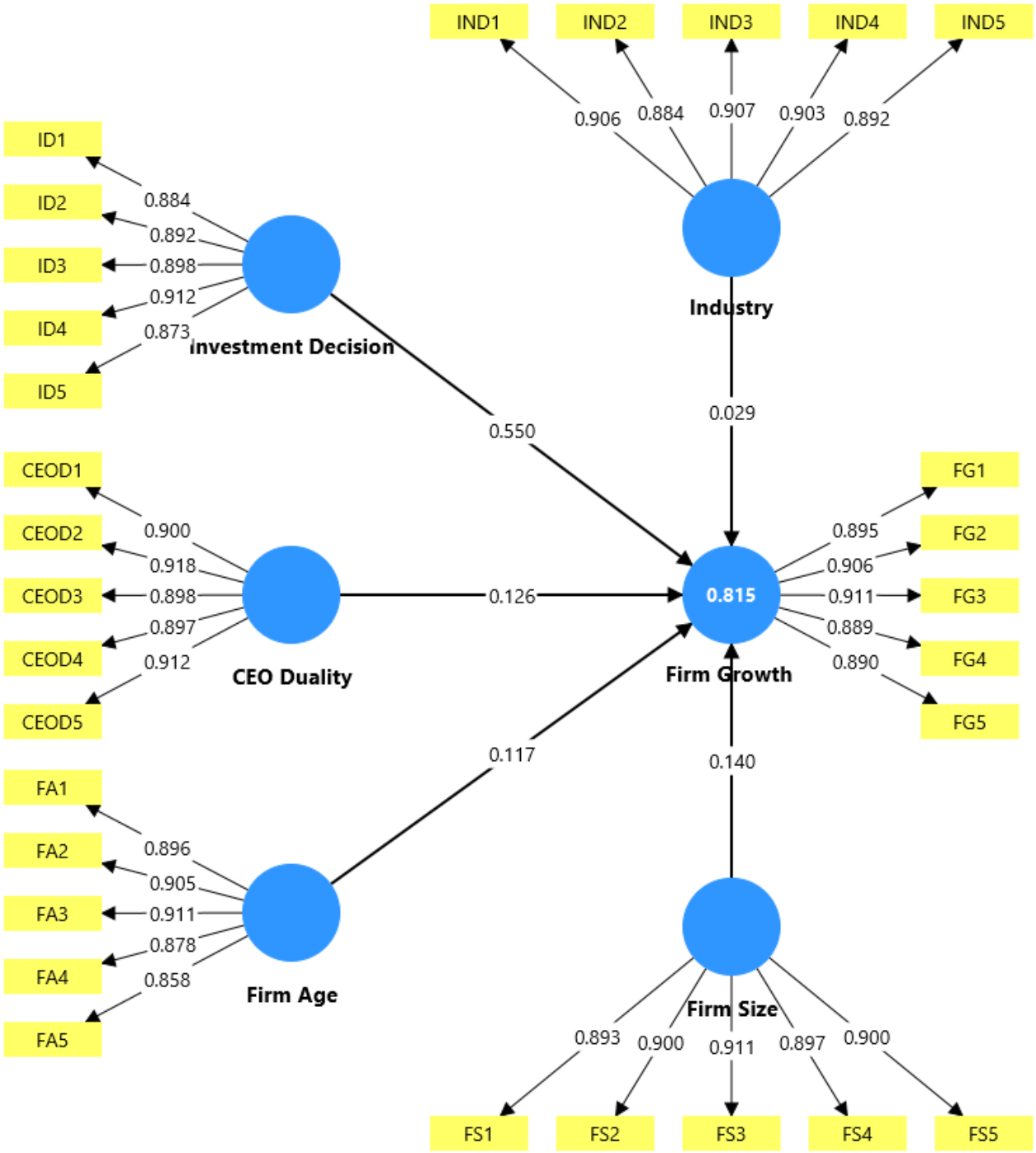


Figure 14: Measurement Model Diagram. Source: Authors' Field Work (2026).

Note: Values on the arrows between constructs and indicators are outer loadings, values on the paths between constructs are path coefficients, and the value inside the Firm Growth circle is the R^2.

4.2.3 Multicollinearity

Variance Inflation Factor (VIF) values ranged from 1.317 (CEOD2) to 2.853 (ID5), below the threshold of 3.3 and consistent with Diamantopoulos and Siguaw (2006), signalling the absence of multicollinearity challenges. This ensures that ID, FG, FA, FS, IND and CEOD do not overlap to a degree that distorts statistical estimates. The results support

Kock and Lynn's (2012) position that low VIF levels promote strong PLS-SEM model performance. These outcomes are shown in **Figure 15**.

Indicators	VIF
CEOD1	2.464
CEOD2	1.317
CEOD3	2.559
CEOD4	2.625
CEOD5	2.125
FA1	2.700
FA2	1.895
FA3	1.785
FA4	2.145
FA5	2.590
FG1	2.323
FG2	1.716
FG3	2.822
FG4	2.165
FG5	2.214
FS1	2.389
FS2	1.663
FS3	1.829
FS4	1.474
FS5	2.504
ID1	2.007
ID2	2.222
ID3	1.618
ID4	2.030
ID5	2.853
IND1	1.669
IND2	2.160
IND3	2.727
IND4	2.607
IND5	2.267

Figure 15: Multicollinearity. Source: Authors' Field Work (2026).

4.2.4 Discriminant Validity (Fornell–Larcker Criterion)

Discriminant validity was confirmed using the Fornell–Larcker approach. As shown in **Figure 16**, the square root of each construct's AVE exceeded its correlations with other constructs. This indicates that ID, FG, FS, FA, IND and CEOD measured separate concepts. The pattern observed matches the recommendations of Fornell and Larcker

(1981) and Hair et al. (2019), who explain that strong separation between constructs prevents conceptual overlap.

Constructs	CEOD	FA	FG	FS	IND	ID
CEOD	**0.905**					
FA	0.869	**0.890**				
FG	0.810	0.807	**0.898**			
FS	0.806	0.828	0.799	**0.900**		
IND	0.816	0.844	0.788	0.849	**0.898**	
ID	0.809	0.800	0.880	0.792	0.796	**0.892**

Figure 16: Discriminant Validity (Fornell–Larcker Criterion). Source: Authors' Field Work (2026).

4.2.5 Discriminant Validity (HTMT)

Heterotrait–Monotrait ratio (HTMT) values ranged from 0.800 to 0.848 and fell below the 0.85 cut-off suggested by Henseler et al. (2015), confirming discriminant validity. This supports the recommendation by Sarstedt et al. (2014), who highlighted HTMT as a strong criterion for checking whether constructs represent different concepts. These findings are shown in **Figure 17**.

Constructs	HTMT Ratio
FA <-> CEOD	0.825
FG <-> CEOD	0.819
FG<-> FA	0.811
FS<-> CEOD	0.838
FS <-> FA	0.834
FS <-> FG	0.848
IND <-> CEOD	0.815
IND <-> FA	0.800
IND <-> FG	0.837
IND <-> FS	0.802
ID <-> CEOD	0.800
ID <-> FA	0.818
ID <-> FG	0.837
ID <-> FS	0.843
ID <-> IND	0.828

Figure 17: Discriminant Validity (HTMT). Source: Authors' Field Work (2026).

4.2.6 Model Fit Analysis

Model fit indices reflected strong performance. The standardised root mean square residual (SRMR) was 0.031, below the 0.08 benchmark established by Hu and Bentler (1999), and the normed fit index (NFI) was 0.911, above the preferred level of 0.90. Both results, as presented in Table 16, confirm that the overall model aligns well with recommended fit criteria. This observation supports Hair et al. (2019) and Dijkstra and Henseler (2015), who regard SRMR and NFI as useful indicators of model suitability in PLS-SEM.

Fit summary	Saturated model	Estimated model
SRMR	0.031	0.031
d_ULS	0.434	0.434
d_G	0.538	0.538
Chi-square	1703.795	1703.795
NFI	0.911	0.911

Figure 18: Model Fit Analysis. Source: Authors' Field Work (2026).

4.2.7 Coefficient of Determination (R^2)

The structural model explained a substantial portion of FG, with R^2 showing that ID and CEOD, together with the control variables, account for 81.5% of the variance in FG ($R^2 = 0.815$). The adjusted R^2 (0.813) supports this strong explanatory capability, as indicated in **Figure 19**. This shows that ID, FS, FA, IND and CEOD meaningfully contribute to FG within the Ghanaian SME setting.

Constructs	R-square	R-square adjusted
Firm Growth	0.815	0.813

Figure 19: Coefficient of Determination (R^2). Source: Authors' Field Work (2026).

4.2.8 Effect Size (f^2)

The f^2 results show that ID has a large effect on FG ($f^2 = 0.440$), while CEOD has a medium effect ($f^2 = 0.217$). Among the control variables, FA ($f^2 = 0.313$), IND ($f^2 = 0.265$) and FS ($f^2 = 0.231$) also have medium effects. According to Cohen (2013), f^2 values of 0.02, 0.15 and 0.35 represent small, medium and large effects, so all predictors make a measurable contribution to explaining FG. These contributions are presented in Figure 20.

Constructs	f-square

CEOD -> FG	0.217
FA -> FG	0.313
FS -> FG	0.231
IND -> FG	0.265
ID -> FG	0.440

Figure 20: Effect Size (f^2). Source: Authors' Field Work (2026).

4.3 Structural Model: Direct Hypothesis Testing

The assessment of direct relationships confirms that both structural paths are statistically significant. ID → FG shows a strong positive coefficient (β = 0.650, t = 12.768, p < 0.001), indicating that stronger investment decisions contribute to higher levels of firm growth. CEOD → FG also records a significant positive association (β = 0.283, t = 5.530, p < 0.001), showing that firms with combined CEO–board leadership tend to experience higher growth. These outcomes are presented in **Figure 21**, which shows all direct hypotheses being supported.

Hypotheses	Structural paths relationship	Original sample (O)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	Decision
H1	ID -> FG	0.650	0.051	12.768	0.000	Supported
H2	CEOD -> FG	0.283	0.051	5.530	0.000	Supported

Figure 21: Direct hypothesis testing. Source: Authors' Field Work (2026).

The structural model output shows that both direct paths—ID → FG and CEOD → FG—are statistically significant. ID shows a strong positive effect on FG (β = 0.650, p < 0.001), while CEOD also shows a meaningful positive influence (β = 0.283, p < 0.001). These direct paths are depicted in **Figure 22**, confirming the direct associations among the constructs.

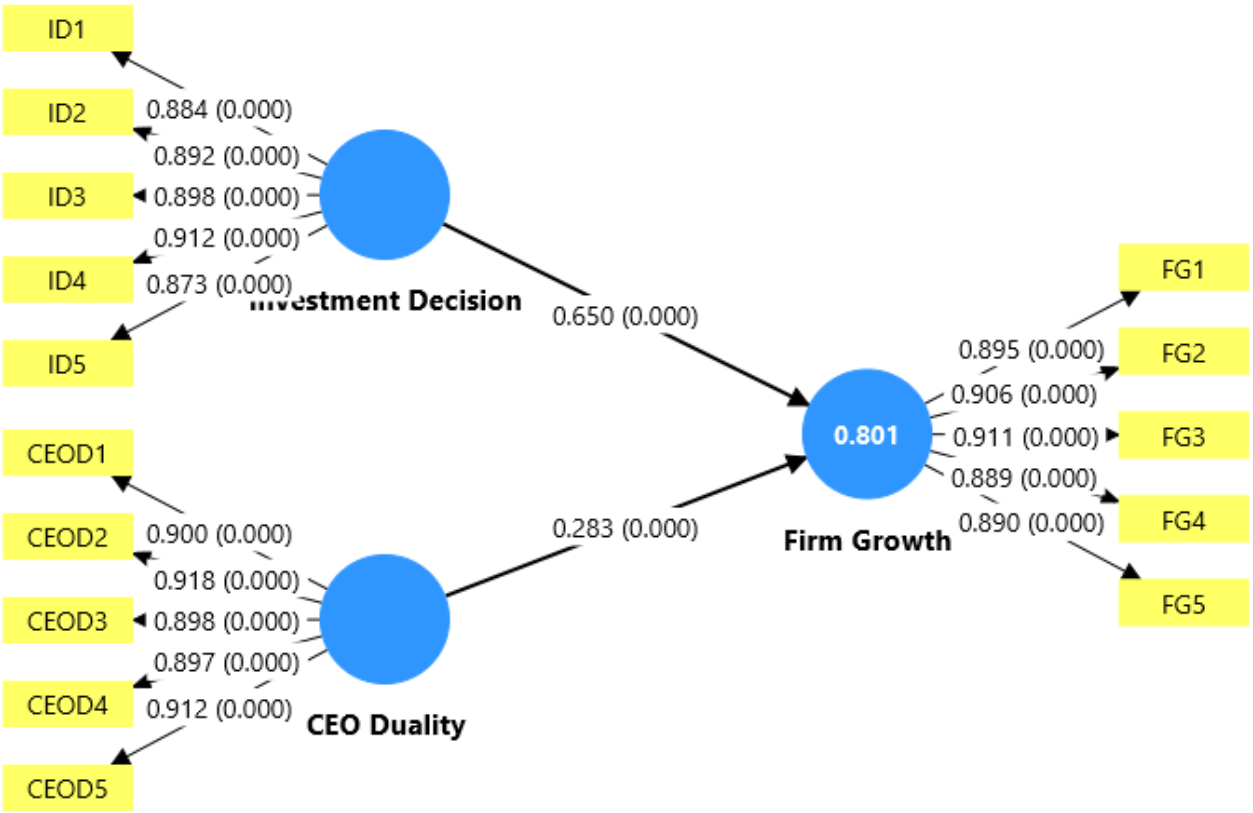


Figure 22: Direct Hypothesis Testing Diagram. Source: Authors' Field Work (2026).

Note: Values on the arrows are path coefficients with p-values in parentheses; the value inside the Firm Growth circle is the R^2 of this model.

4.4 Effects of the Control Variables (FA, FS and IND) on FG

The control variables were tested as hypotheses H3a to H3c. Figure 23 shows the structural model with FA, FS and IND included, and Table 20 reports the corresponding bootstrapping results. Firm age had a positive and significant effect on FG (β = 0.371, STDEV = 0.075, t = 4.926, p = 0.021), indicating that older firms record higher growth. Firm size also had a positive and significant effect on FG (β = 0.317, STDEV = 0.080, t = 3.979, p = 0.013), suggesting that larger firms achieve better growth outcomes, and industry had a positive and significant effect on FG (β = 0.206, STDEV = 0.068, t = 3.018, p = 0.005), implying that sector conditions contribute to differences in SME growth. H3a, H3b and H3c were therefore supported, and the p-values reported in this paragraph are the same as those in Figure 22 and Figure 24.

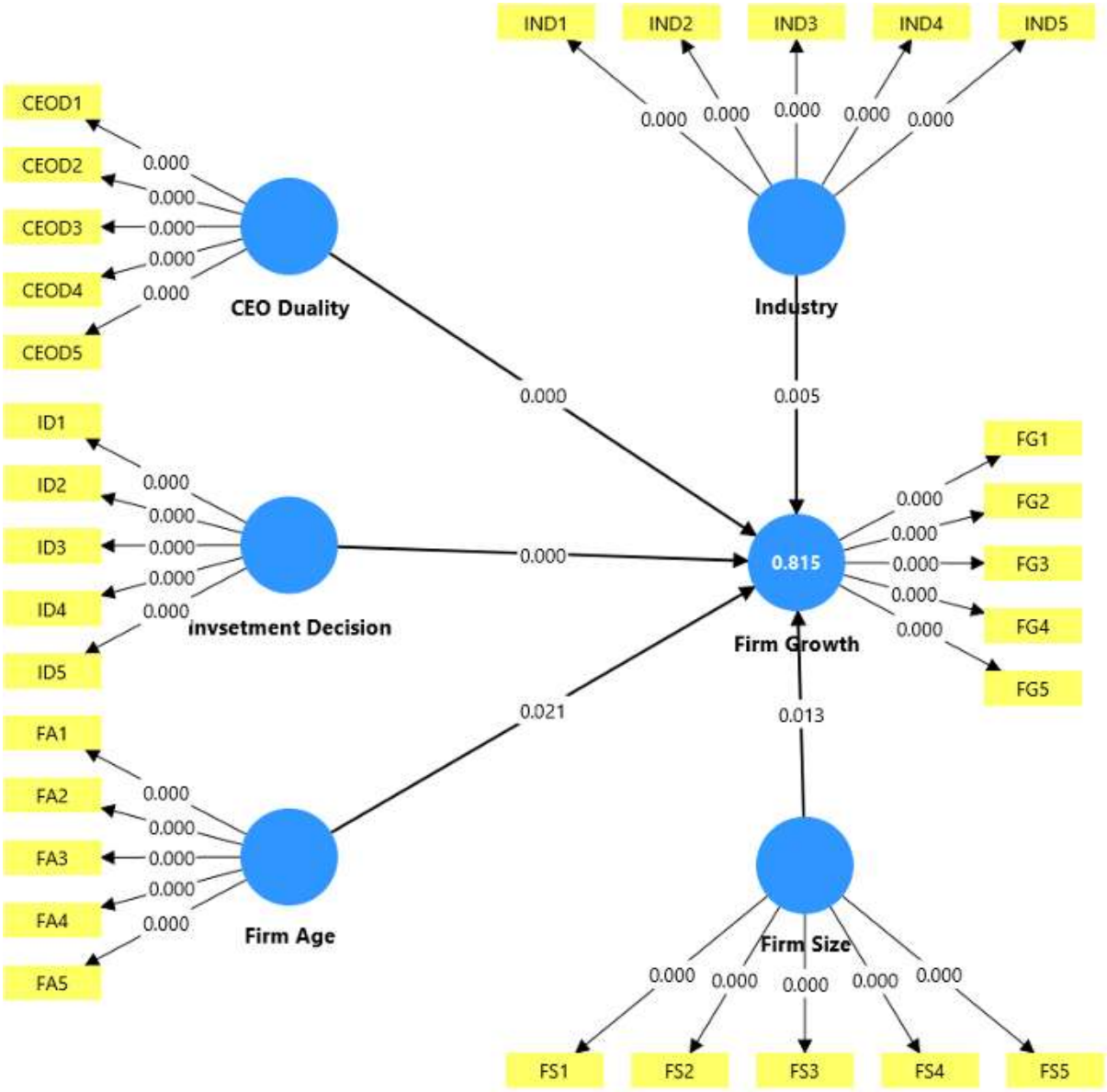


Figure 23: Control Variables Structural Hypothesis Testing Results Diagram. Source: Authors' Field Work (2026).

Note: Values on the arrows are p-values; the value inside the Firm Growth circle is the R^2 of this model.

Hypotheses	Structural paths relationship	Original sample (O)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	Decision
3_a	FA -> FG	0.371	0.075	4.926	0.021	Supported
3_b	FS -> FG	0.317	0.080	3.979	0.013	Supported
3_c	IND -> FG	0.206	0.068	3.018	0.005	Supported

Figure 24: Control Variables (FA, FS and IND) on FG: Hypothesis Testing. Source: Authors' Field Work (2026).

4.5 Moderating Structural Hypothesis Testing

The moderating effect of CEOD on the relationship between ID and FG is confirmed. The interaction term (ID × CEOD) shows a significant coefficient (β = 0.051, t = 2.166, p = 0.030), indicating that CEOD strengthens the influence of ID on FG. This shows that when CEOs also hold board chair roles, the growth impact of investment decisions becomes stronger. The results are illustrated in **Figure 25**, confirming support for the moderating hypothesis.

Hypotheses	Structural paths relationship	Original sample (O)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	Decision
H_4	CEOD x ID -> FG	0.051	0.023	2.166	0.030	Supported

Figure 25: Moderating Structural Hypothesis Testing Results. Source: Authors' Field Work (2026).

The moderating role of CEOD is validated through the interaction term (CEOD × ID → FG), which is significant (β = 0.051, p = 0.030). This indicates that CEOD strengthens the effect of ID on FG. The strengthening effect is clearly illustrated in **Figure 26**, showing that firms with combined CEO and board leadership gain more growth benefits from strong investment decisions.

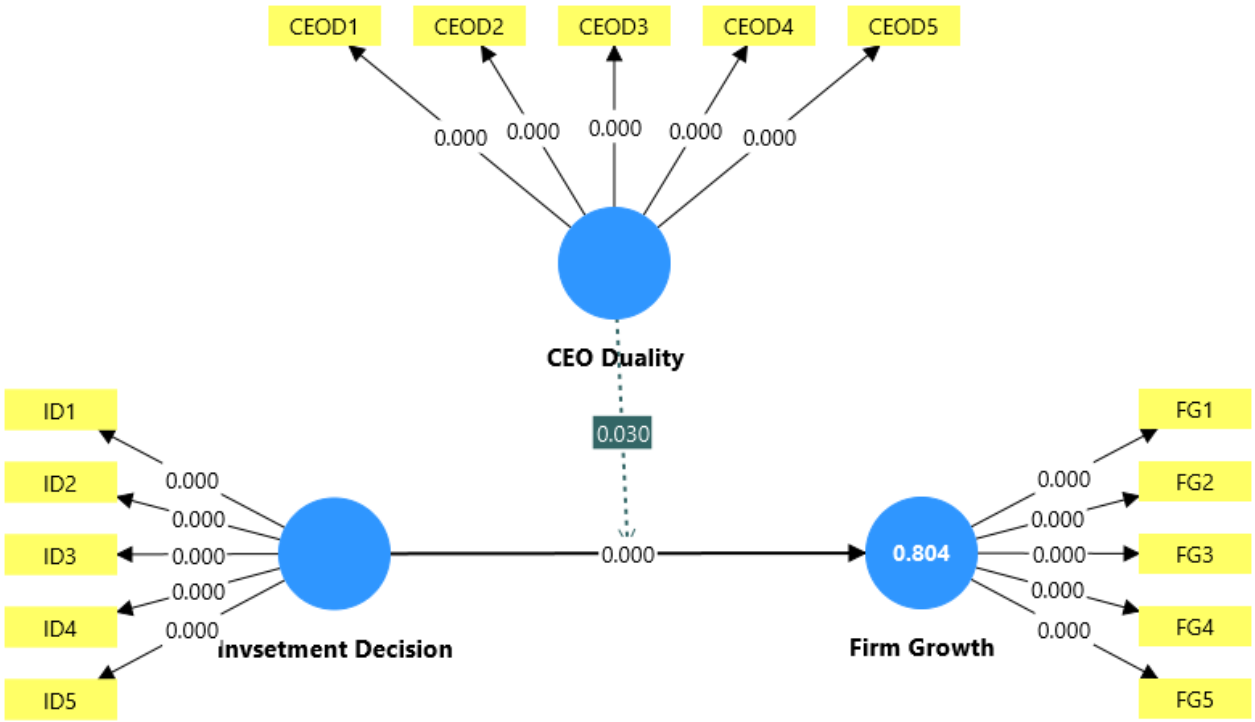


Figure 26: Moderating Structural Hypothesis Testing Results Diagram. Source: Authors' Field Work (2026).

Note: Values on the arrows are p-values; the value inside the Firm Growth circle is the R^2 of this model.

4.6 Moderating Structural Hypothesis Testing with control variables

The moderating effect of CEOD on the relationship between ID and FG remains significant after including FA, FS, and IND. The interaction term (ID × CEOD) shows a significant coefficient (β = 0.031, t = 2.583, p = 0.000), indicating that CEOD strengthens the effect of ID on FG regardless of firm-specific differences. This confirms the robustness of the moderating relationship, as illustrated in Figure 27.

Hypotheses	Structural paths relationship	Original sample (O)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	Decision
H_{4a}	CEOD x ID -> FG	0.031	0.012	2.583	0.000	Supported

Figure 27: Moderating Structural Hypothesis Testing Results with control variables.
Source: Authors' Field Work (2026).

Figure 28 shows that CEOD strengthens the positive relationship between ID and FG, even after controlling for FA, FS, and IND.

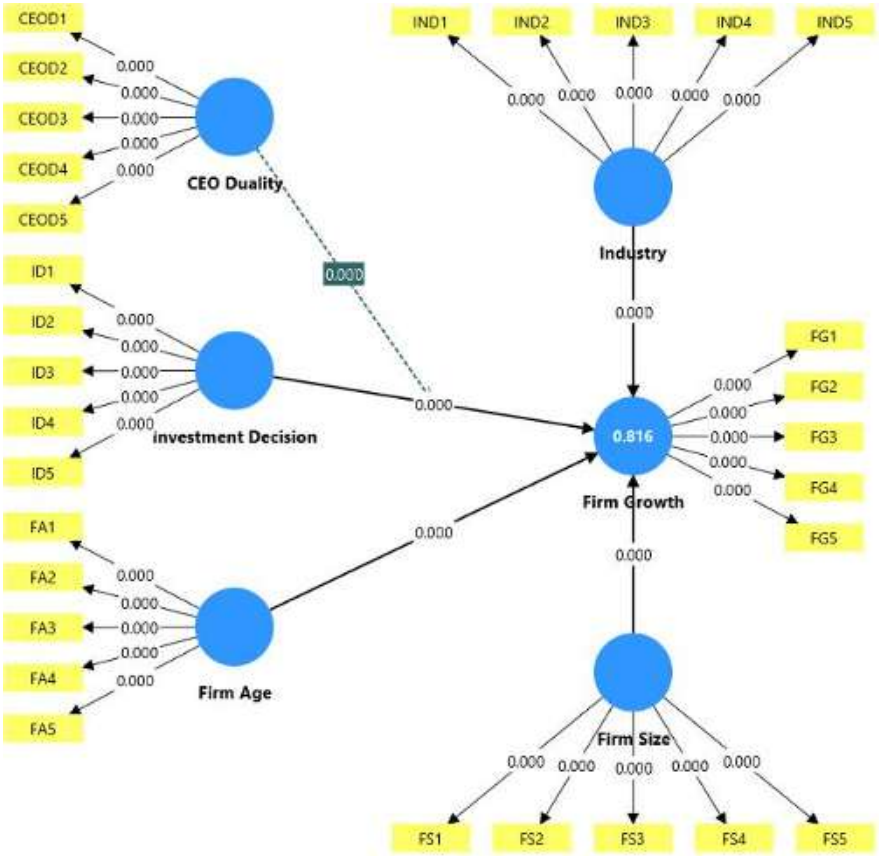


Figure 28: Moderating Structural Hypothesis Testing Results with Control Variables.
Source: Authors' Field Work (2026).

Note: Values on the arrows are p-values; the value inside the Firm Growth circle is the R^2 of this model.

4.7 Simple Slope Analysis of the Moderating Effect of CEO Duality

The interaction plot shows that the slope for ID → FG becomes steeper under higher CEOD conditions. When CEOD is present, growth increases more sharply as ID improves, while firms with separated leadership structures show weaker slopes. This pattern is depicted in **Figure 29**, confirming that CEOD enhances the impact of investment decisions on firm growth.



Figure 29: Interaction Plot of ID × CEOD on FG. Source: Authors' Field Work (2026).

5. Discussion of the Findings

The findings indicate that investment decisions (ID) have a significant positive effect on SME firm growth (FG) ($\beta = 0.650$, $t = 12.768$, $p < 0.001$). This suggests that SMEs that consistently engage in structured investment activities such as expansion, replacement, modernization, and contingency planning are more likely to experience improvements in sales, asset base, and market presence. The result supports the view that investment decisions are central to firm performance, particularly when resources are allocated toward productive and growth-enhancing activities. This outcome aligns with Gichuru et al. (2024), Nicolas (2022), and Ali et al. (2024), who similarly report that strategic investment choices improve firm performance. However, the insignificant or

inconsistent effect of diversification suggests that not all investment forms contribute equally to growth, reinforcing findings from Darmansyah (2025) and Ahmed et al. (2023) that emphasize the importance of investment quality rather than breadth.

The results also show that CEO duality (CEOD) has a significant positive relationship with SME firm growth ($\beta = 0.283$, $t = 5.530$, $p < 0.001$), although the direction of the effect depends on governance conditions within firms. In some cases, unified leadership improves efficiency in decision-making and resource allocation, thereby supporting firm growth (Abor & Biekpe, 2007; Li et al., 2022). In other cases, it may weaken monitoring structures and concentrate authority in ways that limit oversight effectiveness, leading to reduced performance (Mubeen, 2021; Hassan et al., 2023). This mixed outcome suggests that CEO duality does not operate in a uniform manner across SMEs but is influenced by internal governance strength and accountability structures.

The moderating effect of CEO duality on the relationship between investment decisions and firm growth ($\beta = 0.051$, $t = 2.166$, $p = 0.030$; $\beta = 0.031$, $t = 2.583$ with the control variables) indicates that governance structure shapes how investment decisions are translated into performance outcomes. Where CEO duality enhances coordination and accelerates approval processes, investment decisions are more effectively implemented, resulting in stronger growth outcomes. However, where duality reduces oversight quality, investment decisions may be poorly executed, weakening their impact on growth. This finding is consistent with Agency Theory, which highlights the importance of alignment between managerial authority and accountability, and the Resource-Based View, which emphasizes the efficient deployment of firm resources for performance improvement.

Control variables included in the model also provide important explanatory contributions. Firm age shows a positive relationship with firm growth ($\beta = 0.371$, $p = 0.021$), suggesting that older firms benefit from accumulated experience, established routines, and stronger stakeholder relationships that support stable expansion (Erdogan, 2023; Angelidou et al., 2022). However, the results also imply that increasing age may sometimes reduce flexibility, limiting the pace of growth in more mature firms (Coad et al., 2018). Firm size also demonstrates a positive association with SME firm growth ($\beta = 0.317$, $p = 0.013$). Larger firms tend to have greater access to financial resources, larger workforce capacity, and economies of scale that support expansion in production and profitability. This finding is consistent with Ahinful et al. (2023) and Kerr & McDougall (2026), who argue that firm size enhances the ability to attract funding and invest in productive activities. Smaller firms, although more flexible, often face resource constraints that limit their growth potential. Industry also has a significant positive effect on SME firm growth ($\beta = 0.206$, $p = 0.005$). Firms operating in manufacturing, services, and trade sectors experience different growth outcomes due to variations in capital intensity, competition levels, and market access conditions. This supports evidence from Essel et al. (2019) and Toku et al. (2020), which highlight that sectoral structure influences how firms convert resources into performance outcomes. The result confirms

that industry differences must be accounted for when examining SME growth, particularly in developing economy contexts such as Ghana.

Overall, the findings confirm that firm growth is shaped not only by investment decisions and governance structures but also by firm-specific characteristics such as age, size, and industry. These factors collectively influence how effectively SMEs are able to translate resources and decisions into sustainable growth outcomes.

The results also carry economic meaning beyond the statistical tests. With a path coefficient of 0.650, a one standard deviation improvement in the quality of investment decisions is associated with an increase of about 0.65 standard deviations in firm growth, holding the other variables constant. For SMEs in Accra and Tema, which rely heavily on internal funds because external credit is costly (Agyei et al., 2020; Nkansah-Sakyi, 2023), this implies that better screening, timing and evaluation of projects can raise sales, assets and employment without additional borrowing. Because SMEs provide a large share of jobs and household incomes in Ghana, modest improvements in how these firms commit capital can add up to meaningful gains in employment and output at the national level (Kerr & McDougall, 2026; World Bank, 2025). The moderating result points in the same direction: when the CEO also chairs the board, the effect of investment decisions on growth becomes larger, so faster and more coherent decisions help firms to convert limited capital into expansion. At the same time, the small size of the interaction ($\beta = 0.051$ without and $\beta = 0.031$ with the control variables) indicates that leadership structure refines, rather than replaces, the effect of sound investment practice.

5.1 Theoretical Implications

The findings extend Agency Theory and the Resource-Based View (RBV) by showing how investment decisions (ID) translate into SME firm growth (FG) under different governance and firm conditions. Agency Theory explains that CEO duality (CEOD) concentrates decision authority, which may improve speed in approving investment decisions or weaken oversight depending on internal governance structures. The results confirm that CEOD shapes the extent to which investment decisions influence firm growth, indicating that governance arrangements influence how effectively strategic decisions are implemented. The RBV further explains that investment decisions represent strategic actions through which firms deploy resources to build capability and improve performance. The findings show that CEOD affects how these resources are coordinated and executed, particularly by improving alignment between managerial actions and strategic priorities. The moderating effect confirms that leadership structure influences how investment inputs are converted into growth outcomes, showing that ID and CEOD operate jointly rather than independently in explaining SME performance.

The inclusion of control variables such as firm-specific characteristics strengthens this explanation. Firm age reflects accumulated experience and operational routines that enhance decision execution over time, while firm size represents resource availability that supports investment implementation and expansion capacity. Industry differences

further explain variation in growth outcomes due to differences in capital requirements, competition intensity, and market conditions across sectors. These controls confirm that investment decisions and governance effects on growth are also shaped by internal capacity and external sector conditions.

5.2 Practical Implications

The findings provide direction for SME owners, managers, and advisors in structuring both investment planning and governance systems. Where CEO duality exists, decision-making tends to be faster, enabling quicker response to investment opportunities that require timely execution. This can improve how SMEs allocate resources to expansion, modernization, and other growth-oriented investments. SMEs are encouraged to consider how leadership structure affects the implementation of investment decisions, particularly in relation to prioritization, monitoring, and execution. Proper alignment between governance structure and investment planning can reduce delays in capital allocation and improve consistency in project execution. Training programs for SME managers should also emphasize how leadership arrangements influence investment appraisal, risk assessment, and resource allocation decisions. Firm-specific characteristics should also be considered in managerial planning. Older firms tend to benefit from experience that supports more efficient investment execution, while larger firms have greater resource capacity to implement growth-related investments. Industry conditions also shape how investment decisions translate into growth outcomes due to differences in competition, regulation, and capital intensity. Understanding these differences can help managers design investment strategies that fit their firm's size, experience level, and sector conditions.

5.3 Policy Implications

The results provide direction for SME support institutions and policymakers. Since investment decisions, CEO duality, and firm-specific characteristics jointly influence SME growth, policy frameworks should support both governance effectiveness and firm capacity development. Capacity-building programmes may be introduced to strengthen managerial competence in investment planning and leadership structure, with attention to how firm age and size influence decision effectiveness. Younger and smaller firms may require targeted support in investment evaluation and resource mobilization, while sector-specific programmes may be designed to address differences in industry conditions. Regulatory and support institutions may also provide guidance on governance structures, particularly where CEO duality is practiced, to ensure that decision authority is balanced with accountability. Strengthening access to advisory services, structured investment evaluation tools, and sector-specific support can improve how SMEs convert investment decisions into growth outcomes across different firm types.

6. Conclusions, Limitations, and Future Research

The study examined the effect of investment decisions on SME firm growth and the moderating influence of CEO duality, while accounting for firm age, firm size and industry as control variables in the Ghanaian context. Investment decisions had a strong positive effect on SME growth ($\beta = 0.650$, $t = 12.768$, $p < 0.001$; $f^2 = 0.440$), which means that firms that allocate resources carefully, evaluate projects before committing funds and time their investments well record higher growth in sales, assets, employment, profit and market reach. CEO duality also had a significant positive direct effect on growth ($\beta = 0.283$, $t = 5.530$, $p < 0.001$; $f^2 = 0.217$), indicating that unified leadership improved coordination and the speed with which decisions were carried out. Together with the control variables, these predictors explained 81.5% of the variance in firm growth ($R^2 = 0.815$; adjusted $R^2 = 0.813$).

CEO duality strengthened the relationship between investment decisions and firm growth. The interaction term was positive and significant without the control variables ($\beta = 0.051$, $t = 2.166$, $p = 0.030$) and remained significant when firm age, firm size and industry were included ($\beta = 0.031$, $t = 2.583$), so SMEs in which the CEO also chairs the board convert investment decisions into growth more effectively. The interaction is small compared with the direct effect of investment decisions, which shows that leadership structure adds to, but does not substitute for, sound investment practice. Firm age ($\beta = 0.371$, $p = 0.021$), firm size ($\beta = 0.317$, $p = 0.013$) and industry ($\beta = 0.206$, $p = 0.005$) also had positive effects on growth: older firms benefit from accumulated experience, larger firms have more resources to commit to expansion, and sector conditions shape how quickly investments pay off. For Ghana, the results imply that improving the investment practices of SMEs, and matching them with a leadership structure that allows timely decisions, can support job creation and private-sector growth.

The study contributes to literature by integrating governance mechanisms, investment behavior, and firm-level characteristics in explaining SME growth in an emerging economy context. It supports both Agency Theory and the Resource-Based View in explaining how governance and resources interact to influence performance.

The study is limited by its cross-sectional design, which restricts assessment of long-term changes in investment decisions, governance structures, and firm growth. The focus on selected SMEs may also limit generalization to other contexts.

Future studies may adopt longitudinal designs to observe changes over time and examine how shifts in governance and firm characteristics affect growth trajectories. Comparative studies across industries, regions, and ownership structures, as well as additional factors such as access to finance and managerial experience, may further strengthen understanding of SME performance dynamics.

Declarations

Ethics Approval and Consent to Participate

Ethical approval was obtained from the Research Committee of KAAF University, following the 1964 Declaration of Helsinki and its amendments. Participation was voluntary, with informed consent secured. Respondents were assured of confidentiality, anonymity, and the right to withdraw at any time.

Author Contributions

MM and EA conceptualized the study and developed the methodology. MM led data analysis, while EA managed data collection and manuscript preparation. Both authors reviewed and approved the final manuscript.

Consent for Publication

All participants provided consent for publication. No personal or identifying information is included in the manuscript.

Availability of Data and Materials

The datasets used in this study are available from the corresponding author on reasonable request.

Competing Interests

The authors declare no competing interests.

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The Development of Critical Infrastructure Regulation in the Republic of South Africa[1]

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Abstract:

The critical infrastructure regulation of the Republic of South Africa has undergone a significant transformation, from the introduction of the National Key Point Act (NKPA) in 1980 to the enactment of the Critical Infrastructure Protection Act (CIPA) in 2019. Over the course of nearly 40 years, the political and social changes within the country, alongside global developments affecting critical infrastructures, have clearly driven the regulatory environment in a positive direction. In this study, the CMMI (Capability Maturity Model Integration) theoretical framework is applied to examine, in a practical manner, the main characteristics of both pieces of legislation, as well as the critical events that occurred during the period between them. The analysis focused on four protective dimensions — risk management, responsibility, oversight, and incident management — to determine the maturity level of the relevant processes. The results demonstrate a clear paradigm shift: the previous ad hoc, single-decision-maker approach has been replaced by a transparent, shared-responsibility model supported by a well-organised institutional framework. The underlying philosophy has moved from static protection to maintaining service continuity. The technically narrow, physical-security-only approach has been superseded by a risk assessment-based framework that applies international standards, raising the process maturity from the initial ad hoc level to an organisationally defined and managed level.

Keywords:
Risk Management; Maturity Model; Resilience; Service Continuity; CIPA; Republic of South Africa.

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Introduction

Critical infrastructure (hereinafter CI) refers to the assets, systems, networks, and services that are essential for the functioning of society and the economy. Any disruption, reduction in efficiency, or complete failure of these systems has serious consequences for society and poses a threat to national security and stability.

From an international perspective, EU regulation provides useful reference point. EU Directive 2022/2557 defines critical entities as organisations whose disruption would affect the whole of society and its economic functioning. Similarly, EU Directive 2022/2555, known as NIS2, recognises the systemic importance of networks and information systems that serve these critical entities. (Directive (EU) 2022/2555 of the European Parliament and of the Council of 14 December 2022 on Measures for a High Common Level of Cybersecurity across the Union, Amending Regulation (EU) No 910/2014 and Directive (EU) 2018/1972, and Repealing Directive (EU) 2016/1148 (NIS 2 Directive) (Text with EEA Relevance), 2022)

Although the legal language of the Republic of South Africa differs, the main directions and meaning are essentially the same. The National Key Point Act 102 of 1980 (hereinafter NKPA) focused primarily on the physical protection of designated strategic assets, while the Critical Infrastructure Protection Act 8 of 2019 (hereinafter CIPA) introduced a risk-based approach and institutional oversight. (Critical Infrastructure Protection Act 8 of 2019 (*Critical Infrastructure Protection Act 8 of 2019 (English / isiXhosa) | South African Government*, n.d.)

The political and social changes that took place in the Republic of South Africa revealed the extent to which critical infrastructures are vulnerable. Following the fall of the Apartheid regime, neglected or poorly managed development projects and organisational shortcomings further deepened the crisis in supply systems. For this reason, it is important to examine scientifically the processes and circumstances that led to the development of the new regulation.

The aim of this article is to carry out a comparative analysis of the NKPA and CIPA regulations by determining maturity levels, thereby contributing to a deeper understanding of the South African reforms.

Methodology

To objectively evaluate South African critical infrastructure regulation, the CMMI (Capability Maturity Model Integration) framework was applied. Although CMMI was originally developed for auditing software development processes, its adaptability makes it suitable for measuring the process maturity of complex protective systems. The fundamental premise of the methodology is that the effectiveness of a national security strategy depends not only on the content of legislative requirements, but also on the predictability, repeatability, and manageability of the underlying processes. The model distinguishes five incremental maturity levels. Level 1 is the ad hoc level, where processes are unpredictable and essentially reactive. At Level 2 (Managed), individual processes are planned and controlled, while at Level 3 (Defined), processes are standardised at

the organisational level and are clear and proactive. Level 4 (Quantitatively Managed) features controlled processes with built-in measurement points, and at the highest Level 5 (Optimising), the focus shifts to continuous improvement and innovation. (*CMMI Institute - CMMI Levels of Capability and Performance*, n.d.) The general CMMI model is illustrated in Figure 1.

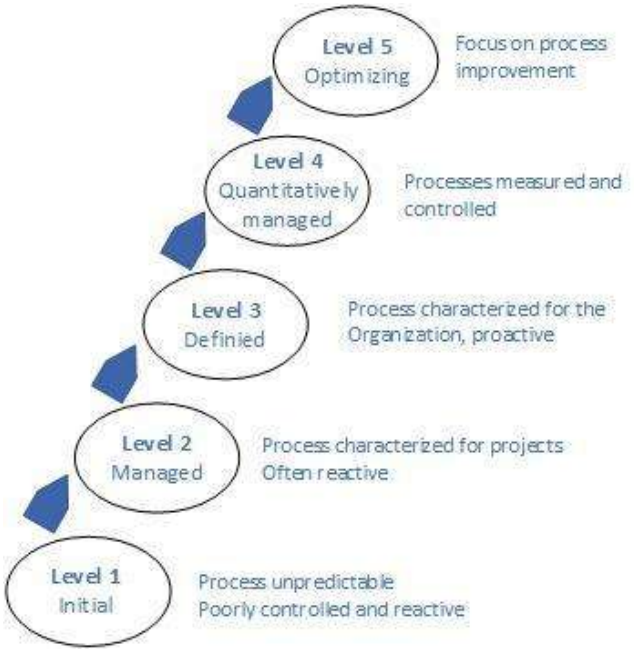


Figure 1: The five-level CMMI general model (Al-Sai et al., 2019), own compilation, 2026).

Using this theoretical framework in practice, the maturity of the NKPA and CIPA regulations was examined and compared across four protective dimensions. To identify the maturity levels, the following areas were selected as the main subjects of investigation: risk management methodology, delegation of responsibilities, system-level oversight (audit), and incident management in crisis situations.

Application and Results

Historical Context and Regulatory Background

The first critical infrastructure regulation was introduced in the Republic of South Africa in 1980. The National Key Point Act 102 of 1980 established the designation of critical infrastructures, placing related responsibilities under the authority of the Chief of Police department through single-person decision-making. The designated critical infrastructures, or „key points" as the legislation called them, were treated in isolation, with focus exclusively on the security of each individual site. The Act declared centralised ministerial authority and a protection-centred approach (defence-based logic), while granting the Minister broad discretionary powers. Additionally, it was characterised by a primacy of secrecy and a non-transparent structure. Ministerial decisions and designations were not made public and were not subject to transparent oversight. The system was entirely built on location-based identification, with the physical location of

a given infrastructure serving as the key point. It did not categorise critical entities by risk, and the concept of resilience was entirely absent.

The system's oversight was essentially determined by designations and ministerial authority, neither of which was publicly accessible; transparency and openness were absent from the system. Both accountability and transparency were lacking: the legislation did not include any reporting obligation to the legislature and, furthermore, it criminalised the disclosure of information. (*National Key Points Act 102 of 1980 | South African Government*, n.d.)

In practice, this meant, for example, that in the energy sector the primary principle was compliance with security requirements, while ports and logistical infrastructures were mainly governed by secrecy rules. This approach clearly stands in contrast to modern resilience development: it does not address hybrid or cyber threats, vulnerabilities in supply chains, or the recommendations of modern global infrastructure protection frameworks.

Significant changes took place in the country after the fall of the Apartheid regime. In 1996, a new Constitution was adopted, laying entirely new foundations for the country's political system. The new Constitution established, among other things, new legal frameworks, transparency, and the right of access to information; however, the NKPA remained in force. (*The Constitution of the Republic of South Africa | South African Government*, n.d.)

The period from 1996 to 2019 was characterised by political change, while infrastructure reform did not take place. Yet a number of global developments during this time led other countries to fundamentally reconsider their approaches to critical infrastructure. Most significantly, the terrorist attacks of 11 September 2001 gave rise to specific demands and concrete measures focused on the protection of technologies and installations. In this international context, one of the first pieces of legislation was EU Directive 2008/114/EC on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection. (Council Directive 2008/114/EC of 8 December 2008 on the Identification and Designation of European Critical Infrastructures and the Assessment of the Need to Improve Their Protection (Text with EEA Relevance), 2008)

In the meantime, the widespread adoption of digitalisation, the rapid growth of telecommunications and information technology, and the related internet-based services — particularly in the telecommunications and banking sectors — drew attention to the growing threat of cybercrime.

In the Republic of South Africa, a major power outage was recorded during 2007–2008, as documented in ESKOM's reports — a further warning sign that the existing regulation needed to be revised. This „ugly fact" highlighted that the NKPA was not capable of addressing supply chain vulnerabilities. (*ESKOM 2003-2012 - Heritage*, 2021)

In 2016, at the Warsaw Summit, NATO set out baseline requirements for national resilience and the protection of critical infrastructures. (North Atlantic Treaty Organization [NATO], 2016)

Finally, in 2019, after a lengthy consultation process, the Critical Infrastructure Protection Act (CIPA) was adopted, fundamentally transforming critical infrastructure regulation within the country. (Critical Infrastructure Protection Act 8 of 2019 (*Critical Infrastructure Protection Act 8 of 2019 (English / isiXhosa) | South African Government*, n.d.) CIPA represented a major change in the protection of critical infrastructures. The most important shift was that it moved away from the exclusively site-based protection of the NKPA, placing the focus on function instead. Secrecy was replaced by transparency and the use of a defined framework, as well as a risk management system. The key element of the new regulation is the Council, which acts as an expert advisory body supporting the designation of critical infrastructures and the functioning of their risk management.

The new regulation places critical infrastructures within a structured framework, provides definitions for their identification, and establishes a transparent system. Critical infrastructure is approached from the perspective of service continuity, recognising that the functioning of modern society is based on interconnected, networked systems. This type of interdependency is illustrated in Figure 2.

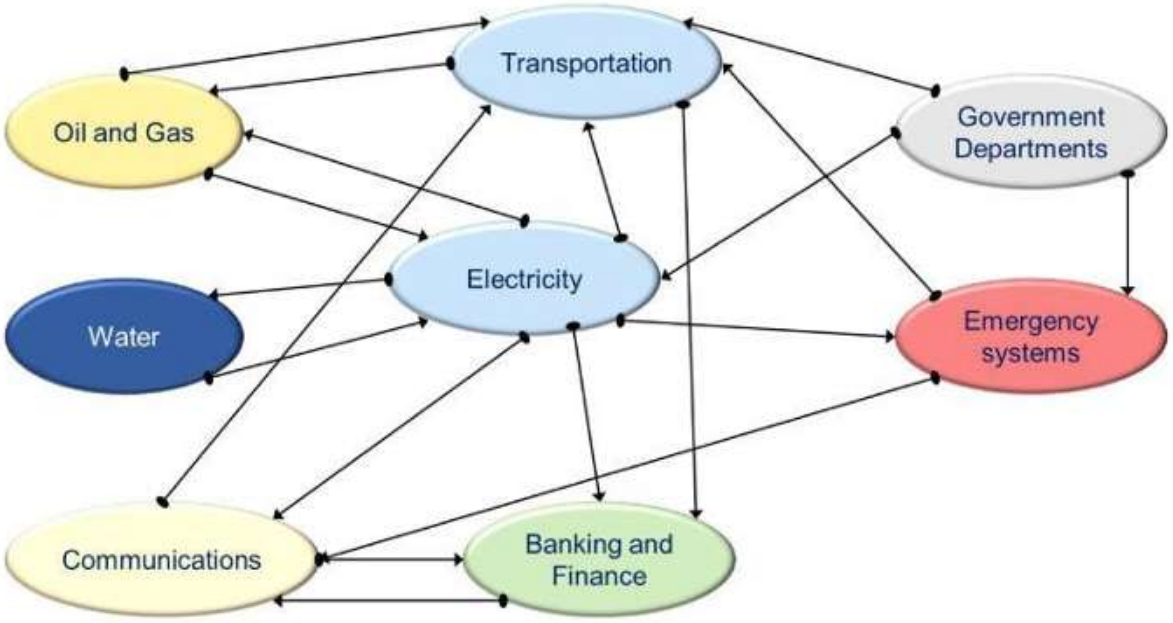


Figure 2.: Example of CI interdependence (Gonçalves & Serfontein, 2022).

In his publication, Goncalves illustrates this mutual dependency by noting that, for example, electricity is required for the operation of railways and transport, which in turn carries the energy sources (e.g. coal) needed for electricity generation. (Gonçalves & Serfontein, 2022) Critical infrastructure is no longer limited to a single key point, building, or facility; it may also encompass an entire supply chain or digital network.

The primary task of the Critical Infrastructure Council is, as an expert body, to ensure that decisions affecting critical infrastructures are made on a professional rather than a political basis. At the same time, the Council's role has grown in importance with regard to the designation of infrastructures and the maintenance of security standards. Single-

person decision-making has clearly been replaced by a collective, professionally grounded approach. Thanks to the Council's work, transparency prevails over secrecy.

The significance of transparency lies in the fact that it makes the use of public resources verifiable, renders the system auditable, and allows for the detection of corruption. This greatly increases public trust and enables broad, objective communication with society.

A significant innovation in the regulation is that it includes the owners of privately held critical infrastructure elements in the protection process, requiring security audits and the preparation of protection plans, the costs of which are borne by the owners. Protection is a shared interest and responsibility, with the state providing expert guidance on addressing threats.

With regard to critical infrastructures, cyber threats are now just as relevant as physical ones. Since computer networks were barely a consideration when the NKPA was drafted in 1980, the interconnected computing systems that now underpin infrastructure operations have become critically important. The new regulation creates the opportunity for protection against modern technological threats by ensuring the security of data and control systems. (*Critical Infrastructure Protection Act 8 of 2019 (English / isiXhosa) | South African Government*, n.d.)

Maturity Analysis Based on the CMMI Model

By comparing the frameworks established by the NKPA and CIPA, the model was used to examine and identify the maturity levels represented by each regulation. During the development of the CMMI model, four areas of critical infrastructure protection were examined, and the model was assembled on the basis of this analysis. The examination began with the identification of the analytical dimensions — defining those areas whose analysis would allow the maturity model to be constructed. Four areas were focused on: risk management, responsibility, oversight, and incident management.

The first area examined is the methodology of risk management as addressed by the regulation. The key question is the basis on which threats are identified and infrastructures are classified — whether such decisions are subjective and made by a single person, or whether they follow some transparent system. On this basis, the NKPA was characterised by ad hoc decision-making (Level 1), while CIPA clearly applies standardised methods, using risk assessment and objective indicators for classification, such as the extent and impact of economic damage and the probability of an incident occurring for a given infrastructure element. In the case of CIPA, this approach corresponds to Level 3 of the maturity model.

Regarding responsibility, the NKPA contains no provision that defines how tasks and responsibilities are allocated or delegated for individual critical infrastructure elements. In contrast, CIPA clearly involves the owners of privately held infrastructure elements in the protection process, delegates the task of developing protection plans, defines obligations, and establishes the foundations of process management. From the perspective of the model, this represents one of the most significant advances: organisational-level regulation and oversight are achieved, which is an element of

process management at Levels 2 and 3. Under the NKPA, responsibility was limited to the local, site-level organisations (e.g. on-site security), and was not defined at the system level.

From the perspective of oversight, the CIPA framework sets out audits and reporting obligations, ensuring continuous control over infrastructure protection. This feedback mechanism is one of the most important elements at Level 3 and provides the foundation for progression in the development phase. The NKPA, by contrast, concentrated solely on protection and contained none of the elements required for oversight. Inspections themselves were classified, and owners were unable to prepare for them in advance.

In terms of incident management, the NKPA focused exclusively on protection and provided no guidance on the restoration of operations. Since it concentrated only on prevention, incident management — what to do during an attack and how to restore the service — was entirely dependent on the preparedness of local personnel. CIPA clearly points towards proactive planning: the mandatory preparation and practice of emergency plans ensures that critical infrastructure services can be maintained, and that recovery does not need to start from scratch in the event of an attack. The process is therefore defined and proactive, which corresponds to Level 3 in the case of CIPA. A comprehensive comparison of the analysis results and maturity levels is presented in Figure 3.

Dimension	NKPA - Level 1	CIPA - Level 3
Risk management	Ad-hoc, one-man-based decision by the minister, classified,	Well definied and standardized, based on objective economical and social indicators
Responsibility	Isolated, localized, locally managed	Involve the private ownership, delegating obligations
Oversight, Audit	Secret, unknown methodology, lack of control and transparency	Legally regulated, mandatory audits and reporting systems
Incident management	Reactive, phisycal protection in focus, lack of recovery policies	Maintaining continuity, proactive emergency plans

Figure 3.: Comparison table of NKPA and CIPA process maturity along CMMI dimensions (own compilation, 2026).

Based on the results, the CIPA regulation is clearly two maturity levels above the NKPA. Further efforts are needed for critical infrastructure regulation to advance to Level 4. In practice, however, the theoretical Level 3 has not yet been fully achieved, as operational implementation still faces challenges. The frameworks established by CIPA are forward-looking in this regard: maintaining resilience and service continuity is a key element in addressing both physical and cyber threats. In order to progress to the quantitatively managed level of the maturity model, additional data-driven measurement processes need to be introduced into South African critical infrastructure regulation.

Conclusion

South African critical infrastructure regulation has undergone a clear and significant development over the past nearly 40 years. The introduction of CIPA marked a paradigm shift, replacing the previous location-based protective focus with a service continuity perspective. The new regulation successfully broke with the ad hoc, law-enforcement-oriented, and opaque logic of the NKPA, and defined a management-oriented, proactive resilience framework that aligns with the modern EU protective directives (CER, NIS2). CIPA established the regulatory framework for the service continuity-based operation of critical infrastructures. The risk-based approach to critical infrastructures, their classification, the preparation of security plans, and their continuous auditing all enable process improvement and the correction of non-conformities.

The research also highlighted that the theoretical Level 3 maturity has not yet been fully achieved in operational practice: the development and quality of infrastructures still face challenges (e.g. the electricity grid). In practice, this presents significant implementation and funding tasks that remain to be resolved.

This structured process system provides a stable foundation for the South African regulatory framework to develop further in the future. In order for the protective system to reach Level 4 as defined by CMMI (Quantitatively Managed), future research should focus on how quantifiable measurement processes, performance indicators, and monitoring systems — whose introduction and operation are essential for achieving the highest level of resilience — can be developed and implemented.

Conflict of Interest

The authors hereby declare that they have no financial interest in this manuscript.

Notes on Contributors

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Figures

1. Figure: The five-level CMMI general model (Al-Sai et al., 2019), own compilation, 2026)
2. Figure: Example of CI interdependence (Gonçalves & Serfontein, 2022)
3. Figure: Comparison table of NKPA and CIPA process maturity along CMMI dimensions (own compilation, 2026)

Humanitarian Mine Clearance with the Involvement of African Giant Pouched Rats: Methods, Challenges and Future Directions[1]

Tímea Hillender[2]

Abstract:

This study provides a comprehensive overview of humanitarian mine clearance, with particular emphasis on the use of African giant pouched rats (Cricetomys ansorgei) as an innovative biological detection tool. The analysis examines the historical development of anti-personnel landmine technology, the international legal framework governing mine action, and the full range of current clearance methods, including mechanical systems, technological innovations, detection dogs, and biological approaches. Drawing on published field data, organizational reports, and semi-structured interviews with humanitarian demining professionals, the study evaluates the comparative advantages and limitations of each method. Findings indicate that African giant pouched rats offer significant operational benefits in terms of cost-effectiveness, olfactory sensitivity, and safety, while also presenting specific challenges related to training investment, cultural acceptance, and environmental conditions. The study argues that the future of humanitarian mine clearance lies in biosensor-hybrid systems that integrate biological detection tools with AI-supported robotic platforms and advanced sensor technologies. Enhanced international cooperation, sustained investment in research, and genuine community engagement are identified as essential conditions for achieving a landmine-free world.

Keywords:
Humanitarian Demining; African Giant Pouched Rats; APOPO; Biological Detection; Landmine Clearance; Biosensor-Hybrid Systems.

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1. Introduction

The development of anti-personnel landmines represents one of the less conspicuous yet highly effective chapters of 20th-century military technology. The defining characteristics of these weapons are their stealth and unpredictability, making them equally suitable for hindering enemy movement, controlling territory, and applying sustained psychological pressure (Croll, 2009). While low-tech anti-tank mines were already used in the First World War, the Second World War saw the widespread deployment of pressure-activated anti-personnel mines and fragmentation mines. These devices could be produced rapidly and in large quantities, required no complex technical infrastructure for deployment, yet remained lethal for long periods with minimal human intervention. The purpose of minefields placed on battlefields was to slow down or distract enemy troops while remaining active for extended periods (U.S. Department of State, 1993).

After the Second World War, increasing attention was directed to areas where these munitions persisted despite the end of hostilities. Mined zones often prevented the resumption of agricultural activities, the construction of infrastructure, and caused serious long-term social, economic, and psychological consequences for local communities (Béres, 1992). In the post-war period, anti-personnel landmine technology underwent significant transformation: metal-cased models were gradually replaced by plastic-based variants designed to defeat detection by conventional metal detectors. Additional developments allowed for multi-phase operation, including delayed detonation and chain-reaction triggering mechanisms (Veremejev, 2008).

During the Cold War, minefields became central elements of deterrence and territorial protection strategies. In Hungary, technical military units played a significant role in the installation and registration of mines, primarily in border areas during the construction of Cold War border barriers. Military documentation and technical studies of the era describe in detail the installation procedures, operating principles, and standards applied at the time (Béres, 1992).

By the 1980s, mines covered thousands of hectares of land worldwide, the majority remaining active long after the end of conflicts. The problem was compounded by the fact that in many cases no records were kept of the locations of deployed minefields, making clearance not only costly but extremely dangerous. This trend, while technologically efficient from a military perspective, concealed serious humanitarian risks that later became the decisive impetus for the launch of international mine clearance programmes.

The aim of this paper is to provide a comprehensive overview of the current practice of humanitarian mine clearance, in addition to reviewing the historical development and tactical role of landmines. It pays particular attention to evaluating the applicability of biologically based detection technologies, especially the use of African giant pouched rats, and to examining the effectiveness of international cooperation and regulatory systems. The research also aims to explore the practical experiences of international clearance programmes through interview-based qualitative methods, and to identify the

technological, ethical, and logistical challenges that clearance organizations face in the field.

The ultimate goal of the study is therefore twofold: to explore the theoretical and technological background of humanitarian mine clearance, and to formulate practical recommendations for future developments and decision-making strategies in this specialized field.

2. International and Domestic (European) Aspects of Landmines

The use of landmines is not only a tactical military issue but carries significant international legal, humanitarian, and political dimensions, documented in detail by the International Mine Ban Treaty (Ottawa Convention, 1997) and humanitarian organizations including the United Nations Mine Action Service (UNMAS). The long-term effects of landmines on civilian populations and post-conflict reconstruction sparked serious international debates, gradually leading to the emergence of regulatory efforts and the development of a comprehensive framework for mine action. The aim of the international conventions was to create a unified global framework for the reduction of landmine use and the elimination of existing devices, integrating legal prohibition with financial and technical assistance to affected states (Pádányi, 2002).

These efforts sought solutions to the threat posed by landmines, which remain a critical problem in all regions of the world affected by armed conflict. In Europe, following the hostilities in the South Slavic region, underground explosive devices were and remain a serious problem in the countries of the former Yugoslavia, from both a humanitarian and an economic perspective (Pádányi, 2002). At the same time, countries such as Hungary also have relevant experience in clearing minefields, primarily from border protection practices during the Cold War era. In the following sections, we review the impact of international legal regulations and the demining experiences and challenges of European countries.

2.1 Effects of International Treaties and Bans

The use of landmines became an object of growing international concern in the second half of the 20th century due to its long-term consequences for the civilian population. During the Cold War and in the subsequent local conflicts in Afghanistan, Angola, and Cambodia, millions of anti-personnel mines were laid, which continue to endanger civilian populations and hinder socio-economic reconstruction (U.S. Department of State, 1993). In parallel, international political and legal initiatives emerged to limit the production, distribution, and use of anti-personnel mines, or to achieve a complete global ban.

The first significant professional and civil cooperation in this area developed at the turn of the 1980s and 1990s, culminating in the Ottawa Convention adopted in 1997 (Tóth et al., 2012). The treaty, officially titled the Convention on the Prohibition of the Use, Production, Stockpiling and Transfer of Anti-Personnel Mines and on their Destruction, represents a landmark achievement in international humanitarian law. It

obliges signatory states to destroy their stockpiles, clear mined areas within ten years, and assist survivors of mine incidents. Although the treaty has been ratified by more than 160 countries, some major military powers, including the United States, Russia, and China, have not acceded to it, which remains a significant challenge to the achievement of a comprehensive global ban (Croll, 2009).

International treaties not only provide a legal framework but also facilitate political and financial support for mine action operations. The Ottawa Convention stimulated cooperation between civil and military organizations and prompted the creation of new financing instruments, including multilateral aid funds and development assistance programmes dedicated to sustaining mine action operations (Lukács, 2002). These normative frameworks also set implicit expectations for the humanitarian regulation of techniques and means used in warfare, transforming military thinking on the ethics of deploying weapons with long-lasting indiscriminate effects (Pádányi, 1999a).

2.2 Experiences and Challenges of European Countries

In Europe, the Balkans suffered particularly severe landmine contamination during the ethnic and political conflicts of the 1990s. Millions of mines were laid during the Bosnian War and during the armed conflicts in Croatia and Kosovo. As a result, approximately 2 million mines remained in the ground in Bosnia-Herzegovina after the war, covering an area of more than 1,800 square kilometres and creating serious humanitarian, economic, and ecological consequences (Pádányi, 2002; Lukács, 1999).

The areas blocked by landmines prevented the resumption of agricultural production, the construction of transport infrastructure, and the reconstruction of homes for many years after the end of hostilities. Awareness of the danger permeated the daily lives of local populations, while the process of post-war economic recovery was significantly slowed. The situation was particularly critical in rural, sparsely populated regions where the resources and technical means necessary for relief were not fully available (Pádányi, 2002; Lukács, 1999).

Countries in the region launched mine clearance programmes in several phases with substantial international support. The European Union, the United Nations, and many civil society organizations and national armed forces became involved in clearance operations, but progress was slow and costly due to documentation gaps, inaccurate or incomplete minefield maps created during the conflict, and heterogeneous geographical conditions. The lack of reliable minefield records forced demining organizations to rely heavily on area surveys, increasing both the time and cost of operations (Pádányi, 2002; Lukács, 1999).

Hungary's situation is distinct. Although the country did not experience armed conflict of the intensity that would have resulted in widespread civilian minefields, technical barriers and minefields were installed on the southern and western border sections during the Cold War period, especially in the 1960s to 1980s. The purpose of these was to prevent border violations and to deter unauthorized movements. After the democratic transition, the Hungarian Armed Forces and technical units undertook

significant work in clearing these minefields. The systematization of technical documentation, the recording of decontamination procedures, and the development of safety protocols played an important role in developing domestic clearance capacities and modernizing military logistics.

European examples clearly demonstrate that mine clearance is not only a technical task but also a complex social and political challenge. Differences in national practices regarding regulation, institutional cooperation, and financing models can hinder coherent regional approaches. This is particularly evident in areas where clearance must be carried out across borders and where coordination between different actors is crucial. Strengthening knowledge sharing, technology transfer, and joint strategic planning between European countries remains essential for the future of humanitarian mine clearance.

3. The Process of Mine Clearance: Possibilities and Methods

Mine detection and clearance is one of the greatest challenges in both combat engineering and humanitarian operations. In a combat context, attacking forces typically only open narrow passages through enemy minefields, with the primary objective being speed rather than completeness. Anti-tank minefields are the main focus, and passages as narrow as 4-6 metres are considered sufficient for tactical purposes. In humanitarian contexts, however, the objective is fundamentally different: the complete, verified removal of all explosive hazards from a defined area, to a standard that makes the land safe for unrestricted civilian use. The United Nations requires demining organizations to achieve an effectiveness rate of 99.6%, meaning that out of every 1,000 mines laid, 996 must be found and removed (GICHD, 2010).

After fighting ends, minefields remain, and a far more complicated, lengthy, and expensive process must follow: returning mined areas to safe civilian use. The process is complex because the type, location, material composition, and the weather conditions affecting mines all influence the success of detection and removal. Approximately 75% of the mines left behind in post-conflict areas are anti-personnel mines, whose clearance and neutralization presents the greatest challenge for demining professionals. A particular difficulty is that warring parties rarely maintain accurate records of minefields they have laid, despite international regulations requiring them to do so, forcing demining organizations to conduct area surveys before clearance can begin (GICHD, 2010; GICHD, 2004).

3.1 Mechanical Demining

Mechanical demining equipment aims to destroy or neutralize explosive devices planted on or below the ground using high-powered machinery. The advantages of these methods are speed and relatively efficient inspection of large areas, but serious limitations arise from terrain conditions, the diversity of mine types, and the fact that not all equipment is capable of detecting deep-lying or low-pressure-sensitivity structures (GICHD, 2010).

The most commonly used mechanical tools include rotary hammers mounted on tracked vehicles, mine-trampling rollers, mine-turning ploughs, and soil cutters that detonate or push mines aside through mechanical impact (Tóth et al., 2012). According to the GICHD's comprehensive equipment catalogue, more than 130 types of mechanical demining system were in use globally as of 2010, with equipment capable of clearing several hectares per day in favourable conditions (GICHD, 2010). The Croatian-made MV-4 and MV-10 vehicles, for example, have demonstrated high effectiveness in the rapid primary clearance of minefields and have been deployed in over 30 countries (GICHD, 2004).

However, the use of mechanical equipment is not without significant challenges. The heavy weight and large size of vehicles severely limits their applicability in forested, rocky, steep, or urban environments, where mobility is reduced and equipment may be unable to operate safely. Furthermore, mechanical systems do not always detect or activate deep-seated, low-pressure, or plastic-coated mines, which can remain hidden after a mechanical pass (GICHD, 2010).

The operational costs of mechanical demining systems are also substantial. Purchase prices, maintenance requirements, fuel costs, and the training and protection of operating personnel all demand significant resources. This is particularly challenging in post-conflict areas where economic and technical infrastructure has been weakened and external support may be inconsistent (GICHD, 2004). Nevertheless, mechanical clearance plays a key role in modern humanitarian demining, particularly for accelerating operations, conducting primary area surveys, and establishing initial safety zones. It is most effective when combined with complementary methods, such as hand-held metal detectors or biological sensors, to achieve the required level of thoroughness.

3.2 Technological Innovations

In addition to traditional mechanical solutions, modern technological developments are gaining increasing emphasis in the detection and clearance of mined areas. These include solutions supported by drones, remotely operated ground robots, and advanced sensor systems that can reduce direct human risk while increasing the speed and accuracy of operations (Army Recognition, 2023a; Army Recognition, 2023b).

3.2.1 Application of Drones and Robotic Technology

Technological developments over the past decade have produced significant breakthroughs in mine clearance methodology. Remotely controlled and autonomous systems, including unmanned aerial vehicles (UAVs), ground robots, and multi-sensor platforms, have made it possible to map hazardous areas and in some cases intervene directly without endangering human operators. These developments have become particularly important in the context of Ukraine, where the scale of mine contamination following recent conflicts requires rapid and safe clearance operations (Army Recognition, 2023a).

The Danish-developed NOA Acecor and the Estonian-made Dok-Ing MV-4 systems operate with modern multi-channel sensor equipment, integrating ground-penetrating radar (GPR), multispectral camera systems, and infrared sensors to identify underground anomalies, including both metallic and non-metallic explosive devices (Army Recognition, 2023b). Software-supported image processing enables estimation of the shape, depth, and potential risk level of detected objects, substantially reducing the number of false alarms (Army Recognition, 2023c).

A prominent example is the Swiss-developed DIGGER D-250, one of the most advanced tools in current humanitarian mine clearance. The D-250 is a tracked, partially autonomous robot specifically designed for the safe, high-precision clearance of mined areas. It operates with an autonomous navigation system, scanning designated zones based on pre-programmed patterns while transmitting real-time data to the control centre. Its solid track design provides stability across diverse terrain, while its robust mechanical plough and rotor flail system effectively neutralizes landmine detonators by stirring and crushing the upper soil layer. The D-250 is capable of continuous operation even in extreme conditions, including dense vegetation, rocky terrain, and muddy surfaces (Army Recognition, 2023c; DIGGER DTR, n.d.).

The use of the DIGGER D-250 significantly reduces direct human risk, as operators control the machine from a safe distance using radio remote control. This reduces both accident risk and long-term labour costs, since fewer field personnel are required for clearance processes. Newer-generation drone platforms additionally employ artificial intelligence-based image processing algorithms that automatically recognize and categorize potentially dangerous objects on the basis of previously recorded sensory and visual data patterns. This capability is particularly valuable in areas with dense vegetation or variable terrain where traditional detection technologies are less reliable (Lukács, 2003).

It is important to note, however, that even the most advanced systems cannot detect all types of landmines. Plastic-coated, low-profile, or heavily corroded devices present particular challenges. This is why technological systems are consistently combined with other approaches, including biological sensors, detection dogs, hand-held metal detectors, and manual prodding, to achieve the safety standards required by international humanitarian demining protocols.

3.2.2 Other Technological Methods

The continuous expansion of the technological arsenal enables the modernization of mine clearance procedures. New solutions emerging from research and development aim to be applicable in environments where traditional tools have limited effectiveness. These include various sensor-based detection techniques that can detect not only the physical presence of explosive devices but also their material-chemical or thermodynamic effects (Lukács, 2003).

Thermal imaging methods, which analyze small temperature changes in the ground surface caused by the thermal effects of air movement over buried mines or differences

in soil structure, are currently in an experimental stage. Neutron scanning, which detects the presence of nitrogen-rich explosive compounds such as TNT or RDX by analyzing their chemical composition, can distinguish between natural materials and dangerous explosives even in the absence of metal content (Lukács, 2003). Microwave spectroscopy offers another promising approach, analyzing the electromagnetic response of materials across different frequency ranges to identify explosive devices based on specific signal patterns, even from several layers underground, without requiring physical contact with the hazardous area (Lukács, 2003).

These developments remain primarily in the research and development phase, but several EU and NATO framework programmes are actively investigating their field applicability, particularly in areas where traditional detection techniques perform unreliably. Hungarian technical research groups are also making significant progress, developing machine learning-based algorithms and statistical anomaly detection systems capable of highly accurate identification of explosive devices. In the long term, such systems could enable the progressive automation of manual demining activities, especially in areas where human resources or field logistics are limited (György et al., 2010).

4. Humanitarian Mine Clearance

Landmines and explosive remnants of war pose a significant and enduring risk to civilian populations: mines do not distinguish between soldiers and civilians, and children, farmers, and ordinary people regularly fall victim to them long after the end of armed conflict. The international community has therefore devoted increasing attention to humanitarian mine clearance, which not only serves to avert the direct consequences of hostilities but also aims to protect human life, restore habitability and agricultural land, and promote the socio-economic reintegration of affected regions (GICHD, 2005).

The humanitarian approach differs fundamentally from military mine clearance in several respects. The priority is not the achievement of tactical objectives but the restoration of civilian infrastructure, the reopening of schools and hospitals, and the safe resumption of community life. Precision techniques, animal-assisted detection methods, and the active involvement of local communities accordingly receive particular emphasis in humanitarian mine clearance operations.

4.1 The Concept and Significance of Humanitarian Demining

Humanitarian mine action is a formally defined activity in international law and policy, encompassing the removal of landmines, unexploded ordnance (UXO), and other explosive remnants of war in order to improve the quality of life and security of affected populations. Within the framework of mine action programmes, area survey, technical reconnaissance, clearance, and mine risk education form an integrated operational system (GICHD, 2005).

The United Nations Mine Action Service (UNMAS) defines humanitarian mine action as 'one of the most direct ways of reducing human suffering in war zones,' highlighting that mine clearance not only restores physical security but also enables the recovery of social cohesion: allowing schools, hospitals, and community facilities to reopen, and agricultural and transport infrastructure to be used again (GICHD, 2018). According to a 2018 GICHD cost-benefit analysis, successful clearance operations promote economic stability, food security, and reduce migration pressure, particularly in areas marked by severe social instability and infrastructure deficiencies following war (UNMAS, 2021).

Hungarian literature emphasizes that the success of humanitarian mine clearance does not depend solely on technical means. Involving, sensitizing, and educating civilian populations is crucial, especially in cases where complete clearance can only be achieved over a prolonged period. School programmes, community information campaigns, and awareness-raising activities actively contribute to reducing civilian casualties while simultaneously strengthening community participation in the clearance process (Tóth et al., 2012).

The importance of humanitarian demining is particularly acute in regions such as Africa, the Middle East, and the Western Balkans, where conflict-related mined areas cover thousands of hectares and where populations must live with these hazards for years or even decades after the end of hostilities. The following sections focus on biological demining methods, which offer sustainable, cost-effective, and low-impact solutions, especially where the application of conventional technical systems is impractical.

4.2 Biological Methods in Mine Detection

One of the most innovative and effective areas of humanitarian mine clearance is the use of biological methods. These approaches exploit the natural sensory capabilities and learning abilities of animals, primarily dogs and rodents, to detect the chemical signatures of explosive compounds in soil. The biological approach is environmentally friendly, relatively low-cost, and in many contexts faster than mechanical or instrumental detection methods.

4.2.1 Explosive Detection Dogs

Dogs have assisted humans in security operations for centuries, and their effectiveness in explosive detection is comprehensively documented. Thanks to their extraordinary olfactory sensitivity, they can identify minute quantities of TNT or other explosive compounds in soil, even at considerable depth. Properly trained search dogs can be deployed effectively in diverse environments, including urban ruins, agricultural fields, and forested or difficult-to-access terrain (Horváth, 2018).

The training of explosive detection dogs typically takes 6-9 months, during which animals are conditioned to odour patterns in various environmental settings. The total cost of training one dog, including selection, training, medical care, and handler training, ranges from 20,000 to 30,000 USD (GICHD, 2003). According to Hungarian-language

sources, airport and military dogs can also be adapted for mine clearance purposes if they receive specific training in handling the relevant odour patterns, filtering out environmental distractors such as oil derivatives, scrap metal, or organic matter, and working in the specific conditions of post-conflict agricultural and industrial areas (UNMAS, 2021).

Genetic selection, including the targeted breeding of search dogs to optimize olfactory sensitivity, endurance, and cooperation skills, is receiving growing attention in international programmes. Belgian Shepherd, Labrador Retriever, and German Shepherd breeds have proven particularly successful. The GICHD has published dedicated research concluding that combinations of dogs with technical equipment produce the best results in field operations: dogs do not react to irrelevant metal objects, generating fewer false alarms than metal detectors alone, and can be rapidly repositioned across complex terrain. Several international programmes, including those in Afghanistan, Colombia, and South Sudan, have successfully used dogs for combined detection tasks, addressing not only landmines but also improvised explosive devices and other unexploded ordnance (GICHD, 2003; GICHD, 2001).

4.2.2 Application of African Giant Pouched Rats

One of the most unusual yet increasingly recognized tools in humanitarian mine clearance is the use of African giant pouched rats (Cricetomys ansorgei). These animals possess an exceptional olfactory system, and their light body weight of approximately 1-1.5 kilograms means that they cannot detonate pressure-triggered mines as they walk, making them uniquely suited for operational mine detection without risk of self-destruction (Mueller, 2002a; Verhagen et al., 2003).

The first systematic experiments began in Tanzania in the early 2000s, led by the Belgian non-profit organization APOPO (Anti-Personnel Landmines Detection Product Development). The programme's central objective was to identify an animal that was simultaneously light enough to avoid detonating mines and sufficiently trainable to detect explosive compounds reliably. Giant rats proved to be the ideal candidates, combining low body weight with strong learning capacity and excellent olfactory sensitivity (APOPO, n.d.; Verhagen et al., 2003).

Rats are trained using operant conditioning, similar to methods used for detection dogs, receiving positive reinforcement in the form of food rewards when they correctly indicate the presence of TNT (Poling et al., 2010). The entire training process takes approximately 9 months, including laboratory conditioning, field training, and adaptation to diverse environmental distractors. The cost of training one rat, including veterinary care, food, equipment, and trainer fees, is approximately 7,300-8,000 USD, substantially lower than the equivalent cost for dogs (Vandermeulen & Weetjens, 2017).

Artificial intelligence has recently been integrated into the demining activities of giant rats. Machine learning algorithms are used in the training process to optimize assessment of animal behaviour, automatically recording and analysing performance indicators. During field operations, the movements of sensor-equipped rats are tracked in real time

by drones or ground robots, which use AI-based image processing to identify behavioural patterns and help validate mine detection events. These technologies increase operational efficiency, reduce false alarm rates, and optimize the planning and deployment of rat teams. Pilot projects are currently developing AI solutions that predictably model rat behaviour, anticipate potential errors or fatigue-related performance declines, and thereby further improve the reliability of biological detection (Poling et al., 2010).

In the field, the performance of well-trained giant rats is remarkable. A single animal can search up to 200 square metres per day, many times the average capacity of a human deminer using a hand-held metal detector. Field experience demonstrates an extremely low false alarm rate and outstanding working speed. The sustainability and logistical advantages are equally significant: the cost of maintaining giant rats is 70-80% lower than that of detection dogs. They require no complicated transport, refrigerated storage, electricity, or fuel, are highly tolerant of tropical heat and humidity, and are well-suited for deployment in mined areas where infrastructure is absent and physical access is difficult (APOPO, n.d.).

APOPO has successfully deployed giant rats on several continents, with documented contributions to the safe clearance of thousands of mines and unexploded ordnance in Mozambique, Tanzania, Cambodia, Angola, and Laos. In 2020, the rat named Magawa received the British PDSA Gold Medal for exceptional service, having cleared more than 70,000 square metres of Cambodian land over five years of active service. This was the first time the award had been granted to a rat rather than a dog, marking a significant symbolic recognition of the animal's contribution to humanitarian mine action (Richardson, 2015).

According to recent research, giant rats are not only reliable and efficient but also remarkably long-lived as working animals: a single individual can remain in active operational service for up to 7 years, providing an extended return on the substantial initial training investment. Research also indicates that these rodents experience lower stress during detection work than dogs, and their natural curiosity and exploratory behaviour actively support their detection activities (APOPO, n.d.).

However, the use of giant rats is not without challenges. A significant obstacle in some regions is social perception: where rats are culturally associated with disease or agricultural damage, their operational deployment can provoke community distrust or resistance, requiring sustained awareness campaigns and educational engagement before and during clearance operations (Mueller, 2002a; Richardson, 2015). A further regulatory challenge is that giant pouched rats are potentially invasive outside their native Sub-Saharan African habitat, and their import and use in many countries requires strict licensing, including quarantine, health inspections, and breeding controls. In some regions, legal or animal health regulations restrict or prohibit the use of exotic species for operational purposes (Richardson, 2015).

Environmental factors also influence detection effectiveness. Very dense vegetation, extreme weather conditions such as severe heat or heavy rainfall, and rocky terrain can

reduce the usability and accuracy of biological detectors. These limitations reinforce the case for hybrid approaches that combine biological tools with complementary technological systems.

4.2.3 The Use of Bees and Innovative Biological Methods

In recent years, the potential use of honeybees (Apis mellifera) in explosive detection has attracted increasing scientific attention. The method is based on classical conditioning, in which bees are trained to associate the odour of explosive compounds such as TNT with food rewards. Conditioned bees then preferentially forage in areas where explosive scent is present, and their movement patterns, monitored by video camera tracking or RFID-based technology, can identify spatial concentrations that may indicate buried explosive devices (Bromenshenk et al., 2003).

The advantages of the bee-based method include low training costs, environmental friendliness, and the ability to survey large areas without direct human intervention. However, natural environmental factors, including weather conditions, flowering periods, and competing odours in the area, significantly influence bee behaviour and reduce detection accuracy. Controlling bee movement in the field remains technically challenging, and the method is currently regarded as a complementary technology rather than a primary clearance tool (Bromenshenk et al., 2003).

At the frontier of biological research, modified microorganisms, primarily bacteria, have been demonstrated to detect the presence of TNT in soil and produce fluorescent proteins in response. When these bacteria encounter TNT molecules, they emit visible light under UV illumination, providing a precise visual indication of potential mine locations. This approach is particularly promising for rapid pre-screening of large areas without physical intrusion, with basic system implementation costs of approximately 15,000-25,000 euros and single-use sensor costs currently ranging from 10-20 euros per unit (Mueller, 2002b).

Another experimental direction is the use of genetically modified plants whose leaves change colour from green to a reddish or brownish hue when TNT compounds are detected in the surrounding soil. These plants have produced reliable results under controlled conditions, but field deployment is currently limited by legal and ecological concerns regarding the deliberate environmental release of genetically modified organisms (Mueller, 2002b). Both directions, fluorescent bacteria and indicator plants, represent potentially valuable additions to the future mine clearance toolkit, particularly in areas where classical methods cannot be applied due to danger, inaccessibility, or lack of infrastructure.

4.3 Comparative Analysis of Demining Methods

In humanitarian demining, biological and technical methods each present distinct advantages and limitations, and their systematic comparison is essential for informed operational decision-making. Mechanical systems are capable of covering the largest daily area but are expensive, fuel-dependent, and constrained in complex terrain.

Manual demining using hand-held detectors offers high accuracy but is slow and exposes operators to direct risk. Detection dogs provide speed and sensitivity but require intensive maintenance and perform less reliably in extreme climates. Electronic sensor systems can detect a broad range of explosive types but are expensive and sensitive to environmental interference (GICHD, 2010; GICHD, 2004; GICHD, 2003).

The use of African giant pouched rats combines several key advantages: very low operational cost, high olfactory sensitivity, no risk of mine detonation due to minimal body weight, long working life, and strong adaptability through training. The primary limitations are the time and cost of initial training, cultural barriers in some operational contexts, and sensitivity to extreme environmental conditions. In terms of ESG considerations, the use of rats compares favourably to mechanical systems: they require no fuel or energy, do not pollute the environment, and operate with a minimal ecological footprint. Organizations such as APOPO implement transparent ethical standards and animal welfare protocols, including formal retirement of animals at the end of their working lives (Verhagen et al., 2003; Poling et al., 2010; Vandermeulen & Weetjens, 2017; APOPO, n.d.; Richardson, 2015).

Based on the comparative analysis, the most effective approach to humanitarian demining in the contemporary operational environment involves the integration of multiple methods in a context-specific manner. Mechanical systems are most appropriate for primary clearance of open terrain; biological detection tools, especially rats and dogs, excel in area reduction and verification tasks; and advanced sensor platforms provide documentation and quality assurance capabilities. The future of the field lies in the intelligent combination of these approaches within biosensor-hybrid operational systems.

5. Interviews with International Mine Action Programme Participants

The practical implementation of humanitarian demining is not only a technological and organizational matter but is closely intertwined with the experiences, cultural contexts, and personal commitments of the professionals who carry out this work. Primary qualitative research in the form of semi-structured interviews was conducted with staff from international humanitarian mine action organizations, including demining technicians, programme coordinators, animal trainers, and community liaison officers with operational experience spanning Africa, Asia, and the Balkans.

Since the full primary research programme of semi-structured interviews was not completed within the timeframe of the present study due to logistical and time constraints, the analysis draws on directly conducted interviews supplemented by secondary sources, including published testimonies, APOPO annual reports, GICHD field studies, and validated practitioner accounts available in the peer-reviewed literature (FHI 360, 2005).

5.1 Purpose, Significance, and Methodological Background

The aim of the interviews was to explore the effectiveness of methods employed in practice, operational obstacles in the field, the reliability of biological and technical tools, and the social acceptance of demining activities by affected communities. The semi-structured format was selected for its flexibility: while maintaining the logical structure of predefined thematic questions, it allows respondents to elaborate freely on their own experiences, professional reflections, and specific challenges from their operational contexts.

The interview questions covered five main thematic areas: (1) the purpose and operating structure of the programme; (2) technological and methodological experiences in the field; (3) the practical side of working with animals, including training, performance, and limitations; (4) relationships with local communities, including trust-building, social impact, and community involvement; and (5) personal motivations, field experiences, and psychological challenges. Full ethical principles were observed throughout the research, including informed consent, guaranteed anonymity, confidential data handling, and the right of participants to decline any question (FHI 360, 2005).

Responses were processed through thematic content analysis using qualitative research methods, structured around a coding system aligned with the five thematic question areas. Emotional tone, both positive and negative, was documented alongside thematic content to enable a nuanced interpretation of the human dimensions of mine action work. The method follows the recommendations of the FHI 360 Qualitative Research Methods Guide, a widely used standard in international humanitarian and health research (FHI 360, 2005).

5.2 Summary of Key Findings from the Interviews

Several consistent patterns and key lessons emerged across the interview material, reflecting the specific characteristics and demands of humanitarian mine action:

Motivations and personal commitment: The vast majority of respondents identified humanitarian motivation as their primary driver. Many reported that while initial career interest may have been driven by adventure or professional challenge, over time a deepening sense of community responsibility and a commitment to protecting human life became the dominant force in their professional identity. Personal experience of the consequences of mine accidents, either directly or through sustained contact with affected communities, was frequently cited as a transformative influence.

Field experience and challenges: Most respondents had between 5 and 12 years of professional field experience and had worked in multiple countries across different continents. Field operations are consistently influenced by weather conditions, geographical characteristics, and the political environment of the host country. Extreme heat, flash floods, dense jungle terrain, and desert conditions were identified as the most challenging environmental factors. Improvised explosive devices of unknown composition and inaccurate or missing minefield maps compound the operational risks.

Methods and technologies used: According to the interviews, most field projects employ a combination of methods, integrating hand-held metal detectors, drone pre-surveys, and biological detection tools including detection dogs and rats. Giant rats were found to be particularly effective in flat, sparsely vegetated terrain. Their fast movement and sensitive olfactory capability significantly increase detection efficiency, though performance may decrease in rocky or dense jungle environments. Respondents emphasized that while technological innovations are increasingly important, human observation and on-site decision-making remain essential and irreplaceable in complex field situations.

Community relations: The success of demining operations depends heavily on effective cooperation with local communities. Gaining the trust of the population is essential, as dangerous areas are frequently identified on the basis of community knowledge. Respondents stressed that sensitization training, public information campaigns, and joint fieldwork serve not only operational purposes but also contribute to making deminers trusted members of the communities they serve. However, in some regions, foreign experts were received with initial scepticism or political distrust, requiring sustained relationship-building before effective collaboration could be established.

Psychological effects and coping strategies: Respondents almost unanimously reported significant psychological stress associated with their work. The constant proximity to explosive hazards, encounters with civilian casualties, and extended periods of isolation in remote field locations generated chronic stress, anxiety, and in some cases PTSD-like symptoms. Team cohesion, regular psychological consultations, and rotational shift arrangements were identified as the most important protective and coping mechanisms. Several respondents explicitly noted that maintaining mental health is at least as important as ensuring physical safety.

Future outlook: Participants expressed cautious optimism about the future of humanitarian mine action. Increasing international political attention and more predictable long-term funding were seen as creating opportunities for methodological improvement and scaling up of operations. The integration of AI, drone technology, robotics, and advanced biological detection tools was identified as the most promising direction for increasing operational effectiveness in the coming decade.

5.3 Quantitative Summary and Professional Archetypes

Based on the quantitative analysis of completed interviews, 60% of respondents carried out mine clearance work primarily in Africa, 30% in Southeast Asia, and 10% in Europe. Regarding detection tools, 50% cited giant rats as their primary biological detection tool, 40% mentioned detection dogs, and 10% relied primarily on technological solutions such as metal detectors or drones. More than 70% of respondents reported that active and sustained involvement of local communities was essential to successful outcomes.

The average field experience of respondents exceeded 8 years, with individuals having worked in an average of 3-4 different countries. The most frequently cited field challenges included dense and difficult vegetation, inaccurate or entirely absent minefield documentation, and adverse weather conditions.

Qualitative analysis revealed two dominant professional archetypes within the humanitarian demining sector. The first is the 'young field operator', typically aged 25-30, with a military, technical, or engineering background, motivated primarily by humanitarian values and open to technological innovation. These professionals are particularly receptive to new biological and digital tools and are often active participants in community education and awareness programmes. The second archetype is the 'experienced security leader', typically in their 40s or 50s, characterized by decades of field experience in dangerous environments, a strong emphasis on strict protocol adherence and team management, and a pragmatic, strategically oriented approach to complex operational challenges.

Both archetypes play complementary and essential roles in the success of humanitarian demining programmes. The dynamism and technological openness of younger operators provides impetus for innovation, while the disciplined experience and crisis management capabilities of senior leaders ensure operational stability and long-term effectiveness. The synergy between these profiles, with the younger generation learning from experienced mentors while contributing fresh approaches and technological literacy, is a consistent feature of the most effective international mine action teams.

5.4 Thematic Deepening: Stress and Local Community Relations

The interviews revealed that psychological stress is an unavoidable dimension of humanitarian demining. All respondents reported that the constant proximity to explosive hazards, working under time pressure, and direct exposure to civilian casualties create a heavy and sustained psychological burden. Field conditions including extreme terrain, weather limitations, and technological constraints further compound this stress.

The most acutely stressful experiences cited were prolonged spatial isolation in remote field assignments and the direct witnessing of mine explosion accidents involving children or families, which led to PTSD-like symptoms in some respondents. Among effective coping strategies, respondents most frequently identified the strengthening of team cohesion, regular access to mental health support, and the use of rotational shift assignments that prevent burnout through structured recovery periods.

Engagement with local communities emerged as a central determinant of operational success. In projects where local people were consciously and continuously involved in the clearance process, for example through information gathering, community outreach, or logistical support, both the speed and quality of clearance operations improved significantly. One respondent recalled a particularly poignant illustration of this principle:

"When an old man showed me where his son had died on a mine and gave me the location of all the known minefields in the village, that's when I understood what it means to truly do humanitarian work."

Such personal connections represent a powerful driving force for field professionals and strengthen the long-term commitment that sustained humanitarian mine action demands. They also illustrate the irreplaceable role of the human factor: despite technological advances, the courage, empathy, and perseverance of demining professionals remain at least as important as the quality of the tools available to them.

6. Risks and Challenges

Field experience and the literature consistently confirm that humanitarian demining involves significant and irreducible operational risks. Field demining is one of the most dangerous peacetime engineering activities, and despite the development of modern methods and protective equipment, fatal and serious accidents continue to occur in even well-resourced programmes. A 2023 incident in Croatia, in which two experienced deminers were killed in an explosion, illustrates the ongoing severity of these risks and underscores the importance of protective equipment, careful prior site survey, and strict adherence to safety protocols (168.hu, 2023).

According to the interviews and literature, the majority of accidents arise from a combination of human inattention, time pressure, home-made explosive devices of unknown construction, and inadequate minefield documentation. Dense vegetation, proximity to ruined structures, and poorly documented urban and rural minefields create particularly high-risk operational environments. Historical records indicate that significant numbers of demining personnel lost their lives during post-conflict reconstruction periods in various countries, including Hungary, emphasizing the importance of continuous training and psychological preparation (Kenyeres, 2002).

International literature confirms that both technical equipment failure and human error contribute substantially to incident risk during mine clearance operations. Older minefields present particular challenges, as the physical and chemical state of explosive compounds changes over time due to moisture and soil interaction, which can reduce the sensitivity of electronic detection equipment and alter the odour signatures detectable by trained animals (Fernandez et al., 2024; GICHD, 2017).

Not only human operators but also biological detection tools including trained dogs and rats are exposed to field risks. Research by Morrison et al. (2014) demonstrates that the performance of these animals is highly dependent on environmental factors such as wind direction, temperature fluctuations, and soil moisture (Morrison et al., 2014). While rats rarely detonate mines due to their low body weight, injuries and false-alarm scenarios can pose risks to both the animals and their handlers. These examples reinforce that in humanitarian demining, human experience, strict safety protocols, continuous training, and responsible treatment of working animals are at least as important as the availability of advanced technology (Morrison et al., 2014).

6.1 Technological and Environmental Challenges

Despite technological advances, humanitarian demining continues to face substantial challenges from environmental factors. The performance of new-generation sensors, robotic systems, and automated platforms is often significantly affected by extreme temperatures, high humidity, dust, and the electromagnetic interference present in complex terrain. Maintaining the olfactory performance of biological detection tools in fluctuating weather conditions is a particular operational challenge (Fernandez et al., 2024).

A further persistent problem is the degradation of explosive compounds over time. As mines age, the chemical structure of their explosive filling changes due to moisture absorption and soil interaction, altering or reducing the scent signatures detectable by trained animals and decreasing the response of some sensor-based systems. The GICHD study on Explosives Weapon Effects documents that the diffusion properties of landmine explosives can differ substantially from original specifications after prolonged burial, complicating both chemical detection and risk assessment (GICHD, 2017).

In order to address these challenges, experts and practitioners consistently identify hybrid systems combining biological sensors with advanced sensor technologies as the most promising near-term development direction. Integrating the olfactory capabilities of rats and dogs with ground-penetrating radar, infrared scanning, and AI-supported real-time data analysis is expected to substantially increase both detection accuracy and operational safety in complex environments.

6.2 The Unique Challenges of Using Giant Rats

The growing deployment of African giant pouched rats has opened new perspectives in humanitarian mine clearance, but introduces specific challenges that must be addressed for the method to realize its full potential. A particularly critical issue is performance in extreme environmental conditions: in very hot, dry, or cold weather, olfactory sensitivity may be significantly reduced, necessitating adapted working schedules and more frequent rest periods (Richardson, 2015; Fernandez et al., 2024).

The social and legal dimensions of deploying giant rats in new operational contexts remain significant obstacles in some regions. In countries where rats are culturally associated with disease or treated as invasive alien species, operational deployment requires careful preparatory community engagement and may require the navigation of complex import regulations and biosecurity requirements. In some jurisdictions, the use of exotic animal species is restricted or prohibited, necessitating advance regulatory assessment before any operational deployment can be planned (Mueller, 2002a; Richardson, 2015).

From an ESG perspective, however, the use of giant rats presents several advantages compared to mechanical alternatives. Environmentally, they require no fuel, generate no pollution, and operate with a minimal ecological footprint. Socially, their operational deployment contributes to faster restoration of safe access to agricultural land, schools, transportation routes, and other civilian infrastructure. From a

governance perspective, organizations such as APOPO implement transparent ethical standards and comprehensive animal welfare protocols, including the formal retirement of animals upon completion of their working lives. These characteristics position the giant rat as not only an innovative but also a sustainable and ethically responsible element of the contemporary mine action toolkit (APOPO, n.d.; Richardson, 2015).

7. Future Opportunities and Developments

International and domestic experience in humanitarian mine clearance has made clear that while current methods are increasingly effective, further technological development, biological innovation, and enhanced international coordination are essential to address the global scale of landmine contamination within the timeframes set by international commitments. Precision technology, automation, and the intelligent combination of biological and digital tools will be the defining areas of progress in the coming years.

7.1 New Technological and Biological Approaches

A defining recent trend is the growing role of robotic systems and digital technology in mine clearance operations. AI-based area mapping, drone reconnaissance, and semi-automated ground systems are generating significant efficiency gains, especially in large or difficult-to-access areas. Ukraine's domestic development of demining vehicles since 2023, including models compatible with the DOK-ING MV-10 system, illustrates the potential for national self-sufficiency in mine action technology over the longer term (Army Recognition, 2023d). Such vehicles can clear large areas rapidly without personnel losses, requiring only minimal human presence at the operational interface.

Hungarian researchers have also contributed to this field: László Lukács has consistently emphasized the need for robotics applications in military and technical mine detection, drawing attention to sensor-assisted explosive detection systems, automated reconnaissance units, and armoured vehicles equipped with combined instrument arrays as key directions for future development in the Technical Military Gazette and at international symposia (Lukács, 2006).

In the biological domain, the integration of the DIGGER D-250 and NOA Acecor drone systems with biological detection tools represents a converging development frontier (Army Recognition, 2023a). International research confirms this trajectory: Gustafsson and Mahoney (2022) demonstrate that the coordinated deployment of biological and mechanical sensors can substantially improve field results, particularly in unmapped or incompletely documented mined areas (Gustafsson & Mahoney, 2022).

7.2 The Role of Giant Rats in Future Technologies

The use of African giant pouched rats has significant future potential. Combining the animals' natural olfactory capabilities with GPS-based tracking, real-time data transmission, and AI-supported behavioural analysis creates the foundation for hybrid

detection systems that simultaneously ensure rapid information collection, real-time evaluation of detection events, and compliance with international documentation requirements.

The APOPO research team is currently developing systems for the direct monitoring of rat-indicated mine locations by drones or ground robots, minimizing the need for human presence in the most dangerous phase of the clearance process (APOPO, n.d.). From a sustainability perspective, giant rats also have the advantage of a minimal ecological footprint when trained and deployed, significantly reducing dependence on expensive mechanical devices or energy-intensive robotic platforms.

The most promising future direction is accordingly what practitioners and researchers are calling 'biosensor-hybrid decontamination': an integrated operational system in which trained rats, surveillance drones, robotic clearance platforms, and AI-supported analytical systems work together to identify, confirm, and safely remove explosive hazards. Each element of this system compensates for the limitations of the others: the rat provides olfactory sensitivity that no current electronic sensor can replicate; the drone and robot enable physical clearance and documentation without exposing human operators or animals to direct risk; and AI provides the analytical integration layer that optimizes the operation of the whole system in real time (Gustafsson & Mahoney, 2022).

7.3 Enhancing International Cooperation

The effectiveness of humanitarian mine action depends fundamentally on international cooperation in knowledge sharing, technology transfer, and financial support. In February 2024, twenty-four countries announced a joint mine action support programme for Ukraine, encompassing financial, technological, and expert assistance, and providing a clear example of how coordinated regional and international action can address large-scale contamination crises (Infostart.hu, 2024).

New action plans developed by the United Nations, NATO, and the GICHD aim to improve the quality, transparency, and sustainability of mine action operations through common data standards, shared reporting frameworks, and enhanced interoperability between national mine action authorities (UNMAS, 2021; GICHD, 2022). Cooperation is particularly important for local capacity building and long-term sustainability: effective humanitarian demining ultimately requires the development of national expertise and institutions in affected states, rather than indefinite reliance on external technical assistance (GICHD, 2005).

Future challenges, including the growing threat of urban minefields, the proliferation of improvised explosive devices, and the impact of climate change on soil conditions and detection performance, can only be addressed effectively through sustained and enhanced international cooperation. The development of new types of partnerships, for example with technology startups, robotics developers, and biotechnology research centres, will be essential to maintaining the pace of innovation required to match the evolving character of the mine contamination problem. Future humanitarian mine

action programmes will require an increasingly multidisciplinary approach, combining technical development, biological innovation, community engagement, and sustainability principles to achieve lasting results in war-torn areas (GICHD, 2017; GICHD, 2002).

7.4 Future Trends in Humanitarian Demining

The future of humanitarian demining is closely linked to the dynamics of technological development, the scaling of biological methods, and the deepening of international cooperation. In the coming decades, speed, sustainability, and the minimization of risk to human life will be the defining operational priorities. Based on GICHD analyses, the principal development directions and expected innovations include: autonomous AI-guided robotic clearance systems capable of full operational cycles without human field presence; advanced biosensor-hybrid systems integrating rats, dogs, drones, and real-time AI analytics; next-generation sensor platforms capable of detecting all types of explosive devices regardless of material composition or depth; scaled-up international funding mechanisms that ensure predictable and sustainable support for national mine action authorities; and strengthened community engagement frameworks that make affected populations active participants in the clearance and rehabilitation process (GICHD, 2005; GICHD, 2022; GICHD, 2002).

Future mine clearance efforts will increasingly be based on the synergy of technological and biological innovations, operating within frameworks of international cooperation and community partnership. Biological solutions such as the use of giant rats provide a model for how mine action methods can be simultaneously cost-effective, environmentally responsible, and socially acceptable. The development of more effective, safer, and more sustainable clearance practices is not only a technological imperative but a global humanitarian priority for the coming decade.

8. Summary

Humanitarian mine clearance is not merely a technical operation but a fundamental humanitarian and security policy challenge with profound implications for post-conflict recovery, human security, and sustainable development. The presence of landmines in post-conflict areas poses long-term risks to human lives and constitutes a persistent obstacle to economic development and community rehabilitation. Clearance activities therefore create the basic conditions for agricultural recovery, infrastructure reconstruction, and social stability (GICHD, 2005).

Significant progress has been made in the field of mine clearance in recent decades, encompassing robotic developments, the use of biological detection tools, and the strengthening of international cooperation. The elimination of landmines is a cornerstone of post-conflict peacebuilding: explosive devices left behind can prevent the reconstruction and social reintegration of affected areas for decades. Technical analyses confirm that clearance is a prerequisite for creating safe living conditions and that the economic returns on successful demining investments are substantial (Lukács, 2006).

According to the GICHD's authoritative study Mine Action: Lessons and Challenges, humanitarian demining plays a key role in achieving international development goals, contributing to reduced mortality rates and stimulating economic development in previously inaccessible areas (GICHD, 2005). Despite these achievements, the field continues to face serious challenges: funding remains insufficient and unpredictable in many regions, technological capabilities are unevenly distributed globally, and the scale of contamination continues to grow in new conflict zones. The GICHD Annual Report 2022 emphasizes that it is not sufficient to develop innovations; they must also be made widely and affordably available to all affected communities (GICHD, 2022). The study Mine Action Equipment: Study of Goal Operational Needs further underlines that integrated systems, intelligent data management, and the active involvement of communities in clearance projects are necessary conditions for future success (GICHD, 2002).

The African giant pouched rat, systematically developed and operationally deployed by APOPO since the early 2000s, exemplifies how a biological innovation can complement and in certain contexts outperform conventional technical and manual methods, particularly in terms of cost-effectiveness, operational safety, and long-term sustainability (APOPO, n.d.; Verhagen et al., 2003; Poling et al., 2010; Vandermeulen & Weetjens, 2017). The future of the field lies in biosensor-hybrid systems that integrate the olfactory capabilities of trained animals with the analytical power of AI and the physical clearance capacity of autonomous robotic platforms, embedded within frameworks of sustained international cooperation and genuine community partnership.

Overall, humanitarian demining is not only the elimination of the legacies of past conflicts but also a commitment to safe and sustainable development for the future: one in which technological innovation, biological methods, international solidarity, and respect for affected communities together create the conditions for a world free of the long shadow of landmines.

Conflict of Interest

The authors hereby declare that no competing financial interest exists for this manuscript.

Notes on Contributor

Timea Hillender is a Hungarian professional with a diverse background in education and humanitarian work. She graduated from the University of Szeged with a degree in Hungarian and German teaching and later obtained a master's degree in German translation from the University of Miskolc. Seeking to broaden her expertise, she completed a second master's degree in Humanitarian Response Management at Bánki Donát Faculty of Mechanical and Safety Engineering, Óbuda University, where her thesis focused on the innovative use of giant pouched rats in landmine detection. She is the founder and president of Afrika Sztorik Afrika Vadvilágáért Egyesület, an association active in Kenya and Tanzania. Through the organization's programs, she supports

women's training and education, including ranger courses and tour guide certification, with the aim of strengthening communities and promoting sustainable development. Since 2023, she has also been working with APOPO, an international NGO renowned for its mine-detection rats. Her current work focuses on empowering women to participate in the breeding and training of these animals, thereby promoting greater female involvement in humanitarian demining efforts.

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Contemporary History of the Democratic Republic of the Congo with a Perspective on the Great Lakes Region[1]

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Abstract:

The Great Lakes region in Africa is an ethnic-geopolitical "hornet's nest" burdened with serious problems at the meeting of several worlds. The three francophone countries that emerged in the former Belgian (or in the case of Rwanda and Burundi, German for a few decades before) colonial territories are usually classified by some divisions as part of the Central African region, which also includes Chad, the Central African Republic, Cameroon, Equatorial Guinea and Gabon. Other groupings – such as this analysis – refer to them as francophone states of the African Great Lakes subregion, alongside Anglo-Saxon Kenya, Uganda and Tanzania. We are convinced that the common or similar historical past also justifies this latter division. In the Great Lakes region, we can speak of 3 historical and one artificial state formation: the conglomerate of provinces that make up the Democratic Republic of the Congo (Congo-Kinshasa, the former Zaire, and the Belgian Congo), Rwanda, and Burundi all have historical precedents, in a given core area. While Uganda was artificially created by the British colonialists in 1896 by separating it from Tanzania and adding several other territories.

Keywords:
Great Lakes; Colonization; Africa's World War; Belgian Congo; Zaïre; Mobutu; Kabila.

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I.1. Geopolitical Framework: The DRC, the Great Powers and the UN

The Democratic Republic of the Congo is the 11th largest country in the world and the largest in Africa, with an area of 2,345,410 km^2, about the size of 4 Frances, and a population of over 105 million. Its capital, Kinshasa (founded by Henry Morton Stanley as Léopoldville between 1881 and 1961), is the third largest city in Africa with a population of 17 million and is also the largest francophone agglomeration in the world.[3] The DRC is the most populous francophone state, ahead of France. Its official language is French, which is spoken by three-quarters of the country's population (typically as a second or third language), but only about half, 42.5 million people, can read and write. The four most important so-called national languages are Swahili (22.26 million, mainly in the east), Lingala (14.43, in the northwest), Tshiluba (6.4, Kasaï province), and Kituba[4] (4.55, in the southwest). In total, more than 250 languages are spoken in the country.

The country's borders were drawn in the Treaty of Berlin in 1885, following natural boundaries except for the southern Angolan border. Its territory is covered by the Congo River (formerly known as Zaïre, which is also the name of a neighboring Angolan province) and its watershed, half of which is covered by equatorial rainforest. The plateaus of Shaba province are fertile savannas, and the eastern Kivu province is fertile volcanic soil, but in recent decades they have been losing their fertility. The people live mainly in villages, concentrated in the eastern half of the country.

The Bantu people arrived in the DRC in several waves between 2000 and 500 BC. The people first settled in the south and along the rivers, avoiding the dense forests. They practiced extensive agriculture, which required more and more deforestation every year. By around 1000 AD, the entire country was populated, the main crop was yam, and pottery was developed.

Four major kingdoms emerged in the (southern) DRC throughout history: the Kingdom of Kongo, 1390-1914; the Kingdom of Kuba, 1625-1904; the Lunda or Mwata Yamvo Kingdom, 1665-1887; and the Luba Kingdom, 1585-1889. Also worth mentioning is the short-lived Yeke Kingdom (1856-1891), also known as *Garanganze* or *M`Siri*. These smaller and larger, mostly prosperous merchant states with different organizational and state structures (federative, confederal) were established in the savannah-like southern areas of the DRC and mostly extended beyond the southern borders of today's DRC (Murray 2003, 166-167).

The Kingdom of Kongo developed along the left bank of the Congo River, roughly from the present-day capital Kinshasa to the Gulf of Guinea, in the area of Cabinda in Congo, including the southern corner of Gabon and the northwestern tip of Angola to Luanda in the south. Its capital was São Salvador (present-day Mbanza Kongo in

[3] Brazzaville, the capital of the Republic of the Congo, is located on the other side of the Congo river, making them the two closest capitals in the world. (Magnan 2017)
[4] Or kikongo (a name mainly used in Brazzaville-Congo). (Les Quatres… 2020)

Angola). The kingdom essentially functioned as a unit of federalized entities, under a central administration. It engaged in advanced trade in ivory, copper, gold, raffia clothing, and pottery. It was a vassal of the Angolan kingdom of Ndongo (or Angola). In 1518, Angola sought Portuguese help to gain independence from Kongo but was driven out by the Portuguese in 1520. The Portuguese tried again in 1556, but Paulo Dias de Novais failed again in 1564 (Batsîkama 2010, Fauvelle – Surun 2019, 40-41).

The Kingdom of Kuba was founded in the southern part of the DRC, in the West Kasaï province, with its center in Mushenge. This kingdom was organized on a confederal basis under the dominance of the Kuba people. This royal clan included nearly 20 different Bantu ethnic groups, including the states of the Luba, Leele, Pende, Dengese and Wong. Shyaam a-Mbul founded the Kingdom of Kuba, and according to legend, he introduced the cultivation of many crops - cassava root, beans, tobacco, etc. - to the area. Since this area had no access to the sea it was not affected by the institution of the slave trade (unlike neighboring Congo). The kingdom declined in the 19th century after the Luba invasion, the Belgians first set foot here in 1884 and then annexed it in 1904. Although the area fell to tribal chiefdoms, it put up a stubborn resistance, so the Belgians tried to break the population with increasingly cruel methods (Obenga 1974).

The Lunda or Mwata Yamvo kingdom extended to the southwestern part of the Katanga region of the DRC, as well as to northeastern Angola and northwestern Zambia. The word Lunda itself means alliance, friendship, and was headed by an emperor or empress, the Numi, and then from 1660 by Mwant Yav, who was appointed by the council of nobles. Mwata Yamvo or Mwant Yav (1660-1675) is considered the first Lunda ruler at the head of the confederation of Lunda tribes, whose territory originally extended to southern Katanga. His name became a royal title, and the kingdom operated on the basis of customary law (*royaume coutimier*). It fell to the Belgian conquest in 1887 (Margarido 1969).

The Luba kingdom extended to the other, northern half of Katanga, as well as to the provinces of East and West Kasaï and Maniema in the north as far as Kasongo, to Kolwezi in the south, and to Lake Tanganyika in the east, and had several capitals. Unlike the other kingdoms, it was a centralized, despotic Bantu state, with the ruling class constantly fighting each other for power, despite blood succession. At the same time, the ruler could even be replaced by his own half-brother. Each ruler chose a new capital for himself. The fate of the Luba kingdom was sealed by long-distance trade. Around 1870-80, East African traders began to obtain ivory and slaves from the Central African savannahs. The demand for slaves also accelerated Belgian colonial efforts, and the empire was divided in 1889 due to internal strife and easily fell into the hands of the Belgians (Anthoine 1996).

In summary, it can be said that throughout history, in the savannah-like southern areas of the DRC, smaller and larger, mostly prosperous merchant states with different organizational structures and state structures (federal, confederal) were established, most of which extended territorially beyond the southern borders of today's DRC.

I.2. The Portuguese Conquest

The first European (Portuguese) explorer, Diogo Cão, appeared in the region in 1482, and in 1489 he signed agreements with the Kingdom of Kongo on an equal footing. Two years later, the king of the Bakongo was baptized, taking the name Joao I. However, the king's religious zeal did not last long, and he soon became an apostate due to the prohibition of polygamy. In 1505, missionaries and slave traders began to colonize the area. During the reign of Joao's son, Alfonso I (1506-1560), an era of prosperity began, the slave trade developed, and the royal power used Christianity to fight witchcraft. When the Portuguese founded the colony of Luanda in Angola in 1575, cassava root appeared in the diet. In the 1700s, the Kongo kingdom slowly began to disappear, while the ivory and the slave trade (Slave Coast; parts of modern-day Togo, Benin, and Nigeria) along the rivers continued to grow. From the region, 4-6,000 slaves were transported to the Americas annually, by 1780 this number had increased to 15,000. In many cases, poor parents sold their children themselves. Kinshasa also emerged as a trading city.

Before the Belgian colonization, it is worth mentioning the short-lived *Yeke Kingdom* (1856-1891), also known as *Garanganze* or *M`Siri*. King Msiri established the most powerful Central African kingdom in the Katanga region, covering an area of about 500.000 km^2. This kingdom controlled the only east-west trade route in the middle of the continent, as the Kalahari Desert and the Lozi Kingdom in the south and the tropical rainforest in the north blocked access. Msiri traded in Katanga copper, slaves and ivory, mainly in exchange for gunpowder and firearms. He had alliances and marriages with the major trading states of the region (e.g. the Sultanate of Zanzibar). A race for the territory began at the end of the 19th century: The Belgian King Charles II King Leopold, hoping for gold, offered a treaty, offering to join the Congo Free State. Cecil Rhodes' expedition sought to acquire the territory for the British South Africa Company. The "Katanga Race" was won by the expedition of Canadian William Stairs (1891–92), who arrived in the territory in the service of Leopold II. He killed Msiri and administered the territory himself until it was annexed to the Belgian Congo (Legros 1996).

Meanwhile, the French colonized the Brazzaville-Congo region on the other side of the Congo River. The Englishman H. M. Stanley, who had quarreled with the British and also entered the Belgian service, mapped the eastern part of the Congo River, concluded treaties with about 450 tribes, and in 1877 crossed the equatorial rainforest. He represented Leopold II for five years. During this time, he made 2.5 million km2 of territory (and its workforce) - namely Zaïre, Rwanda and Burundi - the sole property of the king. Belgian colonization officially increased the property of the king and not the country, Belgium. He began building a 200-kilometer path along the waterfalls to Stanley Pool (now Malebo Pool) - from this point (near Kinshasa) the Congo River can be navigable all the way down to the ocean. Many of the natives who were forced to work lost their lives. Stanley's brutal methods earned him the nickname *Bula Matari* "the Rock Splitter" in England. In 1884, he renamed Kinshasa Léopoldville, which became the capital of Léopold-Congo (Congo Free State). In 1879, Léopold created the AIC

(Association internationale du Congo,) the *International Association of the Congo*[5], which served as a front for his efforts. Then, at the Congress of Berlin on 15 November 1884, Léopold II officially acquired the Congo territory, supposedly to promote its development. In 1897, the entire territory officially became the Society's territory.

On August 20, 1908, the Belgians annexed the Congo, and the Belgian Congo was created, which officially existed until 1960. The inhumane forced labor conditions maintained by the colonizers were revealed, which (death, disease, emigration) claimed 5 million victims since 1885. Between 1908-10, the situation improved somewhat with social and administrative reforms (Gerencsér 1998, 428-429). The balance of colonialism between 1908-50 meant 26 million gold francs in revenue and 235 million gold francs in expenditure for Belgium, in 1950 this amounted to 7 billion gold francs, 10% of the budget. The other side of the coin is that the accusation that Belgium simply plundered the DRC is not valid. Significant infrastructure investments were made (roads, bridges, railways, ports) and church missions played a significant role in the field of education (Lugan 2020, 1075-1076). In any case, in 1955, Congo declared bankruptcy. Between 1920 and 1950, religiously based independence movements were established, mainly among the peasants, but these were still liquidated. Joseph Kasavubu (or Kasa-Vubu) became the leader of the *Bakongo Party*, which had been established two years earlier, in 1955. In 1958, Patrice Lumumba's *Congolese National Movement* (MNC) was established, and then the *African Solidarity Party* (PSA) under the leadership of Antoine Gizenga.

I.3. Independence and Chaos (1960-65)

On 30 June 1960, the Belgian Congo became independent as Zaïre. Kasavubu became president and Lumumba prime minister. Almost immediately, on 5 July, the Public Force (*Force publique*, FP), the Congolese professional army, mutinied, and a civil war began that lasted until 1965. The soldiers mutinied because they saw their situation as precarious, having to salute from one day to the next, the president and vice-president, whom they had previously imprisoned (Ndaywel 1997).

On 11 July 1960, Katanga, led by Moïse Tshombé declared independence. (Tshombé was supported by the French, who hoped that their ally would provide them with access to rich mineral resources.) The country sought help from the United Nations and the United States. On July 14, 1960, the UN deployed 19,828 troops to the region as part of the ONUC[6] mission to ensure the withdrawal of Belgian troops, restore order and, in any case, maintain the unity of the country.

The process of secession continued: in August 1960, the Luba Albert Kalondji broke with Lumumba and declared the independence of the South Kasaï province. Then, on August 25, he entered into a confederation with Katanga. The new confederation

[5] Or International Congo Society

[6] United Nations Organisation in the Congo (*Organisation des Nations unies au Congo*, 1960-63) after United Nations Operation in the Congo (*Opération des Nations unies au Congo*) until 30 June 1964.

owned the lion's share of country's mineral resources, putting the central government in an impossible position.

Power in the country was thus held by 3 centers at that time:

- The central government was represented by Kasavubu in Léopoldville (Kinshasa), supported by the UN and Western countries.
- Gizenga's Lumumbist government in Stanleyville (Kisangani) in the eastern region was supported by the Soviet Union: it was not internationally recognized.
- Tshombé's Katanga government in Élisabethville[7] (Lubumbashi) was supported by France, which was also not internationally recognized.

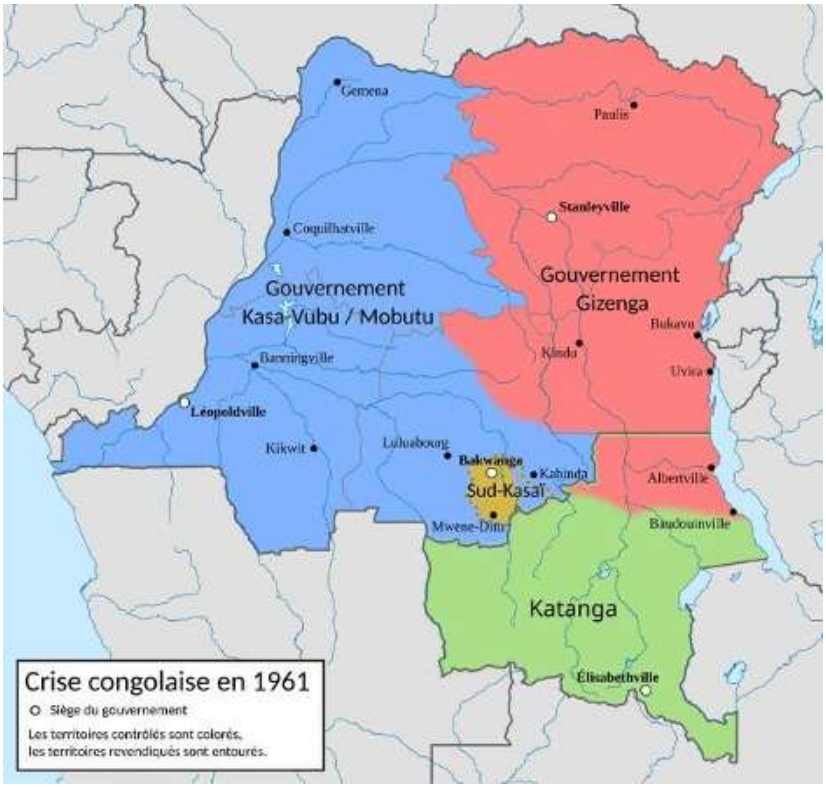


Figure 1: The Map of Congo in 1961 (Congo Crisis). Source: https://fr.wikipedia.org/wiki/Fichier:Map_Congo_crisis_1961.svg (in blue, the Léopoldville government, in red, the rebel government based in Stanleyville, in yellow, autonomous Kasaï, in green, independent Katanga)

The negotiations took place within the framework of the UN, with Secretaries-General Dag Hammarskjöld and U Thant negotiating with Tshombé. According to the official version on 18 September 1961, Dag Hammarskjöld's plane exploded[8] over Northern

[7] Or Elisabethstadt, Élisabeth Gabrielle Valérie Marie de Wittelsbach, the third Queen of the Belgians from 1909 to 1934.

[8] Research, which has been intensifying since the late 1990s, suggests that it was an assassination. There are several versions, either a Belgian mercenary Jan van Risseghem or a German mercenary Heinrich Schafer shot down the plane with a machine gun from an armed DO-28. We consider all of this to be conceivable, political leaders are still advised not to travel by plane in Africa, the number of assassinations

Rhodesia (today's Zambia). Prime *Minister* Lumumba launched a military attack on the breakaway regions. The army killed Luba civilians, and Lumumba became known as the "*Killer of the Lubas of Kasa*". Kasavubu then resigned as PM and handed him over to the Katangans. Luba soldiers killed him in revenge on 17 January 1961.

Upon news of Lumumba's execution, Lumumbist uprisings immediately broke out in the west, east, North Katanga, Maniema and Kivu. The People's Republic of the Congo (PRC) was proclaimed in Stanleyville (Kisangani Province). In Katanga, however, the UN successfully fought against the Katanga gendarmerie, which was overseen by a handful of French mercenaries, and by February 1963 Tshombé had been forced into exile in Spain (Lugan 2020. 1437-1440).

The country descended into anarchy, the opposition, the CNL (National Liberation Council, actively supported by China), was forced to exile to neighboring Congo-Brazzaville, and the army was unable to handle the situation. In the end, the paradoxical situation arose that both the CNL and the army concluded that the separatist Tshombé had to be recalled in order to restore the country's unity. So, on July 6, 1964, President Kasavubu entrusted him with forming a government. In November, all hell broke loose in the DRC, and the militias, drugged and drunk on palm wine, began pogroms against the local and European population. Belgium (in alliance with the United States) was forced to intervene.

To free the European prisoners, paratroopers were dropped in Stanleyville on 23-24 November 1964 as part of Operation *Dragon Rouge* (Red Dragon), after receiving official authorization from Prime Minister Tshombe. Until the last moment, the participants believed that they were going to a NATO military exercise in the Mediterranean. Among other things, using 12 C-130 military transport aircraft received from the US for this purpose and arriving from Evreux (France) 320 commandos freed the Europeans held captive by the Simba rebels in the Hôtel Victoria in Stanleyville. On the night of 25–26 November, during *Operation Dragon Noir* (Black Dragon), 250 more hostages were successfully rescued 400 km away in Paulis (now Isiro), for a total of 2,375 people, significantly increasing the reputation of the Belgian Para-Commando Regiment (Opération Dragon… 2014). In June 1965, Tshombé's party, CONACO (Congolese National Convention), won the elections, but Kasavubu resigned on 15 October and was forced to go into exile in Spain again.

I.4. The Mobutu Regime (1965-1997): the Second Republic (1965-1990)

In November 1965, General Mobutu Sese Seko (born Joseph-Désiré Mobutu) (with American support) gained control of the entire country, combining the powers of president and prime minister in one person. He made Lumumba a national hero, cynically presenting himself as the martyr's successor and the sole executor of his program (Benkes 2004, 12). Washington, Brussels and Paris saw in him a loyal local

and mysterious accidents is significant – and this can only be partly attributed to the very poor condition of the African aircraft fleet.

strongman who could restore order in the country. At that time, Zaïre's level of development was comparable to that of South Korea, while by 1996 it was already one of the poorest countries in the world. Meanwhile, Mobutu had become one of the ten richest people in the world, thanks to the fact that the income from gold and diamond mining increased the president's personal wealth. The diamond fields of Kasai were in the hands of the vassals of Mobutu's son Kongolu, mostly Lebanese, and Kinshasa, where the diamonds were bought for cash, became a place to launder money from the drug trade (Verschave 1998, 227-229).

In July 1967, Paris wanted to play its only card and commissioned the mercenary Bob Denard to take advantage of the uprisings to somehow overthrow Mobutu and install Tshombe in his place (Bat 2015), who was sentenced to death by a Congolese court in March of that year. As far as it can be reconstructed from the scraps of information and contradictory literature, it was not in the United States' interest to overthrow Mobutu and perhaps a race began between the American and French services. Tshombe's plane from Ibiza to Spain was hijacked by a certain Francis Bodenan (a CIA agent) and forced to land in Algeria by Houari Boumédiène. But the Algerian President did not hand him over to Kinshasa, he was imprisoned and died in 1969 - officially of heart failure (Maurin 2021, 644).[9]

In 1969, when Georges Pompidou came to power, there was a rapprochement with the French again. In 1971, Mobutu changed the name of the country to Zaïre, in the spirit of the 3 Z policy (the new currency was also named after the river). In 1972, an "originality campaign" was launched, and Christian names had to be changed back to African ones. (It was then that he also took the name Sese Seko Kuku Ngbendu wa Za Banga[10]). Mobutu placed foreign companies and farms in the hands of the young national bourgeoisie and imposed a 50 percent state share in all new mining enterprises. Many investments were unfinished, state spending increased, and the budget deficit ballooned. In addition to the lack of expertise, nepotism, corruption, and the one-sided development that forced the copper sector, the plantations deteriorated catastrophically, and the production of the processing industry companies declined (Balázs 2001, 164).

In 1977, the Katanga Tigers, with the support of Angolan troops, flooded the Shaba region (formerly Katanga). The background to this situation is that many of them had fled to Angola as former soldiers of Tshombé, where they became members of the Portuguese army, and then began to return after Angola gained independence in 1975. Meanwhile, the DRC (Katanga) became the back base of the Angolan independence movement, supporting Jonas Savimbi's UNITA, founded in 1966. All this also disturbed the circles of the Soviet Union and Cuba, which were allies of Angola. In 1977, Mobutu received, in addition to the help of the French air force (*Opération Verveine*, verbena),

[9] According to Maurin, Bodenan was a double (French and CIA) agent. We, however, believe that it was not in France's interest to hijack Tshombé's plane or to "take it out of circulation" in Algeria. In light of Denard's mandate, this does not seem logical.

[10] meaning: (Mobutu) the warrior who goes from victory to victory and no one can stop him

1,000 Moroccan military assistance to settle the situation and repelled the first attack (Türke 2021, 214). The Shaba-Katanga province itself produced 15,000 tons of cobalt and 450,000 tons of copper at that time, accounting for 75% of the DRC's GNP. A year later, on May 14, 1978, rebels from Angola, supported by East German experts and Cuban soldiers from the Texeira de Sousa base, took 2,000 Europeans hostage in Kolwezi, including 6 French military experts. They then began the systematic murder of the prisoners. On May 19-20, around 600 French (and Belgian) paratroopers - as part of *Operation Leopard* - not only freed the hostages and retook the city but also ensured France's military influence in the country for the long term.

In 1982, after long years in prison, Etienne Tshisekedi secretly founded his party, the UDPS (Union for Democracy and Social Progress). Tshisekedi had previously criticized Mobutu's regime several times and had sent a memorandum to the president calling for the elimination of bad governance. Between 1986 and 1995, clashes between the ALC (Armée de Liberation Congolese) and the army became regular in the Ruwenzori Mountains. On 17 January 1988, the UDPS dared to hold its first public demonstration in Kinshasa, but it was dispersed by security forces, resulting in six deaths. Tshisekedi was arrested again and sentenced to psychiatric treatment.

Alarmed by the changes that had taken place since the end of the Cold War, Mobutu called a national consultation for all of Zaire on 24 January 1990. On 24 April he announced the end of the Second Republic and a democratic transition, allowing a multi-party system and the establishment of a one-year transitional government, followed by free elections. But a student revolt on the Lubumbashi Campus in May, due to the poor economic situation, was brutally suppressed (500 dead), leaving Mobutu internationally isolated. In September 1991, soldiers also revolted over unpaid wages and began looting. Belgium and France also evacuated their citizens due to the unrest. Following the pattern used earlier, they again tried to "clean up the mess" by putting the opposition in a position and shifting responsibility for the consequences: On 15 August 1992, at the height of the economic collapse, Etienne Tshisekedi was appointed Prime Minister, but Mobutu resigned in March of the following year. Ethnic riots broke out in the provinces of Kivu and Shaba and on the Rwandan border, and the following year, 1 million Hutu refugees migrated to Zaïre in connection with the events in Rwanda.

International interest in the DRC temporarily declined with the end of the Cold War. However, the antecedents of the French "rehabilitation" of Mobutu date back to 1990, when a 1,500-strong presidential special detachment, together with France and Habyarimana's army, carried out a military operation in Rwanda to eliminate the RPF (Rwandan Patriotic Front) (Türke 2022). The amount of financial assistance provided to refugees in eastern Zaïre reached 2.5 billion dollars, equivalent to Rwanda's GNP. However, according to HRW, President Mobutu's half-brother, who was responsible for land distribution, and *Hutu Power*, which controlled food distribution, embezzled a significant portion of the money (Rwanda/Zaïre… 1995). The militias were partly financed by the sale of humanitarian aid.

Although French President Mitterrand agreed on 16 October 1993 to receive General Mobutu at a Francophone summit in Mauritius, the Zairean president's actual rehabilitation did not begin until April 1994, in the midst of the Rwandan massacre. According to some, the president became an important figure in the fight against Pan-African aspirations and against the "evil Anglo-Saxon axis" represented by Yoweri Museveni, the Ugandan leader allied with the Rwandan Patriotic Front (RPF) (Verschave 1998, 243-244 and 231-232).

The reason for Mobutu's rehabilitation was thus clear: his task was to provide a rearguard in Zaïre during the war against Rwanda (1994, *Turquoise*). What were the results of the situation created by French policy? (Türke 2016, 58-59)

Mobutu allowed the French to deploy significant logistics in Zaïre. He was an ally of *Hutu Power* which supplied 20,000 tons of coffee to Zaïre. The coffee supplies in the shops were the property of the Mobutu family. François Mitterrand painted a positive picture of the development of Franco-African relations at the Franco-African summit in Biarritz in November 1994. The creation of an African standby force was approved. Although Mobutu played a significant role in the massacres and openly supported the Angolan civil war, this did not prevent the French from allowing the president to participate in the standby force. Thanks to diplomatic support from the Élysée, the interim government led by *Hutu Power*, with the help of Mobutu, managed to thwart the convening of a reconciliation conference in Tanzania. Bruno Delaye explained this as follows: *"We cannot allow the English-speaking countries to decide the future of a French-speaking country."* Thanks to this quick reaction, thousands of innocent people could have been prevented… Some say that Mitterrand thought so: *"In these countries, genocide is not very important."* (Gouteux 2001, 102)

According to a journalist, the French strategy could be described as follows: the primary objective was to make the situation in Rwanda so untenable that it would be possible to return to the previous government and share power. Zaïre, as a hinterland, would allow the FAR (Rwandan government forces) to regroup and train with President Mobutu's guards, and ultimately to invade Rwanda. Or it will be possible to achieve that the FPR (Rwandan Patriotic Front, Tutsi) launches an attack on the FAR bases in Zaïre, which will create the necessary pretext for international intervention, an intervention in Rwanda (Verschave 1998, 245).

According to HRW, France, with the assistance of President Mobutu, supplied *Hutu Power* with artillery, machine guns and assault rifles. A significant portion of these weapons were delivered by air freight companies registered or based in Zaïre. Mobutu allowed Hutu Power to train in Zaïre, and after the defeat of the FAR, France trained *Hutu Power* in the Central African Republic (Rwanda/Zaïre… 1995). The weapons reached the Rwandan armed forces through the Goma airport in the French-controlled zone. The French also left at least one weapons depot in Kamembe, Rwanda. According to UN representatives, the arming of former members of the Rwandan armed forces was organized from Kenya. In addition, in June 1996, Russian planes carrying the weapons crashed in Kinshasa. Thus, part of the equipment of *Operation Turquoise*

(AML-60 and AML-90 armored vehicles, vehicles equipped with 120 mm mortars, anti-aircraft weapons, rocket launchers, howitzers, military trucks) was given to Habyarimana's former army, while the other part was sold to Zairean officers (Verschave 1998, 246-247).

French diplomacy feared the vacuum created by the fall of the Habyarimana clan in Rwanda and aimed to squeeze Uganda and its allies.[11] Mobutu increasingly turned to the Zairean general with the request that he take power and *"take the Great Lakes region under his protective and peace-making wing."* All this had the consequence that Mobutu authorized the massacre of the descendants of the Kasaï in Katanga province and the extermination of the Rwandan (Kinyarwanda)-speaking population around Lake Kivu. *"By deploying its logistics to provide military and humanitarian aid in the Goma area, that is, in Zaïre, and then allowing the creation of Rwandan refugee camps there, Paris made it clear that Mobutu was indispensable."* Following the logic of "the enemies of my enemies are my friends", two opposing axes emerged:

The "Francophone axis" was formed by the alliance of the Central African Republic, the Democratic Republic of the Congo, the Rwandan *Hutu Power* and Sudan (which had been pro-French since 1994), with French support.

The "Anglo-Saxon" axis was formed by the cooperation of Uganda led by Yoweri Museveni, Rwanda led by the Tutsi Paul Kagame, and the South Sudanese movement of John Garang, supported by the United States, which armed the Sudanese opposition through Eritrea and Ethiopia.

Libya supported the Francophone axis financially but also maintained good relations with Rwanda.[12] The Rwandan FPR's rear area was Uganda. As for Uganda, the French-backed axis provided assistance to three guerrilla groups operating in the DRC (Zaire)-Sudan-Uganda border zone: (Verschave 1998, 237-239, Negotiating Peace… 2004, 3*)*

The LRA (*Lord's Resistance Army*) is a Bible-based Christian movement that has been active since 1987. The movement, which operates under the supervision of the priestess Alice Lakwena and the command of Joseph Kony, was armed by Sudan. In 1993, it had only 200-300 soldiers, but by 1997 its number had reached 5,000. The soldiers were well-equipped: they had new camouflage military clothing, their own weapons, rocket launchers and mortars.

The WNBF (*West Nile Bank Front*) was formed around 1995 under the leadership of Juma Oris. The Front's ranks included fighters from Muslim minorities, the Ugandan Aringa minority, the Kakwa (a tribe of the Ugandan dictator Idi Amin Dada), and the Nubians (descendants of slaves of the 19th century Egyptian-Sudanese army).

The ADF (Allied Democratic Forces) only emerged later in the border region between Zaïre and Uganda. Its somewhat "surrealist" force included Hutu elements of the former Rwandan army, as well as the Tabek (members of a Muslim sect that brings together

[11]This was the main reason for the rapprochement between the French and Sudanese secret services, patronized by Charles Pasqua. (Verschave 1998, 80.)

[12] The system of alliances just outlined is merely a simplified scheme, as the composition of the various alliances changed from time to time, often in contradictory ways. (Verschave 1998, 232 and 236)

several ethnic groups), the Bokonyo (an ethnic group living in the Rwenzori Mountains and fighting the Rwandan government for administrative autonomy since 1952). Over the past forty years, they have fought against almost "everyone" (the British, Idi Amin, Obote, Museveni president of Uganda, etc.).

Jacques Chirac became the new French president in May 1995, and French diplomacy in the region remained largely unchanged. Chirac received Mobutu at the Élysée Palace on 24 April 1996, and Jacques Godfrain, the Minister of Cooperation, a relative of Jacques Foccart,[13] announced the official resumption of cooperation between France and Zaïre. The most influential figure in this policy was Paul Barril, a former high-ranking police officer under Mitterrand, whose security consultancy firm advised President Mobutu. Another influential figure in French Africa policy was Christian Tavernier, the head of President Mobutu's mercenary army, who, with the help of Paul Barrill and his 284 soldiers stationed in Watsa, was responsible for securing the CAR-DRC-Sudan supply line supplying the Ugandan guerrillas. Guerrillas operating in South Sudan and the northern DRC maintained contact with each other in the Kaya region, located on the Uganda-Sudan-Congo tri-border. This is where weapons, including those financed by the French, passed through.[14]

I.5. The Kabilas' Takeover and "Africa's World War" (1997-2005)

In September 1996, war broke out in the Kivu province of the DRC. This war caused an earthquake in Rwanda, swept away the regime of General Mobutu and brought about a radical transformation in the life of Zaïre. During the First Congo War (1996-1997), the Democratic Forces for the Liberation of Congo (AFDL, 1996, a coalition led by Kabila) overthrew Mobutu's regime in 1997, and Laurent Désiré Kabila took office – thanks to the powerful support of Uganda and Rwanda. Kabila, who came to power on 17 May 1997, changed the name of the country to the Democratic Republic of the Congo.

The overthrow of Mobutu was a very unpleasant surprise for France. Kabila quickly found himself at odds with France's regional interests, as early as 1997-1998. The main reason for this was his allies at the time, Uganda (Yorevi Museweni), Rwanda (Paul Kagame), Angola and, above all, the United States, and then Sudan, which provided 2,000 soldiers for his country. In addition, Libya also showed itself ready to provide financial support to Kabila's regime. Its political system was based on anti-Tutsi and anti-French sentiment. France united the following interest groups against Kabila's allies and the AFDL: (Verschave 1998, 232-233, 237-239, 251). Congo-Brazzaville (for attacks on Kinshasa); Zairean officers and soldiers; Rwandan soldiers and militias who committed the Rwandan "genocide" and their Burundian allies; the remnants of Idi Amin Dada's army in Uganda; the LRA; like the previous two groups, Muslim fundamentalists (the

[13] General de Gaulle's "Monsieur Africa" was the man who oversaw France's African policy until his death. He was considered President Chirac's right-hand man on African issues.
[14] However, these were not French weapons, but weapons purchased from the Eastern European bloc.

"cleansers" of the Nuba Mountains and other Sudanese regions) supported by the Khartoum regime (Sudan) and Serbian militias carrying out ethnic cleansing.

The crisis – aptly named: "Africa's World War" – culminated on August 2, 1998, when former AFDL fighters from the eastern part of the country incited a rebellion against the new president, which led to the outbreak of the Second Congo War (1998-2003). This war can be considered "predatory in nature", as the country's vast natural resources attracted the interest of neighboring countries. A total of 7 (foreign) countries participated in the conflict: Angola, Zimbabwe, Namibia, Chad, Rwanda, Burundi, Uganda. Within a few months, the crisis spread to the northeastern front. Two movements attempted to overthrow Kabila's regime, the Rally for Congolese Democracy (RCD) in the east of the country (with significant Tutsi participation) and supported by the Rwandan government, and the Movement/Army for the Liberation of Congo (MLC/ALC, 1998-), led by Jean Pierre Bemba, which controlled the north of the country and was supported by the Ugandan government. The civil wars were not therefore isolated. Zimbabwe, Chad and Namibia also sent soldiers to the DRC to reinforce the loyalist army. Meanwhile, Rwanda, Uganda and Burundi supported the rebel forces. Nearly 4 million people lost their lives as a result of the violence. As the internationalization of the crisis also violated international law, the UN Security Council expressed its deep concern about the peace and stability of the Great Lakes region and called for an immediate ceasefire and the immediate withdrawal of foreign troops (History of MONUC 2003).

Despite the mutual distrust between Kabila's DRC and President Chirac's France, both sides soon had to radically redefine their goals before they finally became allies. Kabila was first forced to review his political methods and then, in response to the plundering of Congo by Rwandan troops by his now inconvenient allies, he dismissed his Rwandan and Ugandan advisors on 1 July 1998. France also did everything it could to win back its former ally (who had defected to the United States) and Kabila's attempt to break out of his growing isolation led to an alliance with France. As in the days of Mobutu, some of the weapons were transported through Chadian airports under French supervision. (Verschave 2002, 129) Kabila thus lost his Ugandan and Rwandan allies (who, incidentally, plundered and refused to leave the DRC), but in return he enjoyed the support of the French-led coalition (Angola, *Hutu Power*, Sudan, Chad). For example, Libya, Angola and France financed the military intervention in Zimbabwe that served their interests. So, they "cocked a snook" at the United States: Angola switched sides, while Zimbabwe and Namibia allowed Kabila to keep Kinshasa under his control (Verschave 2002, 126).

In the Ituri region, the conflict between different ethnic groups (farmers and herders) was not new, as the region is a meeting ground for the Bantu (Lugabara and Madi), the "plain Nilotic" (Karamojong) and the "rivers and lakes" such as the Luo (Acholi and Langi) ethnic groups (Lugan 2020, 1461). Under the pretext of helping Kabila take power, Ugandan forces (UPDF – Uganda People's Defence Forces) occupied the region in 1996 and then in 1998, in alliance with Rwanda, persecuting the Hutu population of the

region and then attacking Mobutu's army. The liberation of the area was provided for in the Luanda Agreement of September 2002 (AWEU 2005, 25). According to some estimates, 3.5 million people lost their lives as a result of the war that began in 1998 and lasted five years (Faria 2004, 47-49). Accepting the UN call, on 10 July 1999, the DRC, Angola, Namibia, Rwanda, Uganda and Zimbabwe, as well as the MLC, signed a ceasefire agreement in Lusaka (Zambia), while Burundi, Chad and the RCD abstained. The agreement included the normalization of the situation on the DRC's borders and placed the following main tasks at the forefront: controlling the illegal arms trade; controlling the infiltration of armed groups; initiating a national dialogue; establishing public security; and disarming the various militias and armed groups.

The agreement also established a military commission, composed of two representatives from each side, under the direction of a neutral mediator delegated by the Organization of African Unity (OAU) (MONUC 2004). In order to secure the system, the agreement provided for the deployment of UN troops in cooperation with the OAU. The violence in the DRC threatened to repeat the 1994 "genocide" in neighboring Rwanda. The UN called on the DRC to join the signatories, and, accepting the agreement's proposal, Security Council Resolution 1258 authorized the deployment of 90 military and civilian personnel to the mixed military commission. On 1 November 1999, the Secretary-General decided to establish MONUC (UN Mission in the DRC) and to deploy 500 military observers.

MONUC was not mandated to use military force to bring order to the region (Duffit-Séré 2003, 6-7). As events unfolded, the UN extended the mission's mandate eight times until the summer of 2004, increasing the number of participants almost continuously – from 90 (August 1999) to 10,800 (July 2000-July 2004).[15] In terms of total MONUC personnel, it was seven times larger than the EU ARTEMIS mission. Both missions included civilian and military elements. MONUC was mandated to carry out civilian tasks, namely human rights monitoring, humanitarian aid management, information gathering, child protection, political situation management and medical assistance.

In March 2000, UN Secretary-General Kofi Annan appointed Senegalese General Mountaga Diallo as MONUC commander. In January 2001, violence flared up again with the assassination of President Laurent Désiré Kabila, who was killed by an officer in his own army recruited from Rwandan-controlled Kivu, for reasons unknown, especially since he was immediately beheaded by the presidential guard (Lugan 2020, 1465). Kabila was succeeded by his son, 29-year-old Joseph Kabila, with Angolan and Zimbabwean help. He dismissed members of his father's government and replaced them with his own troops. His two pillars of power are the country's two main ethnic groups, the Lunda from Kasai province, and the Luba (his father's ethnic group) from Katanga province. He began very difficult negotiations on the withdrawal of foreign troops.

[15] Security Council Resolution, http://daccess-ods.un.org/: (UNSC Resolution 1258 of 6 August 1999 – 90 personnel). Then UNSC Resolution 1493 of 28 July 2003: until 30 July 2004 (maximum strength of 10,800 personnel). For further interim UNSC resolutions, see Türke 2016, 66-67.

UN Security Council Resolution 1376 on 9 November 2002 launched MONUC's third phase, which was to carry out DDRRR (Disarmament, Demobilization, Repatriation, Reintegration and Resettlement) tasks for foreign armed forces. On 25 February 2002, the Congolese negotiations began between the warring parties in the South African city of Sun City. These were temporarily interrupted by the reoccupation of the town of Moliro by the RCD-Goma army. All parties agreed on the principles. As a result of the Congo-Rwanda peace agreement signed in Pretoria on 30 July 2002, a kind of *détente* began on 5 October 2002 with the withdrawal of Rwandan troops from the DRC. On September 6, under the Luanda Agreements, Uganda promised to withdraw its troops from Ituri. The Americans not only intervened as a neutral outsider in the events but also provided secret financial assistance to the various factions. Of course, Washington's aim was to gain influence in the region. For a long time, only 65 UN observers (mainly from Uruguay), were stationed in this area, without specific authorization, but later the military protection of these observers became increasingly important (AWEU 2005, 25). On December 30, 2002, the Gbadolite ceasefire agreement was signed under the auspices of MONUC between the MLC, RCD-N and RCD-K/ML. This ended the Second Congo War.

Despite this, the situation became tense again in the first months of 2003. MONUC observers reported serious human rights violations in the Mambasa region, and shortly afterwards they learned of troop movements on the eastern and northeastern borders of the DRC. Following the withdrawal of the Ugandan army from Ituri, militias immediately took over the towns, and atrocities against the civilian population resumed (Grignon 2003, 2). On 10 February 2003, the foreign ministers of Uganda and the DRC signed the Dar es Salaam Agreement in Tanzania, which specified the timetable for the establishment of the Ituri Pacification Commission and the withdrawal of Ugandan troops from Bunia. At the end of the month, MONUC suspended air flights to Bunia due to a serious incident: General Mountaga Diallo's helicopter was shot down over Bunia, causing serious damage.

The situation around Bunia was particularly tense. The population of Ituri region is 5 million and is divided into 12 different ethnic groups.[16] 500,000-600,000 people were displaced and settled in different parts of the region. The two main warring parties were the UPC and the FIPI:

1.) The activities of the Congolese Patriotic Union (UPC) under the command of Thomas Lubanga[17] were mainly carried out by militias from the Hema (150,000 people, who are pastoralists by profession) and Gegere ethnic groups. Until December 2002, UPC received support from Uganda, but Lubanga sought allies in Rwanda and developed cooperation with the RCD-Goma.[18] For this reason, in March 2003, Uganda

[16] A detailed history of the various groups fighting in the DRC and the cooperation between the groups see Prome, 2003, 16-18.

[17] Lubanga was transferred from Kinshasa to The Hague on March 17, 2006, to stand trial at the International Court of Justice.

[18] RDC-Goma was also supported by Rwanda after the RCD-ML and MLC excluded it from the Mambasa ceasefire talks in December 2002. (Ituri… 2003)

exiled the UPC to Bunia. However, the UPC managed to gain strength there as well. Since June 2002, it had about 2,000-3,000 soldiers.

2.) The Party for the Unity and Integrity of the Congo (PUSIC), led by Khawa Mandro, emerged from among the Hema dissatisfied with the UPC. The party, which had existed since November 2002, had a force of 1,000. Khawa's goal was to unite the local population into a coalition, the Party for the Integration and Peace of Ituri (FIPI), formed in December 2002 and supported by Uganda.[19] Khawa's goal was to unite the local population into a coalition, the Party for the Integration and Peace of Ituri (FIPI), formed in December 2002 and supported by Uganda. All this in order to keep the local population under control of the region's mineral resources and to avoid conflicts between the Nanda and officials from Kinshasa.

The Nationalist Front (FNI), a Rwandan-backed organization of the Lendu ethnic group (750,000 people, farmers), was led by Floribert Njabu Ngabu. The members of the organization were trained by the RCD-ML, which also provided military support to the FNI. The FNI had 1,000 soldiers. The Front for Reconciliation, Peace and Integration (FRPI), which operated as the army of the Ngiti political party, was led by Dr. Adirodo and had 400 members. Overall, the number of militants was relatively low, but many of them were children. The conflict between ethnic groups cannot be reduced to the confrontation between the Hema and Lendu groups (see: PUSIC and FIPI). Uganda's main objectives were to maintain chaos and to apply the principle of *divide et impera*, in order to justify its presence and thus ensure the extraction of the natural resources in the region (timber, uranium and the largest gold mine in Africa).

MONUC began deploying military forces in the Ituri region (411, then 600), and on 23 April 700 Uruguayan peacekeepers began their peacekeeping operations. A report to the Parliamentary Assembly of the Western European Union (WEU) stressed that *"these forces do not have the necessary means or authority to deal with the situation"* and that the Rwandan-backed UPC was being held back (AWEU 2004, 15). Child soldiers aged between 12 and 16, drugged and armed with small arms, patrolled the town and kept the population in fear. The mission seemed to be losing control of events: between 7 and 16 May, fierce fighting broke out between the armed Hema and Lendu ethnic groups.

MONUC distributed 10,000 tons of food and provided protection to 15,000 people in the humanitarian aid operation, during which time two of its military observers were brutally murdered near Bunia, and heavy fighting broke out around the MONUC and UPC headquarters. This was the moment when UN Secretary-General Kofi Annan appealed for help from the international community. The attacks on American troops stationed in Iraq ultimately led the Bush administration to refrain from intervening. This was a good thing for the nascent European (Common) Security and Defence Policy (then: ESDP, now: CSDP), which was launching its first missions and operations at that time. On 10 May 2003, France made its participation conditional on three conditions:

[19] The coalition members are: PUSIC, FNI and FPDC (National Force for Congolese Democracy - Alur and Lugbara political party).

the operation being mandated by the UN, the involvement of other states, and the agreement of all parties concerned to deploy the operation. In France, an EU operation was perceived more positively due to the country's dubious role in the region (e.g. support for local mafias) and the French *Operation Turquoise* in Rwanda. At the time of *Operation Turquoise*, the FPR had taken power in Kigali in July 1994, and President Paul Kagame was also heavily involved in the wars in Ituri. The countries involved in the fighting in the region (namely the DRC, Rwanda and Uganda) officially supported the French intervention. *"According to some sources, the department for African affairs at the Élysée explicitly recommended that the intervention be transformed into an EU operation."* (Grignon 2003, 2-3). In addition, Kofi Annan took a dual approach by requesting assistance from both France and the European Union. The Ituri issue was discussed at European level by defence ministers in the General Affairs Council on 19 May (Tardy 2005, 5 and 12).

Meanwhile, a transitional government was formed in the DRC on 30 June 2003, with four vice-presidents elected alongside Kabila, representing the four main forces present in the country: Abdoulaye Yerodia Ndombasi from the presidential camp, Azarias Ruberwa from the RCD, Jean-Pierre Bemba from the MLC and Arthur Zaidi Ngoma as a representative of civil society. The transitional government remained in power until 18 February 2006, when the Third Republic was proclaimed (Lugan 2020, 1457). Operation EUFOR ARTEMIS was launched on 12 June 2003, embedded in the UN peacekeeping mission. Its aim was to assist the local UN mission, MONUC, which had proven incapable of handling such crises.

NATO (and especially the United States) opposed an independent EU operation and did not want to provide support for its implementation (Faria 2004, 45-46 and 57-58) due to its priorities in the Balkans and Afghanistan. And we should not forget the rivalry between the French and the Americans in the DRC over President Kabila. Despite its territorial and temporal limitations, ARTEMIS performed its task relatively successfully during its approximately 2.5-month duration, despite the significant risks assumed (small number of personnel, hostile environment, limited evacuation options). As for the events that followed the operation (which are of course not its direct consequence) stability in the DRC proved to be fragile. On 6 October 2003, the EU condemned the massacres that took place around the village of Katchele in Ituri (Commission Pressroom 2003).

Operation ARTEMIS was followed by three EU operations/missions:

- EUPOL Kinshasa (30 April 2005 – 1 July 2007),
- EUPOL RDC (1 July 2007 – 30 September 2014)
- EUSEC RDC (8 June 2005 – 30 July 2016);
- and EUFOR RDC (23 June 2006 – 30 November 2006).

Two years after Operation ARTEMIS, the European Union was once again operating in the DRC. It launched two missions to support the political process, covering economic, political and security issues. This time, the missions concerned the relatively calmer region in the west of the country (Türke 2016, 93-108).

I.6. The Third Republic (2006-2019) and the End of the Kabila Era

Following the promulgation of the constitution of 18 December 2005, the Third Republic was proclaimed in the DRC on 18 February 2006. The first round of parliamentary and presidential elections (the first free elections in 40 years) was originally scheduled for April 2006, but was postponed three months later, to 30 July 2006. President Kabila was challenged by Jean-Pierre Bemba. On 29 October 2006, Kabila won the second round of the presidential election with 58.05%. Antoine Gizenga[20] was appointed Prime Minister. The European Union provided 150 million euros in support of the elections and sent a 250-strong observation mission led by General Philippe Morillon.

Bemba, known as "Chairman," was not only a close associate of Mobutu, but also had family ties to the former president. (His sister was married to one of the former president's sons). In 1997, after Kabila's Alliance of Democratic Forces for the Liberation of Congo (AFDL) took power, Bemba fled the country. In 1998, he founded the MLC/ALC, which he represented in the interim government as vice-president from 30 June 2003. The Mobutuist wing of the party exerted a strong influence on the president. In 2002, he was accused of buying weapons and authorizing his militias to carry out attacks in the CAR, with the support of Colonel Gaddafi, in support of the regime led by Ange-Félix Patassé. During these incidents, his poorly paid militias committed several crimes (robbery, rape and looting). In the first round of the presidential election held in October 2006, he came in second place with more than 20% of the votes cast. But in the second round he only achieved 42% of the votes cast.[21] The country was essentially divided in two, with Katanga voting for Kabila and the western parts for Bemba. Both candidates had their own armies. Even the presence of international forces did not deter the armies from fighting each other: On 21 August 2006, the presidential guard threw a bomb at Bemba's residence, but he managed to escape an assassination attempt.[22]

2007 began with heavy clashes in Upper-Congo between security forces and members of the separatist *Bundu dia Kongo*. In the 19 January 2007 elections for the 108-member Senate, the Alliance for the Presidential Majority (AMP, Kabila's political platform) won 56 senatorial seats. Bemba's Union for the Nation (UN) platform had to make do with 20 seats in the Senate. Prime Minister Antoine Gizenga's United Lumumba Party (PALU) managed to win only two senatorial seats. The elections confirmed the leading role of the People's Party for Reconstruction and Democracy (PPRD, the

[20] This is the same Antoine Gizenga who was the Lumumbista Prime Minister of the Free Republic of the Congo 45 (!) years ago in 1961.

[21] He was successful in his home province (Equateur Province), as well as in the poorer urban areas of Kinshasa and Bas-Congo. Some reports say he spent $20 million on his campaign (Duku 2006).

[22] The parties – Kabila and Bemba – launched two investigations, and "surprisingly" the conclusions of the investigations were completely different. According to one, the attack was carried out by Bemba's militias, who also kidnapped two police officers, with the aim of causing a clash in front of Western observers. According to the other theory, Kabila's soldiers carried out a deliberate attack or, more accurately, an assassination attempt.

majority party in the AMP) and the Congolese Liberal Movement (MLC) on the Congolese political chessboard. The poor performance of PALU seriously questioned Gizenga's position. Attacks by Laurent Nkunda's CNDP (National Congress for the Defence of the People) in the Kivu region and by the Maï-Maï in the east of the country have become increasingly frequent.

Bemba was elected senator, but his bodyguards did not comply with the ultimatum of 15 March 2007, according to which they should have joined the national army. It should also be emphasized that in the DRC (as in Guinea-Bissau, Türke 2011) programs related to DDR (disarmament, demobilization and reintegration) and SSR (security sector reform) play a role in strengthening the position of the winner. Because by disarming rival groups that cooperate with his opponent, he strengthens his army, as well as the presidential guard, police (etc.). [23]

Without their own army, a political candidate essentially has no chance in the "democratic" elections of Africa. So, it can be decided to what extent these steps promote the construction of competing plural democracies and to what extent they entrench the position of autocratic-minded individuals who have been elected to the presidency for many years, and in the meantime to what extent they succeed in ensuring stability in the given regions. This is how we can judge the extent to which these international programs initiated in the interests of democratization, ignoring the traditional positions of the clans, promote the construction of competing plural democracies. Or to what extent do they contribute to securing the position of autocratic-minded individuals who entrenchment of the presidential seat for many years? And at this price, to what extent do they succeed in ensuring stability in the given regions?

Bemba then issued a ceasefire call and sought refuge in the South African embassy. He then left the country on 11 April 2007 and travelled to Portugal but was arrested in Brussels on 24 May 2008 and summoned to the ICC on charges of crimes against humanity committed between 2002 and 2003 when his militia came to the aid of President of CAR, Ange-Félix Patassé.[24]

On 27 November 2007, the Supreme Court declared Joseph Kabila the winner of the second round. In 2009, the Goma Peace Agreement, signed by the government, the CNDP and the Nigerian mediator and former President Olusegun Obasanjo, “officially” ended the Kivu War (2004–2009). Under the peace agreement, the CNDP was to

[23] The absurdity of the situation is that Bemba had 600-1000 armed men, although officially (!) he could have maintained a guard of 100 (Courtoux 2006).

[24] On 24 May 2008, Bemba was arrested – based on an arrest warrant issued the day before by the International Court of Justice in The Hague – on charges of sexual crimes, war crimes and crimes against humanity committed during his troops' incursion into the KAC between October 2002 and March 2003. His trial began on 22 November 2010 in The Hague. Thus, with the presence of EUFOR, it intervened in the political rivalry of two war criminals – similar to Milosevic (CPI 2008).

become a political party, former rebels held by the DRC authorities were to be released, and Kinshasa was to enact a law granting amnesty to former rebels. Some of the rebels were integrated into the Congolese regular army.[25]

On 28 November 2011, Kabila was re-elected, but his main opponent, Etienne Tshisekedi, former Prime Minister of Zaire (1991, 1992-93 and 1997), challenged the election results and also declared himself president. In 2012, the Kivu conflict resumed, and this time the warring parties declared war directly on the government. Kabila effectively lost control a large part of the country (Kivu, Katanga, Goma provinces, etc.). Thanks to the massive presence of the Ugandan LRA and Rwandan troops, the M23 (based on the CNDP) became the most important factor in the region. After that, the UN (learning from previous mistakes) sent a 20,688-strong mission, MONUSCO, with a strong mandate and a rapid reaction intervention brigade with military helicopters, to the region under the charismatic leadership of Martin Kobler. With this help, the FARDC (Congolese army) was able to win a decisive victory over the M23 in November 2013.

On June 30, 2015, the administrative reform redrawn the borders of the Congolese provinces: increasing their number from the previous 11 to 26 in order to make it more difficult for large regions (such as Katanga) to secede. The reform had been on the agenda for a long time and was carried out with the agreement of the political class. For example, the province of Grand Kivu was divided into three parts in 1988 (North Kivu, South Kivu and Maniema) and the 2006 constitution already mentions the 25 new provinces + Kinshasa (as legal personality).

The advantage of the reform is the enforcement of the principle of subsidiarity, which gives more autonomy to the new regions. The disadvantage is the increased bureaucracy with 26 governors and more than 260 provincial ministers (which increases the possibilities for corruption) and the emergence of new tax levels (Türke 2016, 103-104). According to the constitution, 40% of the central budget resources must be kept at their place of payment, the provinces. In March 2022, 7 years after the reform, 15 of the 26 new provinces still had not managed to establish their own financial directorate. They essentially do not have their own resource management and the amounts allocated to them flow into the financial directorate of a neighboring province (Muamba 2022).

From October 2014, the Muslim rebels of the ADF (United Democratic Forces) began to destabilize the North Kivu region again, organizing pogroms. In May 2015, rebellions against the central government resumed in the Beni region (North Kivu), and the ADF had already killed more than 300 people. On December 20, 2015, the Civil Front 2016 was created, a coalition of civil society and opposition figures (Vital Kamerhe UMC, Moïse Katumbi, Félix Tshisekedi UDPS, Martin Fayulu Ecidé). Their main goal was to prevent Kabila from winning a third term. The Lucha youth movement, founded in 2012, also took an increasingly active part in the resistance. On February 16, 2016, the opposition declared a "dead city day" in protest throughout the country, to which the police responded with arbitrary arrests. The united opposition, which launched in June

[25] This is the main reason why national armies in Africa are extremely heterogeneous and unreliable. See the example of Mali.

under the name *Rassemblement* (Rally), invited former governor Moïse Katumbi to challenge Kabila. In July, a new militia, Kamuina Nsapu, began killing civilians in Kasai province, and in North Kivu, Maï-Maï and FDLR Rwandan rebels resumed pogroms. In September, in Kinshasa, protesters demanding Kabila's departure clashed with police, resulting in 53 deaths, while on October 18, the government, under the auspices of the African Union and mediated by Togolese Edem Kodjopour, attempted to postpone the elections until April 2018. The 31 December 2016 agreement had envisaged holding the elections by the end of 2017 at the latest.

In 2017, 1.3 million people were displaced in the DRC, and in March two UN experts were brutally murdered while investigating human rights abuses in the Kasai region. In April, President Kabila appointed Bruno Tshibala, a dissident from the opposition, as prime minister. On 15 June, Kofi Annan and nine former African presidents issued a statement calling the situation in the DRC untenable. In October, HRW identified 120 armed groups in the two Kivu regions, with the number of displaced people reaching 4 million. At the end of the year, elections were postponed until December 2018, and demonstrations against Kabila and the massacres followed one another in the country. The year 2018 was known for the resurgence of Ebola and the bloodshed around Lake Albert, while on July 13, 2018. And it essentially "started all over again" in Ituri, forcing the UN to publicly condemn the mass ethnic cleansing in the region... (Lugan 2020, 1458-1459).

I.7. Congo after the Kabilas: Félix Tshisekedi's presidency (2019-)

The presidential elections held in December 2018 were won by the opposition candidate Félix Tshisekedi, son of former Prime Minister and resistance leader Étienne Tshisekedi, with 38.6%. His opponents Martin Fayulu received 34.8% and Emmanuel Ramazani Shadary, Kabila's "heir apparent", received 23.8%. Fayulu strongly contested the results and claimed his own victory of 61%, which was confirmed by 40,000 election observers from Cenco and by investigative teams from *RFI*, the *Financial Times* and *TV5 Monde*. Tshisekedi was accused of secretly colluding with Kabila, which can be confirmed by the fact that Kabila immediately received the titles of hereditary senator and honorary president at the beginning of the new term and did not have to hand over his presidential residence called GLM.

In the legislative elections, the FCC won, winning 337 seats out of 500. In mid-January 2019, despite the African Union's request to suspend the announcement of the election results, the Constitutional Court finalized the results on the 20th, which, despite the obvious fraud, is considered the first peaceful transfer of power since independence (RDC: reactions... 2019). Sylvestre Ilunga, the former president of the national railway company, became the prime minister of the 65-member (!) government. The president began his mandate in a very controversial manner, for example, immediately resisting the replacement of officials accused of corruption and crimes against humanity. It is no coincidence that on April 8, 2020, Vital Kamerhe, Tshisekedi's chief of staff and main

political ally, was imprisoned on charges of misappropriation of public funds and sentenced to 20 years of hard labor.

In the summer of 2020, disagreements between Kabila and Tshisekedi increased, mainly over the appointment of the army, the electoral commission and the constitutional court. Then, on 6 December 2020, the president announced the split in the governing coalition between his own political platform, CACH ("Direction for Change"), and former President Kabila's party, FCC (Common Front for Congo). The FCC dominated both parliament and provincial assemblies (Ba-Mweze 2020).

In early 2021, Roger Lumbala, who was captured in Paris at the end of 2020, was indicted on charges of crimes against humanity committed in the northeastern part of the DRC between 2000 and 2003. In February the Italian ambassador was killed in an attack in Goma. On April 30, 2021, the president declared a state of siege in Ituri and North Kivu provinces due to the renewed wave of violence. In the fall he asked for the international community's help in the fight against terrorism against the ADF. The ADF(-Nalu) was formed in 1995 as an opposition to the Ugandan Allied Democratic Forces President Yoveri Museveni. The force consists of 300-600 fighters and has since moved its headquarters to the DRC. In 2017, they announced their affiliation with the Islamic State.

Conclusion

The Democratic Republic of the Congo is an artificially created state-like entity in the former Belgian colony, weakened by historical-ethnic secessionist aspirations since independence. The provinces, artificially connected by the colonial Belgians exclusively along their own interests, are artificially held together by the central government, which is often in need of regional or international assistance. In many cases, these provinces are tied together by closer historical-ethnic ties to the (southern) areas beyond the borders. The southern (Katanga/Shaba, Kasaï) and eastern (Ituri) parts are under little or no state control, and these regions have been (or were) the scene of continuous gateways and waves of violence, with hardly any peaceful periods to be found in their post-independence history. Mobutu's corrupt regime survived for 32 years thanks to American and then French support and influence, and even during the Kabila era, the country barely made any progress on the path to democracy.

The region's integration efforts (Türke 2018) are repeatedly thwarted by civil wars. Behind them, one can discover the imperial ambitions of certain states or ethnic groups (DRC, Rwanda/"Tutsi"), which have been repeatedly stalled and frozen for several years by protracted or internationalized civil war situations. On the other hand, the range of organizational memberships shows a great deal of overlap and confusion, which works against efficiency and reflects the "floating nature" of the region. That is, some states are also members of integration institutions in other (sub)regions (e.g., East or Southern Africa). Paradoxically, this works against closer cooperation across Africa, although in the last decade it has become increasingly clear which forms of integration are capable of acting as relevant actors on the international scene.

Due to the huge size of the DRC and the ongoing destabilized-war situation in the eastern part of the country and the secessionist aspirations there, it proved unable to offer a real political-economic alternative to the neighboring "dwarves" Rwanda and Burundi, which are both demographically and economically weak and once closely part of the Francophone sphere of interest. Moreover, it constantly threatened these with strong political pressure and economic "absorption" – even when the invasion, mainly from Uganda, threatened to tear off their own eastern territories. The region is increasingly drifting towards the Anglo-Saxon forms of integration[26] of South and East Africa – which seem to be more successful than the Francophone ones.

However, the fact that this region is increasingly drifting towards the Anglo-Saxon forms of integration of South and East Africa (necessarily Anglo-Saxon due to the colonial past of these states) is only a sideline of the Francophone-Anglo-Saxon rivalry. Due to historical and ethnic roots, geographical conditions and economic and trade cooperation systems, this process can be considered rational in an economic and financial sense. Francophone (integration) efforts are losing out to Anglo-Saxon-based efforts also in this region: Rwanda has come under complete Anglo-Saxon political and cultural influence, and this trend is also present in Burundi.

Conflict of Interest

The author hereby declares that no competing financial interest exists for this manuscript.

Notes on Contributor

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[26] In the Anglo-Saxon integration bloc(s), these proportions are also more balanced, and education is much more developed. Only one African Francophone university makes it into the African top 50 (2019), the rest are Anglo-Saxon (Niyongere 2019).

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Community Based Security and Crime Prevention: Evaluating the Effectiveness of Vigilante Groups in Gombe State, Nigeria (2013-2023)[1]

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Abstract:

The paper examined the effectiveness of vigilante groups in the prevention of criminality in Gombe State, Nigeria focusing on the activities and effectiveness of the vigilante groups between 2013-2023. Primary data were collected through a field survey conducted in 2024 with respondents providing experiences and perspectives relating to the study period. The study was guided by the following research objectives: reasons for the emergence of vigilante groups and their level of effectiveness in crime prevention in Gombe State. The Broken window theory was adopted which underscores the effectiveness of vigilante groups in Gombe State highlighting how their prompt response to minor offences helps prevent the escalation of crime and strengthens community-level social control. Primary and secondary data were sourced from the selected three Local Government Areas affected by criminality in the State. The study adopted Taro Yamane's formula to determine the sample size and Bourley's Proportional formula to allocate respondents across the Local Governments selected. Using multi-stage cluster sampling and purposive techniques, a sample size of 400 respondents was determined for the study, and questionnaires were administered to all 400 selected respondents. Of the 400 questionnaires administered, 371 were successfully retrieved and found valid for analysis, representing 92.75% response rate. Thus, the remaining 29 questionnaires were not returned. However, 24 Key Informant Interviews were conducted. The Statistical Package for Social Science (SPSS) version 23.0 was used to analyse the quantitative data using descriptive statistics and cross tabulations. The qualitative data were presented in themes and interpreted in a narrative form. Findings revealed that reasons for the emergence of vigilante groups were inadequacies of law enforcement agencies to prevent crime, increased rate of petty crimes, armed robbery and theft, cultural values that support community policing, and political interests of some elites. The study also revealed a predominantly positive perception of vigilante group effectiveness, with 76.28% of respondents rating their performance as effective to varying degrees (effective, fairly effective and very effective) compared with 23.72% who rated it as ineffective. However, the study concluded that modern equipment and logistics should be provided to address root causes of criminality in Gombe State. Vigilante groups should also adopt modern technology, sensitization, and collaborate with religious and community leaders in preventing criminality in the State.

Keywords: Vigilante; Crime; Prevention; Community; Security.

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Introduction

Globally, the issue of insecurity and the inability of the law enforcement agencies to deal with the situation has become a very serious concern and placed increasing demand on policing in the world today. Despite the existence of several formal security mechanisms, there are still incidences of criminal activities across many societies in the world. This results to the formation of informal security structures such as the vigilante groups which contributes to crime prevention and thereby complementing the efforts of the law enforcement agencies. Okunola (2011) states that security is important because it necessitates peace, protection of life and property, liberty as well as a precondition for economic investment and growth.

Durkheim (1970) posits that crimes have been a necessary part of every society. Macionis and Plumer (2005) maintained that all societies have crime and deviance, there is no such thing as a crime free society. However, the existence of crime is necessary even though, it is never a welcomed appeal to most of the members of the society because its presence tends to alter the peace and security of the society, thus, an indispensable requirement for the development of any human society (Onwuegbusi, 2017). Worldwide, criminality constitutes threat to lives and properties, this is so because it retards socio- economic and political development of different countries. The international Statistics of Crime (2014) reported that the problem of insecurity across the globe and particularly the escalation of crime incidence in Africa over the years such as Nigeria has eventually led to the establishment of vigilante security groups giving them full legal and legislative backing in 2008. In essence, the provision of adequate security is a social pre-requisite for the survival of any society. Building on this, Ashton and Bussu (2019) establishes that great efforts are being made by societies over time to combat the rate of criminality which differs across times and countries.

Historically, crime control and prevention were not the duties of the state but the traditional responsibility of every adult in the community. Community-based groups were formed by societies in this regard usually referred to as vigilante groups. Richard (2010) explained that security in Rome was in the hands of some unpaid private individuals appointed by the magistrates in approximately 27BC. Similarly, in Slovakia, vigilante groups were established to curtail mass immigration of people passing through their land. According to Akaayar (2010) vigilante groups in the 19th century were set up in towns and rural communities in the United States of America (USA) to keep order and checkmate illegal activities by criminals. Also, in Britain, vigilante groups were formed as partnership where community members' work together to protect themselves, their properties and communities against crime. In the same vein, communities in some African countries such as Sierra-Leone and Lake Chad established vigilante groups as a result of the ineffectiveness of their respective formal policies to combat crime (Brown, 1975; Chikwendu and et al. 2016). According to Ajayi (2007), the Nigerian task of policing and war against crime dated back to the pre-colonial days where many local communities-maintained warrior groups.

Specifically, in Gombe State, the history of crime prevention dates back to the pre-colonial and colonial period where indigenous institution such as the Islamic legal system, 'yan banga groups and palace guards became ultimately responsible for crime prevention within the community (Rotimi, 2001). With the advent of the civilian government, the state faced a lot of crises comprising of religious, ethnic and political thuggery which made the state to be described using different terms such as Gombawa, 'yankalare, and goje boys (Criminals). However, in 2011, the state witnessed another approach of combating criminality introduced by the then governor referred to as The Youth Rehabilitation and Empowerment Program (YREP) (vigilante) in 2013 which recruited about 3000 youth to assist the police and other government agencies within the state (Umar and Bappi, 2014). Recently, Kehinde and Godwin (2021) noted that there has been heavy reliance on vigilante groups for security purposes at community level and as an important outfit to complement the state law enforcement agencies. Gombe State is not an exception, as crime rates increases in waves due to the inability of the law enforcement agencies to deal with the situation effectively. Thus, the resurgence of vigilante groups was informally established to ensure the security of lives and property of community members. It is against this backdrop that this study was set to assess the effectiveness of vigilante groups in the prevention of criminality in Gombe State.

Conceptual Clarification

Vigilantism

The concept of vigilantism has been defined by several scholars differently. Originally, to be 'vigil' means to be in a continuous state of alert. The term vigilante was derived from the Latin word 'vigilans' which means to be watchful. Vigilantism therefore implies an occurrence where groups are organized with the aim of detecting dangers. Baker (2003) stated that vigilante groups are largely informal and are mainly funded through communal contributions. They are primarily required to keep a watch over their communities and report suspicious persons to the police.

Criminality

Criminal activities refer to the violation of a law which poses threat to public safety. According to Gumus (2003), crime is an illness that attacks the rights of individuals such as rape, theft, armed robbery, kidnapping, and murder to mention but a few. Nigeria as a country has suffered myriads of security problems which affected the country's stability and integration. Presently, the security situation still remains adverse due to the increase of criminal violence which seem to have gone deep-rooted and increasing faster with each passing day (Phenson, 2014). According to the Global Peace Index (2015), Nigeria was ranked the third most unsecured (terrorized) country after Iraq and Afghanistan, which were ranked first and second respectively in the world (Adeyanju, 2015).

Empirical review

Reasons for the Emergence of Vigilante Groups

In most traditional societies across the world, there existed some form of policing prior to the emergence of the present police structure. The task of maintaining law and order as well as the prevention of crime and civil disorder in many societies were mainly the responsibilities of the adults. In the United State of America between 1851 and 1856, the inhabitants of San-Francisco created vigilante groups to deal with the incessant conflicts and crises which characterized the state at that point in time. Similarly, communities in African countries such as South Africa and Sierra-Leone established vigilante groups due to the ineffectiveness of their respective formal policies to combat criminality (Brown, 1975; Chikwendu, et al. 2016). According to Attafuah, (2008), high level of crimes and insecurity is the main motivation behind people to taking the law into their own hands. Strategies adopted by the Vigilante Groups in Crime Prevention

Moncada (2017) posited that the collective use of extra-legal violence while responding to alleged crime is one of the famous vigilantism structures whereas actions by the vigilante groups varied substantially. Vigilante groups in many cases were engaged in a show of force conducted patrols within the neighbourhood (Martinez and Ocampo, 2013). Vigilante groups also set up roadblocks in a bid to catch members of criminal organizations (Gil, 2013). Vigilante groups detained suspects of crime and carry out their own trials in some occurrences (Covarrubias and Cervantyes, 2013). They at times engaged in fire fights with organized crime groups over control of certain towns (Carrion, 2014).

Effectiveness of the Vigilante Security Groups in Crime Prevention

Community policing demands that community members and the vigilante collaborate with police to protect and safeguard their environment against crime and disorder. It, therefore, offers opportunity for the vigilante groups, community members and the police to work together to resolve problems existing within the communities. This is one of the major reasons for the provision of vigilante service laws in Nigeria. Adejoh (2013) noted that the emergence of the vigilante security group in communities in Nigeria is due to high level of insecurity and the unsatisfactory performance of the Nigerian Police. In order words, the vigilante security groups emerged to fill an unmet need. Thus, strengthening and improving the services of the vigilante security group in the rural and urban communities in Gombe State will enhance safety and security of the community members.

Challenges Confronting the Vigilante Groups in Crime Prevention

Despite the perceived effectiveness and commitment of vigilante groups, their operations have been noted to face many challenges. A study conducted by Nwaeze (2015) revealed that lack of firearms, poor funding, lack of patrol vehicles were the major problems confronting vigilante groups. Marx and Archer (1999) noted five

outstanding problems which the vigilante groups were facing, thus, their relationship to the police and legal system; their legitimacy in the eyes of the communities they wish to serve, the recruitment and management of personnel, the choice of appropriate operations, and the maintenance of resources, incentives, motivation for the groups' survival.

Theoretical Framework

Broken Window Theory

The paper adopts the Broken Window Theory which focuses on the control and prevention of crime within the community as against outside the community. It explains how effective and efficient informal policing structures are controlling crimes compared to the formal policing structure made up of 'Strangers' (Zimbardo, 1969). The major proponents of this theory include an American psychologist Philip Zimbardo (1969) and the social scientists James Wilson and George Kelling (1982). These theorists however believed that visible signs of crime, anti-social behaviour and civil disorder create an urban environment which encourages further crime and disorder, including violent crimes. As such, policing these misdemeanours through informal policing methods that target minor crimes such as vandalism, loitering, public drinking, and fare evasion will help to create an atmosphere of order and lawfulness.

The theory assumes that only the community members can safeguard themselves from crimes. This is because they live within the community and can work and watch at all times. They also know who those potential criminals are and how best they can be contained. Furthermore, the core principle of informal policing (vigilante group) structures is the constant maintenance of law and order by members of that community. This is in line with the core notion of the broken window theory, which asserts that the constant presence of police structures makes a community less conducive for crime and criminals. Thus, increased police presence and enforcements of informal rules of conduct and laws can make a community seem less chaotic and safer thereby, increasing the presence and involvement of residents in their community and lowering crime rates (Palmiotto, 2000).

Furthermore, the broken window theory also assumed that heightened perceptions of disorder, increased fear of crime and diminished community social control were significant inhibitors of public participation in crime prevention arising directly from concerns of personal safety and sense of futility often associated with the effort required (Ren, Zhao and Phil, 2019). Charles, Ross and Lindsey (2020) posit that broken window theory emphasized that more serious crimes evolve from minor infractions. It stated that if the first broken window in a building is not repaired, the people who like breaking windows will assume that no one cares about the building and more windows will be broken, soon the building will have no windows. In essence, crime flourished because of the lack of law enforcement (Wilson and Kelling, 1982).

The broken window theory can be incorporated into the concept of informal policing in the sense that collective efforts by both the police and community dwellers can help

alleviate the rate of crime in the community as the police see residents as partners in development and vice versa. Likewise, the theory asserts that if there is a crack anywhere in the community and no one is available or observant enough to take care of it, overtime it becomes a deep ditch that would pose a serious security risk to members of the society. Thus, the theory also submits that most neighbourhood crimes are more often than not perpetrated by offenders who reside near the victims; this makes crime primarily a local problem which can best be solved locally. The contribution of this theory to the study is that there is a possibility that vigilante groups can be effective in dealing with crimes because they consist of community members who are privy to the community issues.

One line of criticism is that there is little empirical evidence that disorder, when left unchallenged, causes crime. Another shortcoming of the theory lies in its failure of validity. To validate the theory in its entirety, it must be shown that disorder causes fear, and that fear causes a breakdown of social control, which in turn causes crime. Finally, crime must be shown to increase levels of disorder. Harcourt (2009) also criticized the theory for fostering zero-tolerance policies which are prejudicial against the disadvantaged segments of society.

However, critics alleged that the theory side-lines the need for formal security provision by the state actors like the police. As much as community policing is key, it cannot supersede the role of police and the government who have a constitutional mandate to provide security.

Otherwise, the strengths of the theory however lie in its ability to enable initiatives within the realm of community crime control, rather than relying on formal policing. It further argues that earlier social disorganization and economic theories offered solutions that are costly and would take a long time to prove effective. Whereas broken window theory is seen by many as a way to effect change quickly and with minimal expense by merely altering the police crime- control strategy. More so, the theory also posits that it is far simpler to attack disorder than it is to attack such gloomy social ills as poverty and inadequate education. Thus, the effectiveness of vigilante groups in their operations as informal security groups offers significant contribution to the prevention of criminalities right from their emergence in human societies.

According to Willson and Kelling (1982), broken window policing advocates for a proactive approach in crime prevention which focuses on minor offenses such as loitering to help maintain order and deter criminal activities across societies. As a result, the theory has fundamentally shaped the law enforcement strategies over the years leading to its adoption in various cities including Gombe State for crime prevention measures. Furthermore, the basis for adopting this proactive policing approach is grounded in the theory, that it prevents more severe crimes from occurring by maintaining a high standard of public order.

The theory has appeared to be very relevant to the findings of the study because the assumption that certain anti-social behaviours open doors for more other anti-social crimes which becomes serious threats to the security and safety of lives and properties

in the societies. Thus, community security arrangement is the most viable option and fundamentally needed. Based on this therefore, it can be seen that the vigilante as informal security groups in Gombe State are the products of community security arrangements to tackle the various internal security challenges bedevilling various localities within and outside the metropolitan areas of the state.

Methodology

The study covered the period between 2013-2023, which constituted the temporal scope for examining the activities and effectiveness of vigilante groups in community-based security and crime prevention in Gombe State. Fieldwork and primary data collection were conducted in 2024, during which respondents provided their experiences relating to the 2013-2023 period. Thus, it represents the period under investigation, while 2024 denotes the period of data collection.

Both quantitative and qualitative methods were used. The study adopted descriptive survey and cross-sectional research design which examined the reasons for the emergence and effectiveness of vigilante groups in crime prevention, and challenges confronting vigilante groups in Gombe State. The choice of this location was influenced by many reasons as such the state government flagged off the GoSTEC Program in which no fewer than 2,000 youths across the state were trained and engaged into various developmental activities including the local security arrangement where they assist the statutory security outfits in the state (Econs Intelligence 2022). The study consisted of purposively selected six wards of Akko, Garko, Jekadafari, Shamaki, Tal, and Tudun Kwaya from the three selected local government areas of Akko LGA, Gombe LGA, and Billiri LGA. However, a sample size of 400 respondents was determined for the study, and questionnaires were administered to all 400 selected respondents. Of the 400 questionnaires administered, 371 were successfully retrieved and found valid for analysis, representing 92.75% response rate. Thus, the remaining 29 questionnaires were not returned. The sample size was also divided using the Bourley's Proportional Allocation Formulae in order to give accuracy and equity in the distribution of the sample size at wards level for the study.

Data generated was processed and analysed using descriptive statistics and cross tabulations through the use of the Statistical Package for Social Sciences (SPSS) version 23. Descriptive analysis using frequency distribution and percentages helps in presenting the data in a summarized form while cross tabulations were used to examine relationship within the data. The qualitative data generated through the interview was transcribed and analysed to compliment the quantitative data. In other words, qualitative data obtained from Key Informant Interviews (KII) was critically analysed through a "thick description approach". This was done via the transcription of the interview and discussion from the recorded tape into a readable form. Thus, the data was presented in themes and explained in descriptive form while triangulating with the quantitative data.

The interpretation of perceived effectiveness, the response categories were grouped into positive and negative assessments. "Very effective", "effective", and "fairly effective" were classified as positive assessments, representing varying degrees of perceived effectiveness, while "ineffective" was classified as a negative assessment. The proportion of the three positive responses aggregated and compared with the proportion reporting "ineffective" was considered the dominant perception of the respondents.

Data Analysis

Responses	**Frequency**	**Percent**
Inadequacies of police and other security agencies	71	19.14
High rate of crimes and insecurity in the state	118	31.81
Cultural and religious values that support community policing	52	14.02
Political interests of some elites and groups	34	9.16
All of the above	96	25.88
Total	**371**	**100**

Figure 1: Reasons Responsible for the Emergence of Vigilante Groups in Gombe State. Source: (Field Survey, 2024).

Figure 1 presents that 71 respondents representing 19.14% of the total responses have the belief that the major reason for the emergence of vigilante groups in Gombe State is due to the inadequacies of police and other security agencies in the state, 118 respondents representing 31.81% attributed the emergence of the groups to the rising high level of criminal activities across the state, 52 respondents representing 14.02% are of the perception that the emergence of vigilante groups in Gombe State can best be linked to the norms, values and culture of the people in the state that support and encourage local policing and local security arrangements, while 34 respondents representing 9.16% however were of the opinion that vigilante groups mainly emerged due to the interest of certain elite groups for certain political or economic interest, and subsequently the 96 respondents representing 25.88% of the respondents believed that all the aforementioned factors have simultaneously been the reason for the emergence of vigilante groups in Gombe State.

These responses point to the fact that many factors were the root cause for the emergence of vigilante groups in Gombe State. While it can be very true that inadequacies of policies, and the rising cases of security threat in the state made the

emergence of the groups necessary. In line with the above finding, an interview with a traditional ruler in Nayi-Nawa area of Akko Local Government, emphasized two factors as the major reasons for the emergence of vigilante groups in the State. The following are extrapolated from his statement:

> "*If I am not wrong, what I think to be the major reason for the emergence of vigilante group in Gombe State is, one, the lack of adequate and required number of state security agencies that will adequately cover all the areas of Gombe State. Secondly, the rising cases of petty-petty crimes in the state, especially in the outskirt's areas like Nayi-Nawa. Some years back when vigilante groups were not very active, coming to Nayi-Nawa in the night has been a high-risk issue, because phone snatchers were spread around, they snatch and run away, and sometimes they threat their victims with matches, knifes and other dangerous weapons. But, with the emergence of the vigilante group, I can tell you without any iota of doubt that these things have drastically reduced*" (Interview, 2024).

In a similar scenario, a traditional ruler stated that in Billiri Local Government Area;

> *"Years before vigilante groups became well active; we in Billiri lived in continuous cog mire of armed robbery especially between the villages. Thugs usually station in between villages and rob whoever falls within their trap. And so, that had been what happened before it was significantly addressed by the vigilantes in collaboration and coordination with the state security agencies*" (Interview, 2024).

The excerpt above demonstrates that the emergence of vigilante groups in its recent form has been a result of various forms of crimes that turned some villages and towns in Gombe State lawless and stateless societies. Vigilante groups therefore emerged to help address such security concern, and at the same time ensure the peaceful existence of Gombe State.

Responses	**Frequency**	**Percent**
Patrolling the streets and neighborhoods at night	192	51.75
Setting up check points and road blocks to search vehicles and passengers	5	1.35
Arresting and detaining of suspected criminals and handing them over to police	55	14.82

Gathering of intelligent information to the police and other relevant security agencies	60	16.17
All of the above	59	15.90
Total	**371**	**100**

Figure 2: The Strategies Employed by Vigilante Groups to Prevent Criminality in Gombe State. Source: (Field Survey, 2024).

Figure 2 indicates that 192 respondents representing 51.75% reported the major strategies employed by the vigilante group to prevent crimes and promote peace and security in Gombe State is patrolling the streets and neighbourhoods to ensure that criminals and thieves did not gain any free space in the state to commit crimes at night, 5 respondents which constitute 1.35% states that the group mount check points and roadblocks to search passengers and vehicles, 55 respondents that represents 14.82% knows vigilante group to be arresting and detaining suspected criminals while handing them over to the police and other security agencies within the state, 60 respondents representing 16.17% also reported that vigilante groups were known to them in terms of intelligent gathering of information to the police and other security agencies, with a view to gain a significant outcome towards combating criminal activities in maintain the peaceful law and order in the state. Nevertheless, 59 respondents that represents 15.90% reported that vigilante groups in Gombe State employed all the aforementioned strategies its operation to prevents crime and ensure sustainable peace and security within the state. These findings suggest that vigilante groups employ different strategies to complement the effort of the police and other security agencies who work to ensure the peace, security and development of Gombe State. However, what is very rare among these strategies is mounting of roadblocks and check points.

An interview with some of the famous vigilante members in Gombe State revealed strategies that are being used by the groups to ensure crimes are reduced and criminals are decisively dealt with. One of such vigilante personnel vividly revealed that:

> "*Yes, we use various strategies to ensure that criminal activities are dealt with. Some of these major strategies are: night patrolling. We do not sleep in the night, we patrol streets, and we patrol remote areas where criminals converge. We also carry out arrests job, especially in the case of such wanted personnel who are on arrest warrant but were able to bit all the plans of the police, so we are so close to them more, and we watch their movements more than the police, therefore, whenever such criminals sneak to come to home or any close by area, we arrest them quickly and hand them over to the relevant authorities. In fact, we employed variety of strategies including providing intelligent information to the state security agencies, and so forth*" (Interview, 2024).

Based on the quantitative and qualitative data above, it can be seen that vigilante groups in Gombe State employ variety of methods and strategies in order to ensure crimes in the state are decisively dealt with. And it appears that such strategies contribute a lot in ensuring that the perpetrators of any crimes are brought into justice, while deterring others from committing such crimes.

Responses	**Frequency**	**Percent**
Very effective	57	15.36
Effective	119	32.08
Fairly effective	107	28.84
Ineffective	88	23.72
Total	**371**	**100**

Figure 3: Effectiveness of Vigilante Groups in the Prevention of Criminality in Gombe State. Source: (Field Survey, 2024).

Figure 3 shows that 57 respondents representing 15.36% of the total responses believe that the performance of the vigilante groups in crime prevention and in the quest for promotion of peace and security in Gombe State is 'very effective', 119 respondents representing 32.08% of the respondents rate the performance of the vigilantes in the prevention of criminalities as 'effective', 107 representing 28.84% of the respondents consider the performance of vigilante groups in the prevention of criminalities and in promoting the peace and security activities of Gombe State as 'Fairly effective" In contrast, 23.72% see the performance of the group as 'Ineffective'. Thus, the finding reveal a predominantly positive perception of the effectiveness of vigilante groups among respondents.

From these responses, it can be concluded that vigilante groups in Gombe State performs significantly great in the contribution of crime prevention and promotion of peace as majority of the respondents stressed clearly that the performance of the groups is effective, very effective and fairly effective. However, differences in locations, security situations, lack of cooperation by members of some societies and wards within the state may likely be the reason why some may see the activities of the vigilante groups as ineffective, because in all places where their offices are situated, vigilante groups seek financial and moral support of the members of such environment, and in any case where such support are not being provided, they could simply vacate as they cannot be able

to continue operating without finance to equip their security equipment. Consequently, their absence in such an area opens a free space for criminals and criminality to continue.

While responding to a question on the effectiveness of vigilante groups in the prevention of criminality in Gombe State, a resident of Burundi Ward of Akko Local Government Area, made it clear that the performance of vigilante groups in the area has been very effective in dealing with criminal activities bedevilling the area. The following is directly quoted from his words:

> "*The activities and performance of the vigilante group has been very effective in curbing criminal activities that are disturbing us here. Few years back, we were used to frequent Kalare confrontations in this area. There was a time when we live in this area in constant fear of possible Kalare boys attacks, because during that time, this area too was saturated with many of them, and whenever they attack other Kalare boys from other areas, some boys in those areas also retaliate through attacking in such a manner, popularly known as "SHARA" (a situation where everybody and everything would be attacked, nobody and nothing is spared, both men, women, children, animals, vehicles, and in fact, everything). This operation usually caused injuries and deaths in some cases. But with the emergence and resurgence of vigilante group, all these issues have been effectively addressed. So, without any doubt, I can tell you that the performances of vigilante groups in this area are very effective*" (Interview, 2024).

Also, an interview with the group leader in Gombe State revealed the level of the successes and effectiveness of the activities of the group in combating crimes in the state. The following include some of the statistics he has given:

> "*We have been working tireless to ensure that we sanitize this environment off the activities of the criminals. And we record and have recorded many successes. For instance, contrary to years before 2019, between 2020 and 2023, we have arrested more than 75 criminals, from whom we in collaboration with the police been able to recover stolen properties worth more millions of naira. Some of the recovered properties include plasma TV set, 7 set of vehicles - 2 Haojue, 1 Kasea, and 4 commercial boxer bikes. So, we have many of these recorded successes, and we are still working to ensure that the state and its environs are at peace and stability*" (Interview, 2024).

In a different account, a resident of Lawushi in Billiri Local Government Area doubt on the effectiveness of the performance of vigilante groups in the area. These are his words:

> "*The performance of the vigilante operations in this area is not very effective. Sometimes, they act like sympathizers of the criminals, they do not cooperate with us, they keep given excuses, sometimes even try to blame the community for its*

security problems. We still suffer cases of night raids by the thugs, phone snatching, day light crimes and other security issues which could have been addressed by the vigilantes. What I think is, one, many of the vigilantes here are ex-criminals who still have sympathy for the criminals in the areas, and secondly, they are not adequate enough to address the issues on ground. Therefore, the performance rate in their activities here is grossly ineffective" (Interview, 2024).

The response from the interview above may not be surprising as it is very common that the operation of vigilante groups in Gombe State is still not fully developed. While some areas might be enjoying full scale activities of the group, some may not be due to the challenges of manpower, and funds as was boldly said by the leader of the Group in Gombe State.

Responses	**Frequency**	**Percent**
Lack of adequate funding	92	24.80
Lack of equipment and training	81	21.83
External interference	85	22.91
Community Acceptance Problem	23	6.20
All of the above	90	24.26
Total	**371**	**100**

Figure 4: Challenges faced by Vigilante Groups in the Prevention of Criminality in Gombe State. Source: (Field Survey, 2024).

Figure 4 indicates that 92 respondents that constitute 24.80% of the total responses see lack of adequate funding as the major problem confronting vigilante groups in their attempt to help drastically prevent the incidence of criminal activities in Gombe State, 81 respondents representing 21.83% of the respondents considered lack of equipment and proper training as the major problems undermining the activities of vigilante groups in Gombe State, 85 respondents representing 22.91% attributed the challenges faced by vigilante groups in Gombe to the interference by police and other security agencies in the activities of the group. However, 23 respondents representing 6.20% of the total responses see the challenges associated to community acceptance issue as the major setback that put cock to the wheel of progress as far as the operations of vigilante groups in Gombe State is concerned. Finally, the remaining 90 respondents representing 24.26% of the responses believe that all the first four challenges simultaneously formed

the core of the challenges disturbing the success of the operations of vigilante groups in Gombe State.

These responses indicate that vigilante groups face various challenges which affect their performance essentially in the prevention of criminalities in Gombe State. This is evident from the findings, as it could be seen that significant number of respondents agreed with all the options, while a significant number of the respondents equally believed that the vigilante groups in Gombe State face all the aforementioned challenges.

In an interview with Commander of vigilante groups in Gombe State, he revealed that;

> "*We in Gombe State as vigilante groups, we face serious challenges some of which include financial problem. Our men who workday and night to ensure the security of people in many cases run out of funds to buy security equipment like bullets for the security guns we use. So, for them to get so, they have to be going round the houses soliciting for ₦200, ₦500 or ₦1000 at most. So, it is very painful, sometimes we completely run out of funds, and we have to seize our operations for a while. Apart from this, we still face the problem of community acceptance. Some members of the community still see our men as ex-criminals or sympathizers of criminals, many look at us with serious suspicion, which demoralizes our men. In addition to this, we face cases of interference from various quarters. The problems are too many, I cannot disclose everything here, but the fact remains the same that we have a lot of problems*" (Interview, 2024).

In a similar interview with a member of vigilante in Bolari east local government area, he stated the following:

> "*You see, we work as vigilante without having a salary or any other emolument to support us. To be frank therefore, we work just for patriotic purposes, not because we get any reward from either the society or the state. To even maintain our guns active, we have to go round and solicit support from the community, and what we get is nothing to write home about, we just manage it like that, and so we need interventions just like a grant of at least not less than ten million naira #10,000,000 for our salaries and other expenses*" (Interview, 2024).

A community member in Burundi quarters of Akko local government area confirmed that he met severally with members of vigilante groups in front of his house soliciting for financial support to purchase equipment in order to replenish their guns with bullets and all that is required. So, it is undeniable that vigilante groups in Gombe State are faced with serious financial problem.

The above findings clearly revealed that vigilante groups in Gombe State are faced with serious challenges often leading to a setback in their operations and other crime prevention activities.

Conclusion

The need for sustainable peace and security has been the motives where forced countries around the world to come up with certain security arrangements in addition to the official state security agencies. These security arrangements are mostly built from the grassroots in order to have a firsthand chance of gathering intelligent information and perform other important tasks to complement the efforts of police in ensuring peace and security in the society. Vigilante group is one of such security arrangements existing in Europe, America, Asia and Africa. Thus, members of vigilante groups live within the community and have occupied a better position to fish out criminal operations within the community relatively quicker than other law enforcement agencies. In recent years, there is a significant collaboration between the vigilante groups and the police in the pursuit of sustainable security and peace in the state. In many instances, they patrol together, share intelligent information, and work at all levels to ensure peace and security in the state. This collaboration led to the recruitment of many youths to join the vigilante group named "Operation Hattara" under the recent government administration of Inuwa Yahaya. Therefore, vigilante in Gombe is very crucial as far as the security of the state is concerned, and all hands should be on deck to ensure that financial problem, community acceptance and external interference slowing the success of crime prevention activities of the group in the state are tackled head-on.

Based on the above findings, this research outlines the following recommendations:

1. There is need for the state government to work toward addressing the root causes of crimes within the state. For instance, most of the youths engaging in thug activities, in-town armed robbery, phone snatching are unemployed or poor youths who were not properly taken care of by their families and the state. Therefore, the state should first address the issue of poverty, unemployment and illiteracy among youths as the root causes of criminality in Gombe State.
2. The research also recommends the use of modern methods such as modern technology, social sensitization and campaign against crimes in collaboration with religious and community leaders to prevent crimes without much adoption of kinetic and militaristic measures.
3. In addition, the vigilante groups should endeavour to be properly organized to enable getting assisted and monitored by the police and the government in general. For instance, recruitment should be transparent based on proper referrals, medical checks, behaviour and criminal record checks as this will strengthen their relationship with the police.

4. More so, the research recommends that members of the vigilante groups should be routinely trained in various aspects of crime prevention and upholding of human rights. Adequate equipment and logistics should be made available to the vigilante groups; this is done in order to enhance their duties effectively.
5. Finally, the research recommends the need for the local, state, and federal government, to wholeheartedly support vigilante groups both financially and morally to overcome their challenges. Specifically, their financial problem which affects the successes of their crime prevention activities.
6. Awareness should also be created on information given to the public concerning the duties of the vigilante groups. Hence, communities should be ready to contribute significantly to the funding of vigilante groups. This will enable members of the community have a cordial relationship with the vigilante groups.
7. Finally, the police and the government on the other hand, should endeavour to carry out strict supervision on the operations of vigilante groups in order to check any abuse of power.

Conflict of Interest

The author declares that no conflict of interest exists for this manuscript.

Notes on Contributors

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Contextualizing Military Information Support Operations (MISO) in Nigeria's Counterinsurgency Operation: Toward Enhancing Operational Effectiveness[1]

Obinna Ukaeje[2]

Abstract:

Military Information Support Operations (MISO) plays a crucial role in counterinsurgency by influencing perceptions, behaviours, and decision-making, which helps to enhance operational effectiveness. However, in Nigeria's counterinsurgency operations, MISO is hardly visible, as it is poorly employed, resulting in severe alienation of the local population, loss of institutional credibility and a rise in misinformation, which are at the core of strengthening insurgent movements and weakening operational effectiveness. Using a qualitative research method, dwelling largely on documented evidence and a thematic review of extant literature, the paper examines MISO within Nigeria's ongoing COIN efforts against insurgency in the northern region. It found that despite its recognition in Nigeria's National Counter Terrorism Strategy (NACTEST), its application in COIN operations has been poor, limited and secondary, detaching it from the overall counterinsurgency strategy, with severe implications on operational effectiveness. The study, therefore, advances full integration of MISO as a major part of the CTCOIN strategy with clear objectives that align with mission objectives to enhance operational effectiveness. The theoretical frame of analysis adopted by this study is the soft power theory developed by Joseph Nye.

Keywords:
Military Information Support Operations; Psychological Operations; Counterinsurgency; Operational Effectiveness; Counterterrorism.

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Introduction

Since the September 11, 2001, terrorist attack in the United States of America (USA) by the Al Qaeda Network, the global security environment has witnessed a significant increase in unconventional/asymmetric warfare by irregular forces like terrorists and Islamic fundamentalist insurgency groups across the globe. These forces exploit vulnerabilities in the social system, such as religious sentiments, youth unemployment, illiteracy, poverty, poor governance, and a weak security system, to integrate themselves into the populace and even recruit members of the communities into their fold to gain support and credibility among the people (Richards, 2025). This strategy creates a safe haven for their criminal empires within the communities, making it difficult for the government to identify and dislodge. This is becoming increasingly common across the African continent, particularly in Sub-Saharan African countries, including the Sahel region and the Lake Chad Basin, where economic and human development indices are at the lowest level (UNDP HDI Report, 2023). This, however, reinforces the criticality of Military Information Support Operations (MISO), known as Psychological Operations (Psyops), in hybrid military operations, such as counterterrorism and counterinsurgency (CT-COIN).

Modern military campaigns in irregular warfare, such as counterinsurgency and counterterrorism operations, have shown that effective integration of MISO into operational strategies is critical to achieving mission objectives (Gurney, 2016). For it to be effective, particularly in longer conflicts with high-level strategic implications, it must include in-depth communication strategies, including long-term messaging plans to multiple target audiences (Gurney, 2016:1). For instance, the United States' efforts in Vietnam and the Soviet attempts in Afghanistan revealed that, despite military technological superiority, there is no substitute for strategic communication and for influencing the local population in counterinsurgency operations. This exposes the limitations of military offensives and the strategic importance of MISO towards successful counterinsurgency operations. Additionally, modern information and communication technology has provided opportunities and access for effective MISO in modern Irregular Warfare (IW) operations. However, not much attention has been paid to this in modern military campaigns against irregular forces in sub-Saharan Africa and Nigeria in particular, where the activities of irregular forces have dominated security challenges for more than two decades. This study adds to existing literature and thinking by foregrounding MISO as a critical component of COIN strategy required for effective COIN operations in Nigeria. The paper posits that MISO, as a critical element of Nigeria's COIN strategy, should be fully integrated with other operational strategies, from the tactical to the strategic level, to fight irregular forces successfully. The remainder of the paper is broadly structured under a number of select themes, namely: conceptual clarifications; the role of MISO in modern irregular warfare; theoretical framework; challenges and limitations of MISO in modern irregular warfare campaigns; conclusion and recommendations.

Methodology

The paper adopts a qualitative and non-empirical approach rooted in interpretive analysis. Data sources include policy documents, research publications (journal articles and textbooks), newspaper reports, verifiable social media reports, and government counterterrorism/counterinsurgency reports from 2016 to 2025. These were analysed using a content analysis technique, which helped to identify recurring themes related to the application of MISO in countering irregular forces in Nigeria. This approach enabled a critical engagement with diverse perspectives and supports the development of a nuanced conceptual framework.

Conceptual Clarification and Theoretical Exploration

Military Information Support Operations

According to the United States Joint Publication 3-13 (2014), "Military Information Support Operations (MISO) is the integrated employment, during military operations, of information-related capabilities to influence or inform audiences to achieve mission objectives". Its core capabilities cut across military deception, psychological operations, public affairs, and, more recently, cyber operations (Troublefield, 2025). It is a critical component of the United States military for countering threats of terrorism and insurgency by undermining legitimacy of adversaries and building support for military actions through strategic communication. The primary goal of MISO is to employ information devices to alter the perceptions and behaviour of foreign authorities and individuals, who play a central role in reducing aggression levels and promoting peaceful solutions to conflicts (JP 2010; JP 3-3 2014). The Joint Publication Manual 3-13 (2014) identifies MISO not as a stand-alone strategy, but one that works with other strategies, like military offensives, to achieve strategic goals, and it is most impactful at the tactical level of operation. In Nigeria, MISO is embedded in the non-kinetic strategies of the CT-COIN operations, defined as "psychological Operations (Psyops)" to complement active combat operations against adversaries. In this study, it is used interchangeably with Psyops.

Counterinsurgency

Counterinsurgency strategy, often referred to by the acronym "COIN", is a broad, long-term, population-centric approach that addresses root causes, governance, and security to win local support. According to Valeriano (1962), the imperative of an insurgency movement is to gain active support or at least passive toleration from a majority of the people; therefore, counterinsurgency must look beyond pure military theory to focus heavily on population dynamics, rigorous field intelligence, and the interaction between the government and the people. Valeriano's expert opinion emphasises winning the support of the local population as the core of counterinsurgency. This view is upheld by Galula (2006), who argues that the primary objective of counterinsurgency is to win the hearts and minds of the population and gain their support rather than control of territory. He further notes that military science is one of the key operational approaches to addressing irregular warfare, such as insurgency, terrorism and guerrilla warfare, and its success is heavily influenced by factors beyond military might (Galula, 1964). Some

of these factors are highlighted in the operational definition of counterinsurgency strategy provided by the United States Government Counterinsurgency Guide (2009), which defines counterinsurgency as the "use of military, political, economic, psychological, and social measures to defeat an insurgency by gaining the support of the local population, addressing the root causes of the conflict, and neutralizing insurgent forces". The US Counterinsurgency Guide also identifies key components such as military operations to secure the population, civic actions to build legitimacy, and psychological operations to undermine support for insurgency. Although this definition has served and continues to serve counterinsurgency efforts globally, nations are at liberty to review their strategies to achieve the same goal: to create a stable environment and to ensure that legitimate authorities maintain control of the state (US JP 3-26, 2014). In Nigeria, the COIN Strategy is embedded in the National Counter Terrorism Strategy (NACTEST), which serves as the blueprint for Nigeria's CT-COIN operations.

Operational Effectiveness

Operational effectiveness refers to the attainment of the desired results from activities initiated to reach predetermined goals. It includes actions and procedures taken to maximise available resources to achieve set goals or objectives prudently and effectively. According to Brathwaite (2018), it is a unit's ability to achieve strategic, operational, or tactical objectives, often defined by the intersection of military skill, morale, and the efficient application of force (Brathwaite, 2018). He further states that it bridges the gap between tactical combat actions and the achievement of broader political goals. The United States Department of Defence (DOD) (2020) defines it as a "measure of the overall ability of a system to accomplish a mission when used by representative personnel in the environment planned or expected for operational employment of the system, considering organization, doctrine, tactics, supportability, survivability, vulnerability, and threats". This implies that operational effectiveness tends to explain the overall capability to accomplish a mission's set goals and objectives. In this regard, full integration of MISO in Nigeria's COIN will enhance the operational effectiveness of the forces.

Theoretical Framework

The analysis of this study is anchored on the soft power theory developed by Joseph Nye in his 1990 book, titled "Bound to Lead: The Changing Nature of American Power". The theory emphasises that a country's power lies not only in coercion (hard power) but in its ability to influence others through persuasion and attraction (soft power). This influence is built on the appeal of the country's culture, political values, and foreign policies, which can lead other nations to desire what it wants and voluntarily adopt its goals (Nye, 2004). He argued that "attraction" is a powerful and often more effective tool than military or economic force (Hard power) (Nye, 2006). Okoli and Ugwu (2019) noted that by leveraging the principles of soft power, such as cultural appeal and cooperative foreign policies, the Nigerian military can enhance its influence and legitimacy among locals affected by insurgency. They further noted that the Nigerian military can enhance its operational effectiveness by building goodwill, trust, and

cooperation with those affected by insurgency through psychological operations that emphasise community engagement and support. Supporting this view, Agbiboa (2021) noted that winning the support of the people can be achieved by promoting Nigerian cultural values and democratic principles in military operations, indicating that the military can change the attitudes of target audiences, bolster its soft power and undermine the appeal of insurgent groups. This aligns with Joseph Nye's concept of soft power, which emphasises the persuasive use of non-coercive strategies in achieving security objectives.

The Role of MISO in Counterinsurgency

In modern irregular warfare, such as counterinsurgency operations, a military offensive alone is inadequate to achieve a force's mission objectives, leading to the integration of non-military approaches. At the core of the non-military approaches is Military Information Support Operations. MISO is a key component of broader military strategic communication that integrates tailored messaging into broader operations to achieve deterrence, crisis response, and security operations (Joint Chiefs of Staff, 2013). Its role in COIN cannot be overemphasised because of its ability to render insurgents ineffective and non-influential by securing relations and support of the local population in an operational environment. The key roles of MISO in COIN are discussed as follows:

Understanding the Culture of the People

The first step towards an effective counterinsurgency operation is understanding the local population's culture within the operational environment, so that the force can understand the culture of the people where the insurgents operate. This would enable them to establish relations and secure the trust of the people. The adoption of MISO as a core component of COIN would ensure that a comprehensive cultural picture of the local population is developed and understood. This is achieved through the use of experts from the media, finance and business, psychologists, organisational network analysts, and scholars from a wide range of disciplines to understand why the local population is drawn into the insurgents' ideology, and to know the aspects that are appealing to them and how the insurgents drew their support (Gwakchang, 2009). The emphasis is to create a functional baseline to understand the values, attitudes, and perceptions of the people, design information and communication strategies to establish a relationship and to degrade the will and capability of the insurgents.

Building Trust and Changing the Narratives

Changing the narratives in counterinsurgency involves utilising information and media instruments, including mainstream and social media, to shape the perceptions, beliefs, and behaviour of relevant audiences, including adversaries, local populations, and international stakeholders (Kvernbekk & Boe-Hansen, 2017). It helps align the cognitive domain of people within the operational environment with the mission's operational goals and build trust with local communities. Some of the identifiable methods include using social media handles (such as tweeter or X, Facebooks, Tik-Tok, Instagram, etc.) to quickly frame the context of a battle, presenting own forces as legitimate and moral

actors while painting the insurgents a evil traitors with the aim of destroying the livelihood of the people; integrating the narrative into strategy to provide purpose to military actions that links tactical actions with long-term political objectives (Blas, 2023); employing counter-narrative by actively countering the insurgents disinformation and misinformation through representative actions, media reportage, and diplomacy to dismantle their legitimacy; and leveraging cultural and psychological insights to create messages that promote trust in friendly forces, highlighting the benefits of cooperation or demonstrating the negative consequences of supporting the insurgents, and encouraging the local population to support military counterinsurgency efforts (Kvernbekk & Boe-Hansen, 2017). For instance, the integration of Strategic Communication in MNJTF COIN operations, using local radio stations like Radio Dandal Kura, Radiou Bouclier, and Radio Ndarason International, facilitated dialogue and cooperation with affected communities, countered misinformation and established trust that led to the weakening of the insurgents' local base and the subsequent degradation of the group between 2022 and 2023 (Saleh & Ukaeje, 2024). Additionally, strategic communication encouraged insurgents to surrender and embrace reintegration programmes across the Lake Chad countries. Over 100,000 members of Boko Haram, including combatants, surrendered to the MNJTF (Aniekwe & Brooks, 2023). This indicates the effective role of MISO in changing the narrative and shaping people's perceptions in COIN operations.

Degrading Adversary Morale

One of the major roles of MISO is targeting an adversary's leadership, command and control to create internal dissent and sow distrust using strategic communication channels (such as online messages, storytelling, media reportage, among others) to exploit existing tensions to weaken the group's cohesion and make adversaries question the legitimacy and decisions of their leaders. For instance, the MNJTF, after the split in Boko Haram in 2016, after ISIS appointed Abu Musab al-Barnawi as leader of ISWAP, side-lining Abubakar Shekau, which resulted in a serious conflict for fighters, territory, and legitimacy between the factions. The MNJTF leveraged its strategic communication channels to put pressure on both, using the split as a force multiplier to boost counterinsurgency operations (UNDP Conflict Assessment, 2022). The strategy was to keep pressure on both, to continue fighting each other while the force exploited the exhaustion and defections. Fortunately, it yielded the expected result by resulting in the death of Abubakar Shekau and Abu Musa al-Barnawi in May 2021 and September 2021, respectively (Ukaeje, 2026). The death of Shekau led to disarray in the Boko Haram camp and the subsequent surrender of its members to MNJTF and Nigeria's Operation HADI KAI (OPHK). It is important to note that the mass surrender of members of Boko Haram after the death of Shekau was facilitated through MNJTF's strategic communication. MISO played a vital role in creating disunity among the insurgents, which led to the degradation of their capacities and the subsequent recapture of the seized territories.

Building International Partnership and Cooperation

Counterinsurgency operations require support from international partners within and outside the region to build legitimacy of the operation, enhance its effectiveness and gather the support of the international community. It also requires the support of foreign partners in areas such as military assistance, including military training, military hardware support, arms and ammunition supply, and other supporting areas like tracking the financing of terrorism through global and regional financial institutions. Incidentally, one of the major strategies to achieve this support is through MISO. It plays a critical role in building foreign partnerships and enhancing security cooperation by influencing partner forces' perceptions, attitudes, and behaviours, enhancing their effectiveness in support of the operation; shaping narratives that promote shared interests and goals; fostering cooperation and collaboration between partner forces; building trust between partner forces; and facilitating cooperation and information sharing. Sadly, this has been missing in counterinsurgency operations in Nigeria. For instance, the major challenges of the MNJTF operations in the Lake Chad were identified by many studies to include lack of intelligence sharing, interoperability challenges (among the different country forces), inconsistency of funding, and support from the international partners (Saleh & Ukaeje, 2024). This shows that much has not been done by the MNJTF and Nigeria's OPHK in encouraging honest commitment and support from other member states, including the international partners in their support for the operation. The MJNTF/OPHK, therefore, needs to review their strategies, ensuring the full integration of MISO to enhance COIN operations.

Challenges of MISO in Counterinsurgency

Unlike conventional warfare, unconventional warfare such as counterinsurgency is not only won through military offensives but through a combination of military offensives (kinetic) and non-military approaches (non-kinetic). Underpinning both strategies is MISO, which is aimed at countering disinformation and misinformation by insurgents and winning the hearts and minds of the population. However, MISO faces some major challenges towards achieving its goal. These are as follows:

Public Trust Issues

At the core of MISO challenges in counterinsurgency operations lies trust among the affected population. Public trust issues cripple MISO by enabling propaganda, misinformation, lowering intelligence cooperation, and undermining the mission's credibility, as seen in Nigeria's counterinsurgency efforts (Tiwa, 2024). As noted by the Former spokesman of the Nigerian Army, Brigadier General Sani Usman (rtd), "one of the most difficult phases of Nigeria's counterinsurgency operations was not only the physical combat in the North-East but the fierce propaganda war waged by Boko Haram to undermine public trust in government institutions." He further noted that the military had to rethink its entire communication strategy to stop the insurgents from shaping public perception at the height of the conflict, noting that the military is in the middle of an information war that is testing credibility, speed, and strategic communication under pressure (Punch, 2025). For instance, despite the government's appeal for

communities not to negotiate with bandits, several communities in Sokoto, Zamfara, and Benue states negotiate and even pay levies to bandits to allow them to harvest their farm produce (The Punch Editorial, 2024; The Guardian Nigeria, 2025; Vanguard, 2025). This indicates that the people in the affected communities have lost trust in the government to protect them, establishing the criticality of MISO in Nigeria's COIN operations.

Poor Knowledge of the Environment

For effective integration of MISO in COIN strategy, the force must have a good knowledge of the culture of the people, the modus operandi of the insurgents, and their relationship with the local population. Poor understanding of the environment makes it difficult to design and deliver an appropriate message that drives strategic communication for MISO. In conflict environments like Northeast and Northwest Nigeria, the activities of the insurgents and bandits are intertwined with the socio-political, socioeconomic, and sociocultural life of the people. Therefore, without adequate knowledge of the environment and culture of the people, it becomes difficult for the forces to come up with appropriate designs to drive MISO. As noted by Mafela (2012), "a lack of knowledge of the culture of other societies could result in great miscommunication between language groups". It can even trigger disenchantment by the local population against the force, push the locals to embrace the insurgents, and undermine the whole process of MISO. The COIN operations against insurgents and their allied terrorist groups in the northeast have frequently been undermined by cultural, religious, and linguistic gaps (Dan-Azumi, 2025; Ukaeje, 2026). These gaps have also been identified as factors contributing to the complexity and protractedness of the conflict, underscoring the critical role of Military Information Support Operations in COIN.

Information Overload

The modern information environment is highly complex and dynamic, with unmonitored and uncensored information coming through various social media networks, such as Facebook, YouTube, Telegram, TikTok, and many others, resulting in an overwhelming volume of data. Unfortunately, this overwhelming volume of data is combined with high levels of uncertainty and diverse formats, which severely hampers both the effectiveness and efficiency of security forces, making it difficult to distinguish between reliable content and inaccuracies. Incidentally, the insurgents and other irregular elements are exploiting this gap to disseminate disinformation and misinformation, making it difficult for the security forces and even the populace to distinguish between reliable information and insurgents' propaganda and misinformation. A striking example of information overload is the ambush of a military convoy of the 25 Task Force Brigade on a rescue mission in Borno on 14 November 2025 that resulted in the abduction and killing of the Brigade Commander, Brigadier General M. Uba and three of his men by ISWAP (Sahara Reporters, 2025). While the attack was ongoing, information came through social media that Brigadier General Uba escaped the attack and was safe. At the same time, conflicting information came up,

revealing that the General was captured by the insurgents, making it difficult for even the Defence Headquarters to decipher reliable information from both, leading to the abduction and subsequent open execution of the General by his abductors. This shows the destructive impact of information overload that the use of MISO must consider in counterinsurgency operations.

Inter-agency Rivalry and Lack of Collaboration

Counterinsurgency operations involve a combination of different services and other security agencies working together to achieve the mission's goals. Therefore, to achieve the mission's goals, effective and efficient coordination of the various forces must not be compromised as it creates operational lapses, which in most instances lead to inter-agency rivalry and lack of collaboration among security forces. Unhealthy rivalries and a lack of collaboration among security forces in an operational environment like counterinsurgency create a lack of trust and a reluctance to share critical information, which is the foundation of effective MISO and other COIN efforts. In most instances, it leads to contradictory messages, duplication of efforts, waste of resources, working at cross-purposes, and conflicting intelligence, which often undermines MISO and the overall efforts of the mission. In August 2019, for instance, one of the most high-profile clashes occurred when soldiers of the 93 Battalion opened fire on a police Intelligence Response Team (IRT) conveying a high-profile kidnap suspect, Hamisu Bala (known as Wadume). The soldiers killed three police officers and a civilian, subsequently releasing the suspect. While the army claimed they acted "in error" because the police vehicle did not stop at a checkpoint, the police maintained they had properly identified themselves, leading to a major public dispute between the two agencies (Business Day Editorial, 2022). Also, in late 2025, security agencies provided contradictory accounts following a bandit ambush in Zamfara State. Initial reports from one security source declared a driver had been killed, while subsequent updates from other tactical units listed him as only injured. Such discrepancies in casualty figures and operational outcomes are common in the Northwest, often adding "chaos to tragedy" and complicating the public's understanding of the security situation (Ogalah, 2025).

Ethical and Legal Constraints

In formulating and executing warfare strategies, feasible options may raise difficult legal and ethical questions. Formulating and executing psychological operations or MISO within a counterinsurgency requires a careful balance between achieving security objectives and adhering to legal and ethical standards, as these operations directly influence the attitudes and behaviours of both insurgent forces and local populations. According to the Geneva Convention on armed conflict and the International Humanitarian Law (IHL), a State is responsible for internationally wrongful acts, including violations of IHL, that are committed by its organs; by persons or entities it empowered to exercise elements of governmental authority; by persons or groups acting in fact on its instructions, or under its direction or control; or by private persons or groups that it acknowledges and adopts as its own conduct (Year Book of the International Law Commission, 2001). This means that when misinformation,

disinformation, or hate speech is spread in the context of an armed conflict, the authors, irrespective of their status (private individual, members of State armed forces or any other party to the armed conflict) have been considered directly bound by the rules of the convention and IHL. In counterinsurgency operations, formulating and executing MISO plans and policies must take into consideration the rules of IHL and the Geneva Convention on Armed Conflict to avoid issues that contravene the rights of unarmed citizens/civilian population. Incidentally, in COIN operations, these legal considerations often hamper effective execution of MISO. Another area of concern is the ethical consideration, which implies that the forces must balance the need for strategic communication with the risk of being seen as manipulative, which could erode legitimacy and trust, and become counterproductive. Such a consideration makes it difficult for MISO to achieve its goal. For instance, part of MISO strategies restrictive communication and surveillance of communications to monitor the communication network of insurgents, but most often when it is applied it creates confusion, particularly among the local population, such as the case of Zamfara in 2021, when the telecommunication system was shutdown to restrict and monitor communication networks of bandits in the State, it created fear among the residents as they could not reach their relation within and outside the State, fuelling misinformation and panic, and eroding pubic trust in the government and security forces (Ilesanmi, 2021; Cleen Foundation, 2024).

Inadequate Human Capacity

In Nigeria's counterinsurgency efforts, the human resource gap has been part of broader challenges, and its impacts manifest in several areas, including Military Information Support Operations. While the Nigerian military has increased focus on non-kinetic operations and trained about 604 special forces in areas including psychological operations in early 2026, the adequacy of MISO experts remains a serious concern (NTA, 2026). Considering the number of human resources needed to support the numerous military operations across the country, estimated at 12,000 personnel biannually by the Minister of Defence in 2023 to enhance the capabilities of the military to meet the security challenges of the country (Premium Times, 2023), 604 special forces are insignificant to the requirement. The Minister of Defence had warned in 2023 that Nigeria's armed forces are broadly overstretched due to numerous security challenges confronting the country, which has affected specialized personnel, including MISO experts, who are constantly spread in other areas (Premium Times, 2023). For instance, the Nigerian Army Division, headquartered in Maiduguri, serves as a permanent building block for counterinsurgency. Therefore, every combat unit in the division deserves a corresponding MISO or Strategic Communication cell to manage community relations and counter-propaganda, but this is not the situation, making it difficult for MISO to achieve its expected outcomes.

Measures for Enhancing MISO for Operational Effectiveness in Nigeria's Counterinsurgency

Review of NACTEST 2016

Given the criticality of MISO in counterinsurgency operations, its effectiveness in Nigeria's counterinsurgency has been debated by experts and academics alike due to its partial integration as part of Nigeria's counterinsurgency strategy. To ensure effective implementation of MISO as a major component of Nigeria's COIN strategy, there is a critical need to review Nigeria's National Counter Terrorism Strategy (NACTEST) to fully integrate and institutionalize MISO as a major pillar of the strategy. The objective is to reinvigorate the department in all military services and boost the commitment of the services and personnel towards achieving their objectives in operations, as well as improve COIN efforts at winning the minds and hearts of the population, which is central to defeating the insurgents. This will involve the National Counter Terrorism Centre (NCTC) under the Office of the National Security Advisor (ONSA) in collaboration with the Ministry of Defence (MOD) and the Defence Headquarters (DHQ) to achieve the support required to ensure effective implementation when the integration is achieved. The plan would include the review of MISO delivery methods with emphasis on understanding the local conflict environment, such as the socio-political, socioeconomic, and sociocultural dynamics, to avoid issues that could be considered coercive or intrusive to the local population, and to gain the trust of the local population, which is the main thrust of MISO.

Strengthening Human Resource and Capacity Development

Adequate human resource and capacity development is critical to developing a robust MISO. Therefore, increasing the number of human resources in MISO and investing in their capacity development, with emphasis on cutting-edge technologies in cybersecurity and information technology, would address the challenges of the human capacity gap in Nigeria counterinsurgency operations. The objective of this strategy is to develop a robust pool of experts in MISO to ensure efficient and effective execution of MISO in COIN operations in Nigeria. Consequently, this will require a deliberate plan that will involve collaboration among all services (Nigerian Army, Nigerian Navy and Nigerian Air Force) and the DHQ. The plan would include the involvement and collaboration of mainstream and social media experts, the Nigerian Communication Commission (NCC), National Information Technology Development Authority (NITDA), and Federal Ministry of Information (FMoI) to drive a formidable information and communication strategy that would stiffen the disinformation and misinformation machinery of the insurgents across the country, while projecting the benefits of cooperation with military forces in operation. This strategy would boost operational effectiveness in Nigeria's counterinsurgency operations.

Strengthening Coordination among the Services and Security Agencies

Strengthening coordination among the services and other security agencies would improve collaboration among the services and other security agencies and enhance MISO in military counterinsurgency operations in Nigeria. This measure would enhance

information sharing, improve joint operations, eliminate rivalry, reduce duplication of efforts, waste of resources, working at cross-purposes, and conflicting intelligence, which undermine MISO. Institutions such as ONSA and NCTC have already provided platforms for collaboration, but implementation remains uneven. Enhanced coordination is vital in addressing interagency rivalry, as is often witnessed among the services and other security agencies in theatres of operations in Nigeria where terrorist groups operate across multiple jurisdictions. NCTC has emphasised that effective Military Information Support Operations and overall security require deep, formalized interagency collaboration (Raphael, 2025). This is one of the reasons the NCTC has in recent times, facilitated the review of Nigeria's counterterrorism and counterinsurgency Strategy.

Recommendations

The study recommended that the Federal Government of Nigeria should:

1. Encourage NCTC to facilitate the review of NACTEST 2016 to ensure the integration of MISO as a major pillar of Nigeria's CT-COIN strategy.

2. Strengthen the capacity of the armed forces by combining budgetary support, human resources and training of personnel in MISO.

3. Ensure that the NCTC establish a robust inter-agency coordination mechanism by institutionalizing a permanent Inter-agency CT-COIN Task Force comprising representatives from all the major Stakeholders from the services, the Nigerian Police, DSS, NIIA, NIS, NCS and other relevant bodies. This task force should operate within a mandated quarterly meeting, a secure shared intelligence platform, and clear protocols to eliminate rivalries and improve information sharing.

Conclusion

The study has critically explored the cruciality of Military Information Support Operations in counterinsurgency, which is increasingly driven by information technology by equalizing power dynamics, extending the battlefield into the digital and cognitive realms. The study revealed that cognitive warfare through social media manipulation, deepfakes, and automated disinformation campaigns has given irregular forces, including insurgents and terrorists, the power to shape narratives, erode trust in institutions, and influence public opinion, helping to sustain their activities. This is exemplified in the manipulation of social media through misinformation and disinformation by insurgents in Nigeria. The study therefore noted that this development reinforces the cruciality of MISO to be institutionalized as a major component of a broader strategy in counterinsurgency, stressing that MISO provides the needed cognitive tool, especially in counterinsurgency operations, to counter the extremist narrative, disrupt terrorist operations, influence perceptions, attitudes and behaviour of target audiences and mobilize support for counterinsurgency and counterterrorism efforts, as well as promote cooperation and collaboration with the

local population. It, however, acknowledged that MISO can be impeded by a number of challenges, including public trust issues, poor knowledge of the environment, interagency rivalry, ethical and legal constraints, information overload, and inadequate human resources and capacity. These challenges need to be addressed to enhance MISO for overall operational effectiveness in Nigeria's counterinsurgency operations. It is on this note that the study identified review of NACTEST 2016, strengthening human resources and capacity development, and strengthening coordination among the services and other security agencies as measures to address these challenges.

Conflict of Interest

The author hereby declare that no competing financial interest exists for this manuscript.

Notes on Contributor

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Book Review: Sustainable Food Systems in Sub-Saharan Africa: Plant Derived Nutritious Foods[1][2]

Szilvia Juhászné Veress[3]

Bibliographic and Publication Background of the Volume

The edited volume *Sustainable Food Systems in Sub-Saharan Africa: Plant Derived Nutritious Foods – Volume 1* was published by Springer Nature Switzerland in 2026 as an open-access scientific publication. The book was edited by Bal Ram Singh, Liveness Jessica Banda, Andy Safalaoh, Agnes Mwangwela, Ruth Haug, Lars Olav Eik, Jennifer Joy West and Rattan Lal, representing leading institutions in Norway, Malawi, and the United States. The publication forms part of a broader initiative aimed at advancing sustainable food systems and improving food and nutrition security in Sub-Saharan Africa. The volume contains 574 pages and 28 chapters organized into five major thematic sections, bringing together the work of more than 110 scientists from Africa, Europe, Asia, and North America. The book is freely accessible under a Creative Commons Attribution 4.0 International License, reflecting its intention to contribute to both scientific advancement and practical development efforts.

Introduction

Food security, agricultural sustainability, and climate resilience have become central concerns in contemporary international development discourse. These challenges are particularly pronounced in Sub-Saharan Africa, where rapid population growth, environmental degradation, climate variability, and persistent poverty continue to threaten agricultural production and nutritional wellbeing. The edited volume *Sustainable Food Systems in Sub-Saharan Africa: Plant Derived Nutritious Foods* addresses these interconnected challenges through a multidisciplinary examination of food systems, agricultural innovation, soil management, nutrition, and policy interventions.

The volume emerges from the FoodMa Programme, a collaborative initiative between the Norwegian University of Life Sciences and the Lilongwe University of Agriculture and Natural Resources. As outlined in the preface, the programme sought to identify and disseminate technologies and practices capable of enhancing the

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[2] Bal Ram Singh, Liveness Jessica Banda, Andy Safalaoh, Agnes Mwangwela, Ruth Haug, Lars Olav Eik, Jennifer Joy West, Rattan Lal (Eds.). *Sustainable Food Systems in Sub-Saharan Africa: Plant Derived Nutritious Foods.* Cham: Springer, 2026. ISBN: 978-3-032-11287-3. pp. 572. Open access.
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productivity, resilience, and nutritional quality of smallholder farming systems in Sub-Saharan Africa. Rather than focusing solely on agricultural yields, the book adopts a broader food-systems perspective that incorporates nutritional security, environmental sustainability, social inclusion, and climate adaptation.

The Editors

The scientific quality of the volume is strongly supported by the expertise of its editors. Bal Ram Singh, Professor Emeritus at the Norwegian University of Life Sciences, is internationally recognized for his work on soil fertility, tropical agriculture, and carbon sequestration. Rattan Lal, Distinguished University Professor at The Ohio State University and recipient of the 2020 World Food Prize, is one of the world's leading authorities on soil health and climate-resilient agriculture. Ruth Haug contributes extensive experience in food systems, food security, agricultural policy, and international development.

The editorial team is further strengthened by the contributions of Agnes Mwangwela, Liveness Jessica Banda, and Andy Safalaoh from the Lilongwe University of Agriculture and Natural Resources, whose research backgrounds encompass food science, animal science, nutrition, and sustainable agricultural development. Collectively, the editors represent a broad range of disciplinary perspectives that are reflected throughout the volume.

Structure of the Volume

The volume is organized into five thematic sections: *Plant Food Systems and Innovative Technologies*; *Nutrient-Dense and Biofortified Food*; *Soils, Climate Change and Carbon Sequestration*; *Policy Formulation and Implementation for Smallholders*; and *Prospects of Green Revolution and Research Perspectives*. This structure allows readers to progress from the biophysical foundations of food production toward broader socioeconomic and policy considerations. The arrangement also reflects the editors' intention to present food systems as interconnected networks involving soils, crops, nutrition, governance, and rural livelihoods.

Plant Food Systems and Innovative Technologies

The first thematic section examines agricultural innovations that can contribute to sustainable food production under increasingly challenging environmental conditions. The chapters emphasize that food systems in Sub-Saharan Africa remain heavily dependent on a limited number of staple crops despite the region's rich agro-biodiversity. The contributors argue that improving food security requires not only increasing production but also strengthening the sustainability and resilience of agricultural systems.

Several chapters focus on soil fertility management, highlighting integrated nutrient management, biological nitrogen fixation, and improved nitrogen use efficiency as

critical factors in enhancing crop productivity. Studies on Bambara groundnut cultivation and lowland rice production demonstrate the potential of biologically based approaches to reduce dependency on external inputs while maintaining yields. The volume also devotes considerable attention to biochar technologies, presenting empirical evidence from Malawi, Ethiopia, and Tanzania. These studies suggest that biochar can improve soil health, increase crop productivity, and contribute to climate resilience through enhanced water retention and nutrient availability.

The section concludes with a comprehensive review of agroecological practices in Malawi. Rather than promoting conventional intensification alone, the authors advocate agroecological approaches that integrate ecological processes, local knowledge, and sustainable land management. This perspective distinguishes the volume from many agricultural development publications that prioritize productivity gains without equally considering ecological sustainability.

Nutrient-Dense and Biofortified Food

The second thematic section addresses one of the most pressing yet often overlooked dimensions of food security: nutritional quality. The contributors emphasize that food insecurity in Sub-Saharan Africa is not merely a question of caloric insufficiency but also of widespread micronutrient deficiencies, particularly deficiencies in iron, zinc, iodine, and vitamin A.

The chapters examine the potential of biofortification and nutrition-sensitive agriculture as strategies for addressing hidden hunger. Particular emphasis is placed on the soil–plant–animal–human nexus, illustrating how soil health directly influences crop nutrient content and, ultimately, human nutrition. The volume highlights the role of biofortified crops and nutrient-rich traditional foods as cost-effective approaches for improving public health outcomes.

Another important contribution of this section is its integration of agroecology and nutrition. Rather than treating agricultural production and human health as separate fields, the authors demonstrate their interdependence. This integrated perspective broadens the understanding of food security and aligns with emerging international debates on sustainable and healthy food systems.

Soils, Climate Change and Carbon Sequestration

The third section forms one of the intellectual cores of the volume. It focuses on the interactions between soil management, climate adaptation, and environmental sustainability. Drawing heavily on contemporary soil science and climate research, the chapters demonstrate that soil health is fundamental not only for agricultural productivity but also for climate change mitigation and adaptation.

The chapter on climate adaptability and soil carbon sequestration highlights the capacity of improved soil management to enhance resilience while simultaneously contributing to greenhouse gas mitigation. Complementing this perspective, the chapter

on agroforestry innovations presents evidence that integrating trees into farming systems can improve soil fertility, biodiversity, and climate resilience.

Several contributions are based on empirical studies conducted in Malawi and Kenya. Research on in-situ rainwater harvesting demonstrates how relatively simple water management techniques can strengthen farmers' adaptive capacity in drought-prone environments. Similarly, the chapter on integrated landscape management presents a landscape-scale approach to sustainable land management that seeks to reconcile agricultural production with environmental conservation.

A particularly valuable feature of this section is its attention to indigenous vegetables and local adaptation strategies. By recognizing local knowledge and underutilized crops, the authors challenge the assumption that agricultural modernization must rely exclusively on external technological solutions.

Policy Formulation and Implementation for Smallholders

The fourth thematic section shifts attention from biophysical systems to institutional and social dimensions of agricultural development. The contributors investigate how policies, extension systems, gender relations, and market structures influence the adoption of sustainable agricultural practices among smallholder farmers.

The chapter entitled *The Legume Pendulum* provides a detailed analysis of the role of legumes in improving both food security and household income in Malawi. Other contributions explore intrahousehold gender relations, demonstrating how access to productive resources remains shaped by gender inequalities. These findings highlight the importance of considering social structures when designing agricultural interventions.

Several chapters evaluate extension services and farmer-centred innovation approaches. The authors argue that sustainable agricultural transformation depends not only on technological innovation but also on effective knowledge dissemination and participatory learning processes. The chapters on communication channels and farmer field schools provide particularly useful insights into how information regarding climate-smart agriculture can be transmitted more effectively to rural communities.

The section also includes analyses of improved maize varieties, land rental markets, and commercial agriculture. Collectively, these studies demonstrate that agricultural sustainability is closely linked to institutional arrangements, access to information, and equitable participation in rural development processes.

Prospects of Green Revolution and Research Perspectives

The final thematic section adopts a more synthetic and forward-looking perspective. The chapter *Road Map to Promoting Green Revolution in Sub-Saharan Africa* revisits the concept of the Green Revolution within contemporary sustainability debates. Unlike earlier models that emphasized intensive input use, the authors propose a soil-centred and environmentally sustainable transformation pathway. Soil health, biodiversity

conservation, climate adaptation, and farmer participation are identified as central pillars of future agricultural development.

The concluding chapter on research gaps and future perspectives provides a particularly valuable contribution. It identifies several areas requiring further investigation, including the long-term impacts of climate adaptation strategies, the nutritional consequences of agricultural interventions, the genetic improvement of indigenous crops, and the development of integrated food-system models. These reflections not only summarize the book's findings but also establish a future research agenda for scholars working in the field of sustainable food systems.

Assessment of the Scholarly Literature

One of the volume's major strengths lies in its extensive and multidisciplinary scholarly foundation. The chapters draw upon research from agronomy, soil science, nutrition, development studies, and environmental governance. Frequent references to FAO reports, CGIAR research programs, IFPRI publications, and IPCC assessments ensure that the analyses are situated within broader international debates.

Particularly noteworthy is the integration of African scholarship. While many publications on African agriculture rely predominantly on perspectives from the Global North, this volume provides substantial space for African researchers and locally generated evidence. This contributes significantly to the relevance and credibility of the analyses.

Comparison with Related Volumes

The volume may be compared with several recent works addressing food security, climate-smart agriculture, and sustainable development in Africa, including *Nutrition, Sustainable Agriculture and Climate Change in Africa* (Odularu, 2020), *Multifunctional Land Uses in Africa* (Simelton & Ostwald, 2019), *Towards Sustainable Food Production in Africa* (Fanadzo et al., 2023), and *Sustainable Agroecological Practices in Sub-Saharan Africa in the Face of Climate Change* (Otieno, 2024).

What distinguishes the present volume is its strong integration of nutrition, soil science, climate adaptation, and policy analysis. Unlike many comparable publications that focus primarily on agricultural productivity or climate-smart agriculture, this book consistently links food production to nutritional outcomes and human wellbeing. Its extensive use of empirical case studies, particularly from Malawi, also provides a level of contextual depth rarely achieved in broader regional overviews.

Critical Evaluation

The volume possesses numerous strengths, including its interdisciplinary scope, strong empirical basis, and policy relevance. The integration of natural and social sciences allows for a holistic understanding of food systems that reflects contemporary theoretical developments in sustainability science.

Nevertheless, certain limitations should be acknowledged. A substantial proportion of the empirical evidence originates from Malawi, which may constrain the generalizability of some findings to the wider Sub-Saharan African region. In addition, topics such as urban food systems, regional food trade, consumer behaviour, and food processing industries receive comparatively limited attention. These omissions do not diminish the value of the volume but suggest potential directions for future research and subsequent volumes.

Conclusion

Sustainable Food Systems in Sub-Saharan Africa: Plant Derived Nutritious Foods represents a substantial contribution to contemporary scholarship on food security, agricultural sustainability, and rural development. By integrating soil science, nutrition, climate adaptation, and policy analysis, the volume offers a comprehensive examination of the challenges and opportunities facing food systems in Sub-Saharan Africa. Its strong empirical foundation, multidisciplinary perspective, and practical relevance make it an important resource for researchers, graduate students, development practitioners, and policymakers seeking to understand and promote sustainable food systems in one of the world's most vulnerable yet dynamic regions.

Book Review: Russia and Ukraine: An Undeclared World War

Buffer Zones, Energy Weapons, and the Return of Great Power Politics[1][2]

Abdallah Abdel-Ati Al-Naggar[3]

In February 2022, when Russian forces entered Ukrainian territory, many observers sought to understand the seemingly sudden outbreak of Europe's largest military conflict since the II. World War. However, as Prof. Atef Moatamid demonstrates in his well-researched study, *Russia and Ukraine: An Undeclared World War*, this conflict is not a rupture but the explosive culmination of deep-seated geopolitical tensions – *exactly like tectonic plates grinding beneath the earth's surface* - that have been building for over three decades, if not a full millennium.

Few scholars possess Moatamid's qualifications. A professor at Cairo University, geographer and translator who earned his doctorate from St. Petersburg in 2001, he served as Egypt's Cultural Counsellor in Moscow during the 2014 Crimea crisis. This unique experience provides him with what most Western analysts lack: an insider's understanding of Russian strategic thinking, scholarly distance, and an Egyptian perspective attuned to the Global South's delicate balancing act between Moscow and Washington.

Across eleven chapters Moatamid traces the geographical, historical, and cultural roots of today's crisis. Drawing on Russian, English and Arabic sources, Moatamid reveals how geography has always shaped - and still shapes - the fate of nations caught between Europe and Asia.

Historical Depth and Geographical Determinism

Moatamid's narrative begins not in 2022, nor in 1991 with the Soviet collapse, but in 988 CE, when Rus' emissaries arrived in Constantinople seeking an alliance with Byzantium. This millennium-long perspective reveals patterns invisible to those focused only on contemporary events. The author traces how the Slavic peoples who would become Russians emerged within a geographical crucible contested by successive waves of Scythians, Sarmatians, Goths, Huns, Khazars, and Mongols, each leaving an imprint on Russian political culture and strategic consciousness.

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[2] Atef Moatamid. *Russia and Ukraine: An Undeclared World War*. (Originally published in Arabic). Cairo: Dar El Shorouk, 2024. 264 pp. ISBN: 9789770938782.

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Moatamid's account of Kievan Rus'[4] is especially revealing, highlighting the irony that modern Russia and Ukraine share a common origin in medieval Kiev. He notes that the capital of present-day besieged Ukraine was once the cradle of Russian civilisation, a historical complexity that Putin has exploited to justify his claims that Russians and Ukrainians constitute "one people". However, Moatamid also illustrates how this shared heritage conceals centuries of divergence, as Ukraine became a corridor between competing civilisations while Muscovy (the Grand Principality of Moscow) developed its own imperial trajectory.

The author's geographical perspective is clear in his analysis of how Russia's landlocked position prompted centuries of expansion towards warm-water ports. From Ivan the Terrible's 16th-century conquests to Peter the Great's founding of St. Petersburg and Catherine the Great's advance to the Black Sea, Russian leaders pursued what Moatamid describes as a policy of "swallowing enemies" rather than simply defending borders. Russia built ring after ring of buffer zones to protect its heartland: Finland shielded St. Petersburg from the north, the Caucasus blocked Turkey and Persia to the south, and Central Asia prevented British advances from India. Ukraine is the most critical of all, situated between core Russia and NATO's eastern edge.

Energy as Weapon: The Gazprom Factor

One of the book's most original contributions concerns its extended analysis of energy geopolitics, particularly the role of Gazprom, Putin's strategic instrument. The numbers are really staggering; Gazprom produces nearly 20% of global natural gas output and accounts for 25–40% of Russia's budget revenues. European dependence on Russian energy averaged 30% before 2022, with some Eastern European states relying on Russian gas for 90–95% of their needs. Germany alone depended on Russia for 32% of its energy consumption. As Moatamid pointedly notes, Western research institutes calculated that in the first fifty days of the 2022 war, Europe paid Russia €50 billion for gas (€1 billion/day). As Egyptian journalist Talaat Ismail observed in his *Al-Ahram*[5] review (7 March 2024): "Europe funds the Russian war against Europe […] Putin kills European peoples with European peoples' money".

The author examines how Russia weaponized energy dependence, especially through incidents in January 2006 and 2009 when Gazprom cut gas supplies to Ukraine during severe winters, causing widespread shortages across Europe. Rather than simple economic disputes, these were calculated demonstrations of Russia's ability to "freeze entire European countries with the push of a button". Russia's construction of the Nord Stream pipelines through the Baltic Sea and TurkStream through the Black Sea served to encircle Ukraine, reducing its geopolitical value as a transit corridor while tightening Moscow's energy grip on Europe.

For postcolonial nations wary of great power politics, this perspective carries

[4] Kievan Rus' (9th–13th c.): first East Slavic state ruled by Varangians from Kiev, the shared cradle of Russian/Ukrainian civilizations.

[5] The most well-known and popular Arabic-language daily in the Arab World.

particular weight. Egypt has navigated complex energy politics, developed its Eastern Mediterranean gas fields while balancing relationships with multiple powers. The Russia-Ukraine conflict has disrupted global energy markets and food supplies, with severe consequences for import-dependent African nations. Moatamid's examination of how Russia leveraged energy dominance offers hard lessons about the geopolitical vulnerabilities created by resource dependence, lessons applicable far beyond Europe's borders.

NATO Expansion and the Psychology of Humiliation

Moatamid devotes considerable attention to NATO's eastward expansion, which he identifies as perhaps the most important cause of the current war. He documents how, following German reunification in 1990, Western leaders allegedly promised Soviet President Mikhail Gorbachev that NATO would not expand "one inch eastward", a promise that, whether verbal or implied, was systematically broken. Poland, the Czech Republic and Hungary joined NATO in 1999; the Baltic states in 2004; Albania and Croatia in 2009; Montenegro in 2017; North Macedonia in 2020; and, most provocatively, Finland in 2023 and Sweden in 2024 in direct response to the invasion of Ukraine.

The author persuasively argues that Russian perceptions of betrayal and humiliation fueled revanchist nationalism. The 1999 NATO bombing of Serbia, Russia's traditional Balkan ally - carried out despite Russian opposition and in violation of UN Security Council authority - particularly wounded Russian pride and served as a dress rehearsal for what the West might do to Russia itself. These humiliations accumulated during the chaotic Yeltsin years (1991–1999), when Russia experienced economic collapse, oligarchic plunder, and geopolitical marginalization.

Putin's rise to power in 2000 marked a decisive turning point. As Moatamid observes, Putin, who witnessed the fall of the Berlin Wall, launched a systematic campaign to restore Russian power and dignity. He crushed the Chechen insurgency, subdued the oligarchs, reasserted state control over energy resources, and rebuilt military capabilities. The 2008 war with Georgia and the 2014 annexation of Crimea represented escalating challenges to the post-Cold War order. The invasion of Ukraine in 2022 was *the logical culmination of decades of accumulating resentment and revanchism.*

An Egyptian and African Perspective

Unlike most Western accounts, Moatamid writes from his Egyptian perspective and his sensitivity to how non-Western nations view this conflict. This perspective is not merely academic detachment but informed by lived experience. Egypt, like much of the Global South, finds itself caught between competing powers it did not create. For Egypt and much of Africa, the Russia-Ukraine war has imposed severe costs despite the geographical distance. Disrupted grain exports from Ukraine and Russia - both major suppliers to African markets - have driven food price inflation and threatened food security across the continent. Egypt, which imports more than 80% of its wheat, has

been particularly vulnerable.[6] Sanctions against Russia have complicated African nations' economic relationships and forced uncomfortable diplomatic choices. Many African states abstained in UN votes condemning Russian aggression, reflecting not necessarily support for Moscow but rather a desire to maintain strategic autonomy and avoid entanglement in what they perceive as fundamentally a great power conflict.

Moatamid's book helps African readers understand the deeper forces driving this war without requiring alignment with either side's narrative. His so-called "geographical interpretation" emphasizes structural factors - landlocked powers seeking sea access, the enduring logic of buffer zones, energy dependencies, and the clash between expanding and contracting empires - that transcend simplistic morality tales. This perspective resonates with postcolonial nations that have learned to view great power competition with skepticism, recognizing that the interests of ordinary people often diverge sharply from the ambitions of distant capitals.

Style, Strengths, and Limitations

Moatamid writes with clarity, making complex analysis accessible even to non-specialists. The book's structure, moving chronologically from medieval origins through imperial expansion, Soviet collapse, and Putin's restoration project, provides readers with essential context often missing from journalistic accounts. The author effectively uses direct quotations from Putin and Zelensky to convey the psychological dimensions of the conflict. All these elements add value to the scientific contribution compiled by Moatamid.

That said, the book is not without limitations. While Moatamid strives for analytical balance, his account sometimes accepts Russian grievances too uncritically. NATO expansion certainly contributed to Russian insecurity, but the book gives insufficient attention to why Eastern European nations sought NATO membership – namely, their historical experiences of Russian domination and their desire for protection against the aggression Russia has now demonstrated. The book also lacks field interviews or sufficient direct Ukrainian viewpoints, weakening Kyiv's representation of its sovereignty and hopes for European integration. The voices of Ukrainians themselves, and their aspirations for sovereignty and integration with Europe, occasionally recede behind the great power framing.

Additionally, while the geographical and historical analysis is thorough, the book offers less guidance on potential resolutions or future trajectories. Published in 2024 as the war continues with no end, - despite peace initiatives including Trump's unsuccessful mediation attempts in 2025 and 2026 - readers might have benefited from more sustained engagement with possible endgames, negotiation frameworks, or scenarios for post-war reconstruction and reconciliation.

[6] For more details on the impact of the war on Egypt, see: Zoltán Prantner, Abdallah Abdel-Ati Al-Naggar: Economic and Political Impact of the Russia-Ukraine War on Egypt. Cairo: Historical Kan Periodical, 16(59), 2023, 272–281.

Why this book matters?

Despite the aforementioned reservations or above explained limitations, *Russia and Ukraine: An Undeclared World War* reshapes how we understand Europe's gravest crisis in generations. Prof. Atef Moatamid combines scholarly rigor with accessibility, deep knowledge of Russian history and culture with critical distance, and geographical analysis with attention to human agency and psychological factors. His Egyptian perspective enriches the discourse, reminding us that this conflict resonates far beyond Europe's borders, affecting food security, energy markets, and geopolitical alignments across the Global South. This war will leave its mark on the future for decades, and neither Russia, Ukraine, nor Eastern Europe will be as they were before.

For scholars, policymakers, and informed citizens seeking to understand how we reached this dangerous moment and what it means for the international order, Moatamid's study provides an indispensable guide. This book deserves readers far beyond the Arab world, anyone wrestling with the return of great power rivalry should read it. Moatamid leaves us with an uncomfortable question: Was this war inevitable, inscribed in Russia's geography and historical memory? The book suggests a disturbing truth: perhaps it was.

Book Review: The Arms Trade and International Criminal Law: Reframing Accountability for Complicit Weapon Suppliers[1][2]

Miklós Szakali[3]

Tomas Hamilton is an international lawyer at Guernica 37 Chambers in London and Adjunct Professor at the University of Amsterdam. He specializes in international human rights and criminal law. He continued his studies at prestigious institutions, a BA (Hons) from the University of Oxford, an LLB (Bachelor of Laws) from the College of Law, an LLM (Master of Laws) from the University of Cambridge, and a PhD in Law from King's College London.

As for Tomas Hamilton field experiences, he has worked as a Human Rights Officer at the UN Fact-Finding Mission on Venezuela, Senior Legal Consultant at the UN Assistance to the Khmer Rouge Trials (UNAKRT) at the Extraordinary Chambers in the Court of Cambodia (ECCC), Associate Legal Officer at the International Criminal Court (ICC) in The Hague, and at a leading criminal law firm in London. His theoretical background and practical experiences establish the professionalism and credibility of his book.

Based on the title of the book and the author's professional background, it was obvious that the book examines international legal options for combating the illegal arms trade, especially its main organizers and conspirators, as this would increase international security and reduce the commission and spread of mass violence.

I would highlight the comprehensive nature of the applied research methodology. This includes an extensive analysis of relevant legislation, a thorough review of the literature, interviews with judges, lawyers and prosecutors of the International Criminal Court (ICC), the author's empirical experience, and a case study of the Second Congo War, which guarantee the credibility of the conclusions and findings.

The book explores the fundamental question of how to combat the illegal arms trade and apply international criminal law to the arms smugglers and brokers who provide weapons for the commission of mass violent crimes. The question may arise at all because, when the ICC was established (effective: 1 July 2002), the Rome Statute essentially defined four core crimes that it must investigate and prosecute: genocide, crimes against humanity, war crimes and the crime of aggression (effective: Kampala Conference 2010). Therefore, illicit arms trafficking is not among the core crimes that

[1] DOI: 10.12700/jceeas.2026.6.3.492

[2] Tomas Hamilton. *The Arms Trade and International Criminal Law: Reframing Accountability for Complicit Weapon Suppliers*. Great Clarendon Street, Oxford: Oxford University Press, 2025. Print ISBN: 9780192868671, Online ISBN: 9780191964701. pp. 228, US$ 139.66 (paperback).

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the ICC should address as a priority. The author believes that the ICC should also address the illicit arms trade, as it fundamentally contributes to the commission of mass violent crimes. This is complicated by the fact that the primary exercise of jurisdiction over the arms trade is the responsibility of nations and thus reflects state interests rather than the enforcement of international criminal law.

In the early 2000s, targeted efforts were made worldwide to regulate the illicit arms trade. In the African region, this included the 2001 Southern African Development Community (SADC) *"Protocol on Arms, Ammunition and Other Related Equipment"* [4]. This required member states to introduce legislation to control the activities of arms brokers operating in their territories. However, by the end of 2009, only two member states had targeted arms trade regulations in place, Mauritius and South Africa. As we can see, both the Rome Statute and the SADC Protocol primarily delegate responsibility for combating the illicit arms trade to nations that were not too eager to comply with the provisions of the agreement.

To support the author's hypothesis, the first part of the book provides an in-depth analysis of the relevant national and international laws, their interpretation and their relationship to each other. The book focuses on the examination of the Arms Trade Treaty (ATT), which is considered the guiding international regulation of the arms trade. The agreement aims to prevent the flow of weapons to conflict zones and their transfer to perpetrators of international crimes. However, it states that the obligations imposed on parties by the ATT (establishment of a national control system, law enforcement) are constructively ambiguous. It also fails to adequately address the problem of brokering activities in third states, although it calls on states to regulate brokering activities in their national legal systems, but does not impose an obligation for official registration or licensing. It also does not provide *ex post facto* accountability for international crimes. These inconsistencies allow states to regulate at different levels and degrees of severity, which is contrary to the intention of the treaty. It is therefore not surprising that the author concludes that the current arms export regime is ineffective in achieving the fundamental objective of the ATT. He therefore sees an opportunity in the application of international criminal law, including the involvement of the ICC, particularly in *ex post facto* investigations and criminal proceedings, in a way that complements the existing regulatory system.

Chapters 4 and 5 examine the specific legal interpretation of *actus reus* and *mens rea* in the context of arms trafficking. This is important because in most criminal cases both conditions must be proven for a conviction. The author thoroughly analyses Articles 25 and 28 of the Rome Statute, which define the possible cases of liability. It states that Article 25(3)(c) and (d) provide an opportunity to act against complicity. Criminal assistance can be interpreted as including the illegal arms trade, but of course the

[4] Besenyő János — Molnár Erik, Fegyverkereskedelem jelenlegi helyzete és szabályozása Afrika déli részén, KNBSZ Szakmai Szemle 2012/1., Budapest, 2012.

interpretation can cover a much wider range of suppliers, given that it is not only arms that can be used to facilitate the commission of mass crimes. However, it should also be taken into account that mass crimes can be committed without the use of weapons. In cases such as looting, arson, and rape, it is very difficult to prove in court how important the weapons carried by the group were, or whether the crime would have occurred without them simply because of aggressive attitude and numerical superiority. For obvious reasons, the above articles define in detail the criteria for liability, taking into account a number of possibilities (degree of contribution, "neutral" contribution, accidental absence, common purpose, etc.), but at the same time they make it difficult to prove and apply personal liability. This is especially true in the case of an arms manufacturer, dealer or broker who has no connection (political, religious, emotional, etc.) with the group committing the crimes but simply provides arms and war materials on a commercial basis.

For me, the most informative and interesting chapters were Chapters 6 and 7, in which the author presents the legal culture of the ICC, the understanding of its mandate, and its practice in selecting the cases in which the ICC is willing to act. The identification of the legal culture of the ICC is based on the author's personal interviews with 32 ICC legal staff (judges, lawyers, and other legal professionals). This was a huge undertaking, but essential for the credibility of the findings. The interviews clearly demonstrated the ICC's insistence on prosecuting high-ranking political and military leaders involved in mass crimes, in line with the core crimes set out in the ICC's mandate. In this way the high international visibility of the ICC cases would serve as a deterrent in preventing similar cases. ICC staff believe that the arms trade is fundamentally regulated by the ATT and consider national authorities to be best placed to tackle illicit trade and brokering. Action against arms dealers and brokers was considered too dangerous, complicated (hard to obtain evidence) and too complex. Although they did not add, in my opinion, it is also included that bringing an arms dealer or broker to justice involves a lot of work and danger, but it does not convey the same message as convicting a world-famous dictator or a notorious military leader. Based on the interviews, the author emphasizes that the opinion of ICC officials to refrain from taking action against arms trafficking is not legally based, but is mainly dictated by institutional culture, and he maintains his opinion on the possible role of the ICC in prosecuting illegal arms dealers and brokers.

In Chapters 8 and 9, the author analyses the successful UN investigation into weapons of mass violence through the case study of the Second Congo War, and then the fact that criminal accountability was missing. The Second Congo War was one of the bloodiest wars on the African continent between 1998 and 2003, involving 9 African countries, some 25-armed groups, and claiming an estimated 3.9 million lives and almost as many refugees. However, this massive disaster did not receive the necessary publicity, so it became known only to a relatively narrow circle. The analysis shows that the Security Council embargo system and national export controls have failed to prevent the flow of Small Arms and Light Weapons (SALW) to the eastern Democratic Republic of Congo (DRC). However, the regulations contained in the ATT have not been

sufficient even for *ex post facto* investigations. This was the first case in which the newly established ICC (1 July 2002) has initiated criminal prosecution under the Rome Statute. In this situation, the Court's activities were determined by the "childhood diseases" characteristic of all beginnings. The first Court Prosecutor began the investigation against the arms dealers with great enthusiasm, but the public arrest warrant did not follow the enthusiasm. At the same time, political games and considerations also strongly influenced the Prosecutor's final decision, which led to the indictment of four leaders of non-state armed groups. This decision was made following an agreement with the leaders of the Congolese government, but the illicit involvement of the governments of Rwanda, Uganda and the Democratic Republic of Congo was not examined. This clearly shows the factual relationship between politics and law, an issue that arises repeatedly in the book.

In my opinion, the author, guided by good intentions, presented how illegal arms trafficking and brokering could be more effectively combatted by applying criminal law. When examining the theoretical issues, he demonstrated great professional knowledge and understanding of the relevant literature. He presented the case study based on his practical experience, highlighting its main points. Nevertheless, by examining both theoretical and practical aspects in its contexts, he highlighted the ineffectiveness of the legislation in terms of compliance with embargoes and the prevention of mass armed crimes. The *ex post facto* procedure he also emphasized, although legally important, does not prevent the flow of weapons into the conflict zone and the commission of mass crimes in practice. I believe that *ex post facto* procedures can have at most a limited deterrent effect in these cases. However, it should not be forgotten that arms dealers and brokers could not exist without the knowledge and consent of the major arms companies and the state agencies that oversee them. Arms smugglers are in fact involved in both the legal and illegal arms trade. This is also supported by the Viktor Bout case, which is also mentioned in the book (p. 172). Viktor Bout supplied weapons to Sudan on behalf of the UN and to Iraq on behalf of the United States. But of course, he also supplied weapons to the Liberian dictator, as well as to the dictators of Burundi, Sierra Leone and the Central African Republic. He was convicted in 2012, and after his release in 2022, he returned to Russia and built a political career.

The case study of the Second Congo War can be considered a “textbook case” in many ways, but in 2025 I am no longer convinced of its relevance. Today’s conflicts have become much more complex (international alliances, cutting-edge technologies, expansion of operational dimensions, etc.), international organizations such as the UN and the EU have lost significant weight and have no real influence on the development of international security. The international arena has been dominated by power politics, which serves the interests of a few great powers while ignoring international law. Accordingly, the validity of international criminal law and the role of the ICC have also become questionable. The president of the world's leading power has declared that he does not need international law, considering his own morality and way of thinking as authoritative. But we can mention the arrest warrants issued against the Russian

President and the Israeli Prime Minister (just to mention the most prominent), which no country has executed, thereby degrading the significance of the ICC. Based on all this, I believe that the author's basic idea, the extension of criminal law to the illegal arms trade, is useful and legally sound, but at the same time it seems very little in the current situation. A fundamental transformation of the international security architecture is inevitable, in line with the international legal system and the organizational/law enforcement structure and mandate that support it.

The book is a truly thought-provoking work. I highly recommend it to anyone who enjoys thinking about the interactions between security and law, and perhaps how international law can become a source and support for international security.

Book Review: Drones in the African Battlespaces[1][2]

András Málnássy[3]

The growing use of unmanned aerial systems (UAS) has changed the way of modern wars. Most studies and research on drone warfare mainly focus on the United States, Russia, Ukraine or the Middle East. However, Africa has received much less attention, even though military drones are becoming increasingly important across the continent. Drones in the African Battlespaces, edited by Wayne Stephen Coetzee and Dries Putter examines the strategic, geopolitical, operational and legal aspects of military drone use in Africa. The authors highlight that the African continent has its own complex security environment. Different geopolitical interests, domestic security problems, technological developments and governance challenges all shape the way drones are used. As the volume demonstrate, drones are not only military tools but also technologies that influence state sovereignty, regional security and the changing character of armed conflict.

The introductory chapter outlines the main ideas of the volume. Coetzee and Putter identify three themes that appear throughout the book: the strategic and geopolitical impact of drone proliferation, the operational role of drones in African conflicts and the ethical and legal issues connected to their increasing use (pp. 1–8). These themes provide a clear structure and help connect the different chapters despite the wide range of topics and case studies.

In the second chapter, Graeme Plint and Dries Putter argue that drones should not be viewed only as unmanned aircraft. They suggest a broader approach that includes autonomous systems operating in the air, on land and at sea, instead. They explain that military effectiveness today depends not only on individual platforms but also on the integration of autonomous technologies, artificial intelligence, communication systems and command-and-control capabilities (pp. 9–16). This broader perspective helps take drone technology within the wider process of military innovation.

The geopolitical aspects of drone proliferation are examined in detail by Francis Okpaleke and Samuel Oyewole. Their discussion of "drone colonialism" is one of the most interesting chapters in the volume (p. 29). The authors argue that drone exports should not be seen only as commercial deals but also as instruments of geopolitical influence. According to their analysis, countries such as the United States, China, Türkiye

[1] DOI: 10.12700/jceeas.2026.6.3.553
[2] Wayne Stephen Coetzee, Dries Putter (Eds.). *Drones in the African Battlespaces*. Cham. Springer, 2025. ISBN: 978-3-031-87146-7, pp. 174. US$ 160.
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and Iran use drone exports to strengthen their strategic partnerships with African states (pp. 30–39). These transfers are closely connected to broader military cooperation, including training, intelligence sharing and political cooperation. At the same time, the authors do not present African states as passive recipients of foreign influence. Instead, they show that many governments actively seek drone capabilities to improve counterterrorism operations and border security while balancing relations with competing global players (pp. 40–51).

The operational use of drones is another important theme of the book. In their chapter on the Turkish Bayraktar TB2 in Sub-Saharan Africa, Brendon Cannon and Ash Rossiter question the common view that armed drones are game changers on the battlefield (pp. 51–55). They argue that the effectiveness of drones depends on several local factors, such as geography, logistics, environmental conditions and the availability of trained personnel. For this reason, the authors describe drones as force multipliers that can improve military operations but cannot guarantee strategic success on their own (pp. 56–62).

Arinze Ngwube takes a similar approach in his analysis of France's use of drones during Operation Barkhane (p. 64). He recognises the important role of drones in intelligence gathering, surveillance and precision strikes against jihadist groups operating in the Sahel. At the same time, he discusses the ethical and strategic challenges linked to technology-based counterinsurgency operations (pp. 68-69). The chapter examines issues such as civilian casualties, state sovereignty and the long-term impact of military intervention. Ngwube concludes that advanced military technology alone cannot solve the political and socio-economic causes of instability in the region (pp. 74–80).

The volume also looks beyond combat operations and explores the institutional and governance aspects of drone adoption. Using the so-called Securitisation Theory (ST) (pp. 81–82), Kyle John Bester and Danille Elize Arendse examine how drone technology has been introduced into the South African military (pp. 92–94). They argue that military innovation is shaped not only by technological developments but also by political debates, legal frameworks, institutional capacity and budget limitations. The chapter shows that the successful integration of new military technologies depends as much on governance and state capacity as on technological capability itself (pp. 95–97).

The maritime use of drones is discussed by Tshegofatso Johanna Ramachela, who examines a topic that has received much less attention in the literature on drone warfare in Africa. The author argues that unmanned systems can improve maritime surveillance and support efforts against piracy, illegal fishing and maritime trafficking (pp. 99–110). At the same time, the chapter points out that many African countries still depend on foreign suppliers for these technologies. This raises important questions about regional cooperation and local defence industries (pp. 110–123).

In the next chapter Karen Allen focuses on the growing use of drones by violent non-state actors (p. 126). The author argues that, although drone use in Africa has not yet reached the level seen in Ukraine or the Middle East, the increasing availability of commercial drones and open-source technical knowledge is likely to change the security

environment in the coming years (pp. 127–133). The author shows that these groups already use drones for intelligence gathering, surveillance, propaganda, recruitment and potentially offensive operations (pp. 139–141). The chapter illustrates how easily available technologies are changing the nature of asymmetric warfare (pp. 135–145).

In the concluding chapter, Wayne Stephen Coetzee and Dries Putter bring together the main findings of the volume and present several policy recommendations (pp. 154–155). They discuss the need for stronger regulatory frameworks, greater investment in local technological development, closer regional cooperation, ethical governance, cybersecurity and the wider civilian use of drone technologies (pp. 155–161). By connecting academic research with practical policy recommendations, the authors make the volume relevant not only for researchers but also for policymakers and security practitioners.

Overall, one of the main strengths of the book is its multidisciplinary approach. The contributors combine perspectives from political science, strategic studies, military studies, intelligence, security policy and technology studies. As a result, the book goes beyond a purely technological discussion and places drone proliferation in the broader context of sovereignty, geopolitical competition, hybrid warfare and technological dependence. Another important strength and aspect is its balanced approach. The authors do not present drones either as revolutionary weapons or simply as instruments of foreign influence. The volume also reminds the reader that technological innovation alone does not determine success in war. As with other emerging technologies, including artificial intelligence (AI), drones are most effective when they are integrated with sound strategy, effective institutions and trained personnel. The authors show that drones are dual-use technologies that can support surveillance, counterterrorism, maritime security and humanitarian operations while also creating new ethical, legal and security challenges.

The volume is valuable for scholars, policymakers and practitioners interested in the growing role of drones in Africa's security environment and in the changing nature of modern warfare and new technologies. At the same time, the book has some limitations also. Although it provides a detailed discussion of the major external suppliers of drones, including the United States, China, Türkiye and Iran, it pays less attention to African defence industries and domestic innovation. A more detailed discussion of drone production in countries such as South Africa, Morocco, Algeria, Ethiopia, Kenya, Niger and Nigeria would have strengthened the analysis by showing whether African states may become producers as well as users of these technologies. In addition, although the book focuses on Africa, more comparisons with recent conflicts in Ukraine or the Middle East would have provided a broader perspective and placed the African case studies within a wider discussion on military innovation.

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