Encroachments over pipelines, servitudes and properties

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KEYWORDS

Critical infrastructure protection; remote sensing; land governance; land reform, spatial inequality; Spatial Planning Land Use Management Act (SPLUMA) (1), formal and informal encroachments

SUMMARY

Critical water infrastructure across rapidly urbanising regions is increasingly exposed to encroachment risks arising from informal settlements, unregulated development and illegal land occupation. In South Africa, bulk potable water pipelines operate within registered servitudes and wayleaves that are frequently compromised by both formal and informal encroachments, threatening public safety, service continuity and infrastructure integrity. Rand Water manages an extensive pipeline network, where encroachment has been identified as one of the organisation's highest strategic risks.

This paper presents a structured servitude encroachment plan developed for Rand Water, integrating spatial information management, legislative compliance and technological innovation. The study draws on empirical data from satellite-based assessments and report from consultant, Geographic Information Systems (GIS) and risk profile of encroachments affecting critical water infrastructure. Particular attention is given to the legal and institutional challenges arising from the intersection of infrastructure protection mandates and socio-economic realities, including informal settlements and unlawful occupation of land.

The paper proposes a technology-enabled framework for encroachment monitoring, supported by remote sensing, drone surveillance and intergovernmental intervention. The findings demonstrate that early detection, spatial prioritisation and collaborative governance significantly reduce operational delays, safety risks and long-term costs. The study contributes practical insights for land professionals, town planners, GIS specialists and infrastructure custodians seeking to balance infrastructure protection, human rights considerations and sustainable land governance within rapidly transforming urban and rural environments.

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1. INTRODUCTION

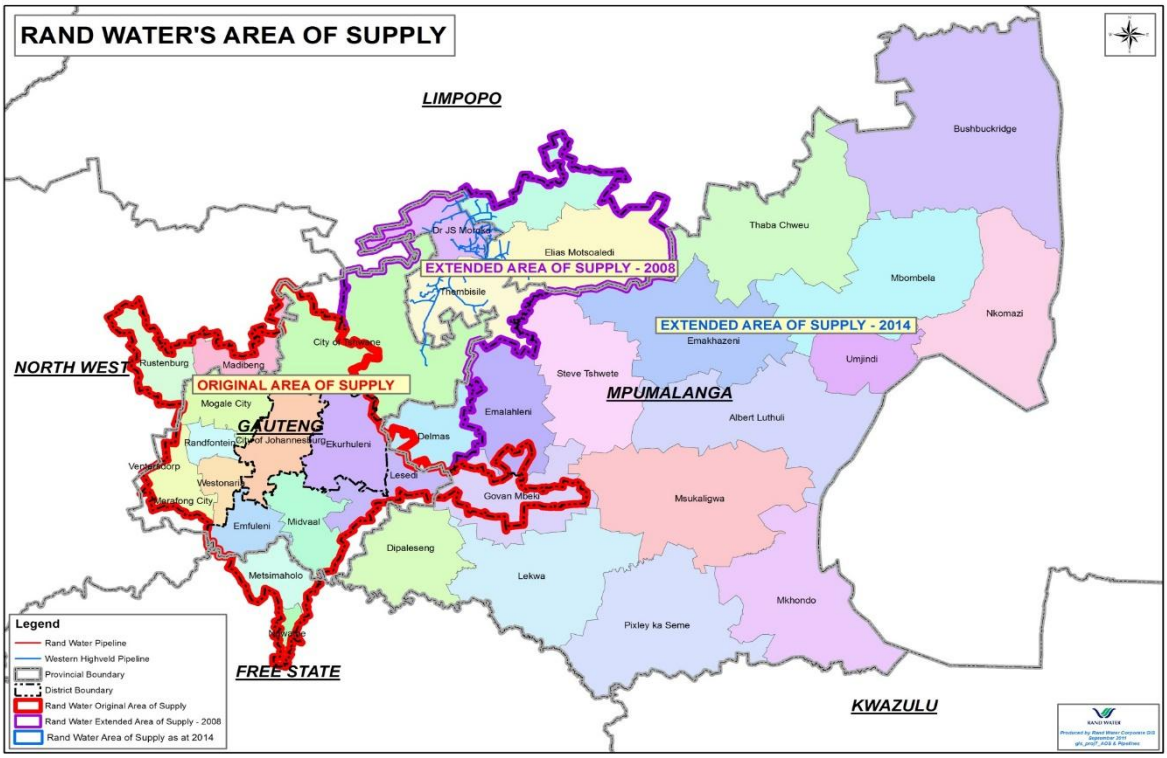
The protection of critical infrastructure namely water pipelines has become an increasingly complex challenge in rapidly urbanising regions, particularly in developing economies where population growth, housing shortages and spatial inequality place sustained pressure on available land. Water supply infrastructure is especially vulnerable, as bulk pipelines, reservoirs and auxiliary structures (cathodic protection, valves, etc) often traverse densely populated urban and rural areas through servitudes that are not visibly demarcated or adequately protected.

In South Africa, bulk water infrastructure plays a fundamental role in supporting economic activity, public health and social stability. Rand Water, as the largest bulk water utility on the African continent, operates an extensive potable water pipeline network of approximately 3,660 kilometres across Gauteng, Free State, Northwest and Mpumalanga provinces. These pipelines supply water to municipalities, industries, mines and millions of end-users. However, the increasing incidence of land encroachment within and along pipeline servitudes poses a material threat to the safety, reliability and sustainability of this network.

Encroachment on pipeline servitudes, whether through formal developments, informal settlements or illegal activities (zama zamas) has emerged as a critical risk for infrastructure owners. In the case of high-pressure bulk water pipelines, encroachment significantly elevates the likelihood of catastrophic failure, restricted access for maintenance and emergency repairs and potential loss of life and/or property damage. As a result, servitude encroachment has been ranked number two (2) on Rand Water's Strategic Risk Register, necessitating an organisation-wide, co-ordinated response.

This paper addresses servitude encroachment not merely as an operational challenge, but as a spatial governance issue situated at the intersection of land administration, infrastructure management and socio-economic development. It explores how spatial information systems, legislative instruments and institutional co-ordination can be combined to proactively manage and mitigate encroachment risks affecting critical water infrastructure.

Figure 1: Rand Water's Area of Supply



2. PROBLEM STATEMENT AND CONTEXT

Encroachment on infrastructure servitudes occurs when individuals or entities occupy, build upon or otherwise interfere with land reserved for the protection and operation of essential infrastructure. Within Rand Water's operational environment, encroachments manifest in both formal and informal forms. Formal encroachments typically involve authorised landowners who construct permanent structures such as houses, boundary walls or swimming pools within registered pipeline servitudes, often in contravention of title deed restrictions. Informal encroachments, by contrast, involve unlawful occupation of servitude land by communities establishing temporary or permanent structures, frequently without access to formal services or secure tenure.

While formal encroachments can usually be resolved through conventional legal processes, informal encroachments present more complex challenges. The removal of informal structures often results in homelessness, triggering constitutional protections and statutory requirements under the Prevention of Illegal Eviction from and Unlawful Occupation of Land Act (PIE Act). This legal reality introduces prolonged court processes, intergovernmental dependencies and significant social considerations, all of which complicate timely infrastructure protection interventions.

2.1 Challenge faced by Rand Water

- Inability to repair, renew and augment existing infrastructure in an encroached servitude
- Inability to remove the encroachers speedily due to many processes that must be followed which involves inter-governmental engagements
- Inability of local authorities to enforce by-laws which will protect critical infrastructure
- Inadequate funding or lack of funding to address the accommodation of the reallocated encroachers
- Backlog of housing: people settle on pipeline servitudes
- Safety/risks issues and loss of lives
- Local authorities-scarcity of land
- Resistance from encroachers
- Area of supply-vast area for Rand Water's District Superintendents to patrol
- Insufficient legislation to assist parastatals (the current legislation favours the encroachers not the parastatals).

2.2 Risks to Rand Water

- Encroachers vandalize Rand Water assets and make it difficult to access pipelines and valve chambers
- New pipelines/infrastructure to be constructed are delayed or result in increased project costs because the encroachers must be relocated (additional cost and standing time)
- Existing infrastructure to be maintained/replaced is delayed due to lack of access to servitude areas
- There are personal safety issues for staff that must work on the pipelines
- Potential loss of lives/property around pipes that are encroached and burst
- Delayed access to repair burst pipes could negatively impact on water supply contracts
- When disaster strikes, it will in all probability become Rand Water's problem and responsibility.

2.3 Consequences of Pipe Bursts

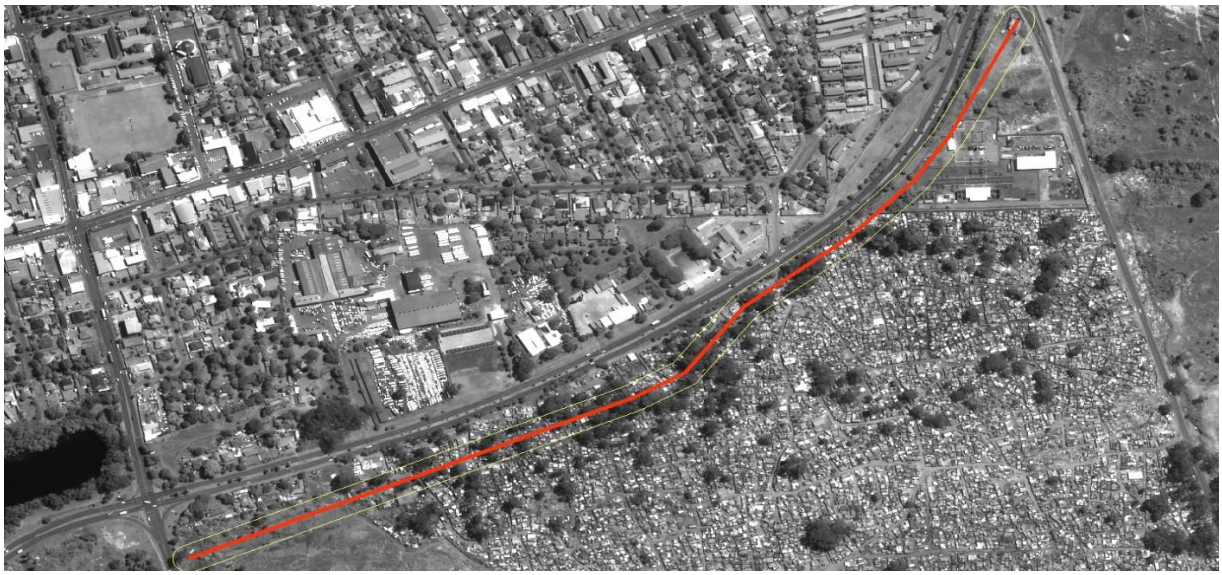
- Could result in multiple fatalities
- Displacement of communities
- Damage to infrastructure
- Interruption of water services
- Even those who may not be on top of the pipeline, but adjacent to these pipelines can be at risk.

Figure 2: Burst Water Pipe

The consequences of encroachment on bulk water pipelines are severe. Structures built directly above or adjacent to high-pressure pipelines increase the risk of injury or fatality in the event of a pipe burst. Encroachments also impede routine inspections, maintenance activities and emergency response efforts, leading to extended service interruptions and increased operational costs. Furthermore, illegal activities such as vandalism, theft of valve covers, unauthorised water connections and illegal mining within servitudes and properties exacerbate infrastructure degradation and safety risks for both communities and utility personnel.

Despite the scale of the problem, historical encroachment management has often been reactive, fragmented and underpinned by incomplete spatial data. While initiatives such as physical patrols, public awareness campaigns and legal interventions have yielded isolated successes, the absence of an integrated, technology-driven monitoring and decision-making framework has limited long-term effectiveness.

Figure 3: Typical Informal Encroachment



Against this backdrop, the core problem addressed by this paper is the lack of a co-ordinated, spatially enabled processes that balances infrastructure protection, legislative compliance and socio-economic realities.

3. RAND WATER ENCROACHMENT INITIATIVES

The organisation embarked on several initiatives to manage the encroachment risk over properties and servitudes and identified the potential impact of encroachments to the Rand Water business.

The following are some of the initiatives that the organisation implemented as internal controls:

- The establishment of the Property and Encroachment Committee (PEC) with the objective of overseeing and managing the encroachments issues across the organisation
- Informal encroachment physical awareness, simulation programs and the local radio advert on encroachment risk, erection of the encroachment awareness billboards along servitudes and encroached areas.
- Daily physical patrols on servitudes to identify the encroachments and assess conditions of the infrastructure.
- Proactive approach, example being that in 2012/2013, the K5 emergency project (2) pipeline community members were relocated with assistance of the local municipality to alternative municipal land where it was safe to reside and settle while Rand Water implemented the new pipeline.
- Rand Water has previously engaged external stakeholders affected by the encroachment risk, such as Eskom, Sasol and Transnet. The purpose of the engagement was to execute a joint effort in exploring options to manage or eliminate encroachment risk.

4. LITERATURE REVIEW AND INTERNATIONAL CONTEXT

The challenge of protecting infrastructure servitudes from encroachment is not unique to South Africa. Globally, infrastructure owners and public utilities face increasing pressure from rapid urbanisation, informal settlement growth and competing land-use demands. Research indicates that infrastructure encroachment is most prevalent in regions experiencing high population growth, spatial inequality and limited enforcement of land-use controls (UN-Habitat, 2020) (3).

International studies emphasise that encroachment on linear infrastructure, such as pipelines, railways, gas and transmission corridors poses disproportionate risks compared to point-based assets. Linear infrastructure often spans multiple administrative boundaries, complicating governance and enforcement, while its physical invisibility below ground increases the likelihood of unlawful occupation (Bennett et al., 2019) (4). In many developing contexts, servitudes are poorly demarcated, inadequately monitored and weakly integrated into municipal spatial development frameworks.

From a land administration perspective, servitude encroachment reflects systemic shortcomings in cadastral management, spatial planning and intergovernmental co-ordination. Where land information is outdated or fragmented, infrastructure custodians are forced into reactive enforcement, often at significant financial and social costs.

Technological innovation has emerged as a critical enabler in addressing encroachment risks. GIS, high resolution satellite imagery, unmanned aerial vehicles (UAV's) and spatial analytics are increasingly used to detect land-use change, identify encroachment hotspots and support evidence-based decision-making. Case studies from countries such as Australia, India and Brazil demonstrate that remote sensing significantly improves early detection and reduces long-term relocation and litigation costs when integrated into infrastructure asset management frameworks (5).

However, literature also cautions that technology alone is insufficient. Successful encroachment management requires institutional alignment, legal clarity, community engagement and political support. Without these elements, spatial data may identify risks without enabling effective intervention. This paper contributes to the literature by demonstrating how spatial technologies can be operationalised within a legally constrained, socio-economically complex environment, offering practical insights for land professionals and infrastructure custodians operating in similar contexts.

5. LEGISLATIVE AND POLICY FRAMEWORK

5.1 Critical Infrastructure Protection Act (CIPA)

The protection of essential infrastructure in South Africa is governed by the Critical Infrastructure Protection Act 8 of 2019 (CIPA), which replaced the National Key Points Act of 1980 (6). CIPA establishes a legal framework for identifying, safeguarding and enhancing the resilience of infrastructure deemed critical to national security, public safety and economic stability. In the context of bulk water supply, pipelines, reservoirs and associated structures

constitute critical infrastructure due to their indispensable role in sustaining communities and industries.

CIPA places a statutory obligation on infrastructure owners to assess risks, implement security measures and collaborate with state authorities to prevent damage, sabotage or unlawful interference. Importantly, the Act enables enhanced security measures, inter-agency co-operation and stricter penalties for offences affecting designated infrastructure. For Rand Water, the application of CIPA provides an essential legal basis for strengthening surveillance, access control and enforcement within pipeline servitudes and properties.

However, while CIPA strengthens the protection mandate, it does not operate in isolation. The enforcement of infrastructure protection measures must be balanced against other constitutional and legislative obligations, particularly those relating to land occupation and housing rights.

5.2 Prevention of Illegal Eviction from and Unlawful Occupation of Land Act (PIE Act)

The Prevention of Illegal Eviction from and Unlawful Occupation of Land Act, 1998 was enacted to give effect to Section 26 of the South African Constitution, which guarantees the right to adequate housing and protection against arbitrary evictions (7). The PIE Act regulates the eviction of unlawful occupiers, requiring court oversight, procedural fairness and consideration of the personal circumstances of affected individuals.

While the unlawful occupation of land remains illegal, the PIE Act significantly constrains the ability of landowners and infrastructure custodians to remove encroachers without due process. Courts may require municipalities and landowners to provide or facilitate alternative accommodation, particularly where eviction would result in homelessness. Failure to comply with the Act constitutes a criminal offence, exposing infrastructure owners to legal and reputational risk.

In practice, the PIE Act introduces prolonged timelines, intergovernmental dependencies and financial obligations that complicate infrastructure protection efforts. For critical water infrastructure, delays in resolving encroachments increase exposure to safety risks and service disruptions, creating tension between public safety imperatives and socio-economic protections.

5.3 Legislative Tension and Implications for Infrastructure Governance

The co-existence of CIPA and the PIE Act creates a complex governance environment for infrastructure custodians. On one hand, CIPA mandates proactive protection of critical assets; on the other, the PIE Act prioritises human dignity and housing security. This legislative tension necessitates a co-ordinated, evidence-based approach that enables risk prioritisation, early intervention and negotiated solutions.

For land professionals, surveyors and spatial planners, this context underscores the importance of accurate servitude registration, spatial visibility and integration of infrastructure corridors

into municipal planning instruments. Early identification of encroachment risk through spatial monitoring allows infrastructure owners to engage municipalities and communities before occupation intensifies, reducing the likelihood of forced evictions and costly relocations.

6. METHODOLOGY AND STRATEGIC APPROACH

This paper adopts a practice-based, mixed-methods approach and combining remote sensing analysis.

6.1 Data Collection and Spatial Analysis (Post 2016 to 2026)

Primary spatial data still to be obtained through:

- Satellite imagery and remote sensing assessments conducted in partnership with the South African National Space Agency (SANSA) (8)
- Consultants reports and recommendations on the extent of the encroachments, high risks areas and mechanisms to combat existing and future encroachments

The SANSA assessment provided a baseline in 2016 in understanding of the scale, distribution and typology of encroachments across Rand Water's pipeline network. Encroachments were categorised into formal developments, informal structures and informal settlements and prioritised based on proximity to pipelines, population density and potential safety impact. Satellite-based assessments conducted in collaboration with the South African National Space Agency (SANSA) revealed the extent of encroachments across Rand Water's network, highlighting the need for continuous spatial monitoring and prioritised risk management. Twenty-two informal encroachments were identified by the study in 2016.

As of Dec 2025, a consultant was appointed to map Rand Water's pipeline servitudes and properties and produce high resolution maps of the encroached areas. Recommendation will be provided in the final report on the removal, relocation and prevention of encroachments.

6.2 Analytical Framework

A SWOT analysis was employed to evaluate Rand Water's existing encroachment management practices, identifying strengths, weaknesses, opportunities and threats within the organisational and external environment. This analysis informed the development of targeted interventions, highlighting the need for improved technology utilisation, institutional coordination and proactive monitoring.

Risk prioritisation was central to the methodology. Encroachments were assessed according to:

- Potential impact on public safety
- Accessibility for maintenance and emergency response
- Legal complexity and socio-economic implications
- Financial exposure and infrastructure vulnerability

6.3 Development of an Implementation Plan

The servitude encroachment plan was developed as an integrated framework comprising:

- Assessment and planning through spatial data consolidation and risk mapping
- Continuous monitoring using satellite imagery, drones and GIS tools
- Prevention mechanisms grounded in legislation, technology and community engagement
- Removal and mitigation processes aligned with legal requirements and intergovernmental co-operation
- Short- and long-term implementation plans linked to resources and budgetary provision

This methodological approach ensures that encroachment management is embedded within broader asset management and spatial governance processes, rather than treated as an isolated enforcement function.

7. RESULTS AND FINDINGS (Work in Progress)

7.1 Extent and Spatial Distribution of Encroachments

The analysis of spatial and operational data confirms that servitude encroachment is widespread across Rand Water's pipeline network and affects multiple systems and municipalities.

Encroachments are unevenly distributed, with concentrations occurring primarily in metropolitan municipalities experiencing rapid urban growth, including the cities of Johannesburg, Ekurhuleni and Tshwane. Informal settlements represent the highest-risk category due to population density, proximity to pipelines and limited access for maintenance or emergency intervention.

This pattern highlights the critical importance of early detection and rapid response.

7.2 Temporal Gaps in Encroachment Data

A significant finding of the study is the absence of comprehensive encroachment data between 2017 and 2025. This data gap limits the organisation's ability to assess trends, evaluate the effectiveness of previous interventions and forecast future risks. The lack of continuous spatial monitoring has resulted in a predominantly reactive management approach, where encroachments are addressed only once they reach an advanced and legally complex stage.

This reinforces the strategic value of continuous satellite monitoring and GIS-based asset management systems, which enable early identification of land-use changes within servitudes and properties. This is now in progress by a consultant appointed by Rand Water for 6 months.

7.3 Financial and Operational Impacts (2012)

Encroachment has demonstrable financial implications for Rand Water. The case study of the K5/K8 relocation project (8), involving the relocation of 51 households, illustrates the magnitude of costs associated with informal encroachment management pertaining to preparation, materials for rebuilding, water provision and professional services.

Beyond direct relocation costs, encroachments contribute to:

- Increased pipeline deviation and re-design costs
- Extended project delays
- Higher security and maintenance expenditure
- Elevated legal and reputational risk

These findings confirm that proactive prevention and early intervention are substantially more cost-effective than late-stage relocation and litigation.

8. COLLBORATIVE DISCUSSION WITH STAKEHOLDERS

8.1 Encroachment as a Spatial Governance Challenge

It can be seen that servitude encroachment is not merely an operational or legal issue, but a systemic spatial governance challenge. The persistence of encroachments reflects misalignment between infrastructure planning, municipal land-use management and socio-economic realities. In many instances, servitudes are inadequately reflected in municipal spatial development frameworks or are poorly understood by communities and developers.

From a land administration perspective, this underscores the importance of integrating infrastructure servitudes into cadastral systems, zoning schemes and development control processes. Surveyors and spatial planners play a critical role in ensuring that servitudes are accurately surveyed, registered and communicated to all stakeholders.

8.2 The Role of Spatial Technologies

It can be demonstrated that GIS, satellite imagery and drone technology are powerful enablers of proactive encroachment management. When integrated into asset management processes, these technologies allow infrastructure custodians to:

- Detect early land-use changes
- Prioritise high-risk and hot spot areas
- Support evidence-based legal and intergovernmental engagement
- Reduce reliance on reactive enforcement

However, the effectiveness of technology is contingent upon institutional readiness, clear governance structures and compliance to civil aviation rules. Without these, spatial data risks becoming descriptive rather than transformative.

9. INTERVENTION FRAMEWORK

9.1 Short-Term Interventions

Short-term measures focus on stabilising high-risk areas and establishing institutional capacity. These include:

- Appointment of specialised service providers for encroachment mapping, monitoring and management
- Consolidation of encroachment data into a central GIS platform
- Reporting on recommended proposals to mitigate the risks
- Formal designation of pipelines as critical infrastructure under CIPA
- Strengthened co-ordination between legal, operational and land services units

These interventions are designed to improve visibility, accountability and response time.

9.2 Long-Term Interventions

Long-term interventions aim to institutionalise proactive encroachment management through:

- Continuous satellite monitoring and spatial analytics
- Deployment of drone surveillance in identified hotspots
- Sharing of spatial encroached data with stakeholders
- Integration of servitude data into municipal planning instruments
- Adoption of innovative protection technologies, such as fibre-optic monitoring and smart lock systems
- Community-based protection initiatives facilitated through partnerships and local employment
- Contractor to remove, relocate and prevent existing and future encroachments

Together, these measures support a shift from reactive enforcement to sustainable infrastructure governance.

10. CONCLUSION

Encroachment on critical water infrastructure remains a complex and escalating challenge, with no single or immediate solution. While Rand Water can strengthen its encroachment management plan through the introduction of appropriate technologies and improved data acquisition, these interventions alone will not resolve the issue. Rather, they should be viewed as enabling tools to support informed decision-making, proactive monitoring and co-ordinated action.

A clearly defined and supported internal and external engagement framework is essential. This framework must be underpinned by strong collaboration across all spheres of government. Meaningful progress will require executive-level engagement by public entities, including

Chief Executives, with key government departments such as Human Settlements and the Office of the Presidency, to elevate encroachment from an operational concern to a national strategic priority.

The continued growth of encroachment reflects systemic challenges, including housing shortages, urbanisation pressures and fragmented accountability among stakeholders. Addressing these challenges demands an integrated, multi-sectoral approach involving local, provincial, and national government, supported by regulatory enforcement, spatial planning alignment and sustainable human settlement solutions.

Equally important is the recognition of the social dimension of encroachment. Encroachers are not merely unlawful occupants, but individuals and communities driven by socio-economic necessity. Any intervention strategy must therefore balance infrastructure protection with human dignity, social justice and constitutional obligations. Relocation and enforcement measures should be accompanied by social support mechanisms and alternative housing solutions to ensure ethical and sustainable outcomes.

Encroachment management cannot be addressed in isolation. It requires strong leadership, intergovernmental co-operation, technological enablement and a humane, people-centred approach. Failure to act decisively and collaboratively will continue to place strategic water infrastructure, service delivery and public safety at risk.

11. RECOMMENDATIONS

The following recommendations are proposed:

1. Strengthen the integration of servitude data into municipal land-use planning and development control processes
2. Prioritise early intervention and prevention over reactive eviction and relocation
3. Enhance intergovernmental co-ordination to align infrastructure protection with housing and spatial development objectives
4. Position land professionals, surveyors and spatial planners as central actors in infrastructure risk management
5. The introduction of “Red Ants” in removing unlawful encroachers
6. To investigate the use of drones and/or satellite technology to monitor illegal presence of encroachers (informal) and structures (formal)
7. To resuscitate the South African Servitude Management Agency (SASEMA) proposal, which will address all encroachment issues. The impacted stakeholders e.g. Eskom, Sasol, Transnet, etc will have to commit financial support in appointing SASEMA as an approved structure in resolving all encroachments matters.
8. Resuscitate the engagement with the office of the Presidency and to include SALGA (South African Local Government Association) and any other relevant stakeholder/s
9. Report from the consultant to acquire high resolution imagery using remote sensing technology to map informal encroachments along Rand Water’s pipeline servitudes

must be considered. These findings will inform the formation of a tender to appoint a contractor to remove, relocate, monitor and prevent informal encroachments.

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