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DATE: 20 – 22 August 2025

Simulating Disaster Before It Strikes: EO and AI-Powered Risk Modelling for Climate Resilience in South Africa

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SHOWCASE SESSION 2

SHORT BIO

Nandi Mtethwa is an Engagement Manager at the Research Institute for Innovation and Sustainability (RIIS). She leads projects that apply Earth observation and data analytics to disaster preparedness, climate resilience, and decision-making across Africa. Her work includes the Africa Earth Observation Challenge and GIS-driven risk modelling, championing African-led solutions that connect space technologies with community needs.

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Many massive TSFs sit within meters of homes and farms - silent threats until climate extremes strike

- South Africa has hundreds of tailings storage facilities (TSFs), many holding tens of millions of cubic metres of mine waste.
- These giant structures are often right next to communities.
- The 2022 Jagersfontein disaster showed what happens when abnormal rainfall meets engineering failure: toxic slurry, homes destroyed, ecosystems poisoned.


TSFs in densely populated areas, Gauteng


Jagersfontein dam breach, Free State


TSFs in densely populated areas, , Free State

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Disasters don't wait for response plans - foresight is the only way to move faster than the flood

Once a dam fails, floods move faster than response systems can react.

In Jagersfontein, communities had minutes, not hours — by then, it was too late. The first hours determine not only lives saved, but also how infrastructure, ecosystems, and economies withstand the shock. Without foresight and simulation, every decision is delayed, every consequence magnified

Foresight shifts the timeline: instead of waiting for a breach, we anticipate it.

By simulating disasters before they strike, we give communities, governments, and companies the ability to:

- Mark evacuation routes.
- Reinforce critical infrastructure.
- Prepare ecosystems for recovery.

This is the heart of our work in Sekhukhune: **not response, but readiness**.

Resilience lasts when users shape the solutions they will rely on in crisis

Our work in Sekhukhune was built on co-design and trust-building.

We worked hand-in-hand with:

- Engineering teams – assessing the integrity of the TSF.
- Environmental specialists – conducting impact assessments.
- Health and safety teams – strengthening emergency response planning.
- Socio-economic development teams – ensuring community needs were central.

Outcomes

Defined assembly points, evacuation routes, and communication strategies that were practical, community-owned, and immediately usable.

This ensured simulations became living tools — not reports on a shelf.

The PIE Model: Seeing risk in full context

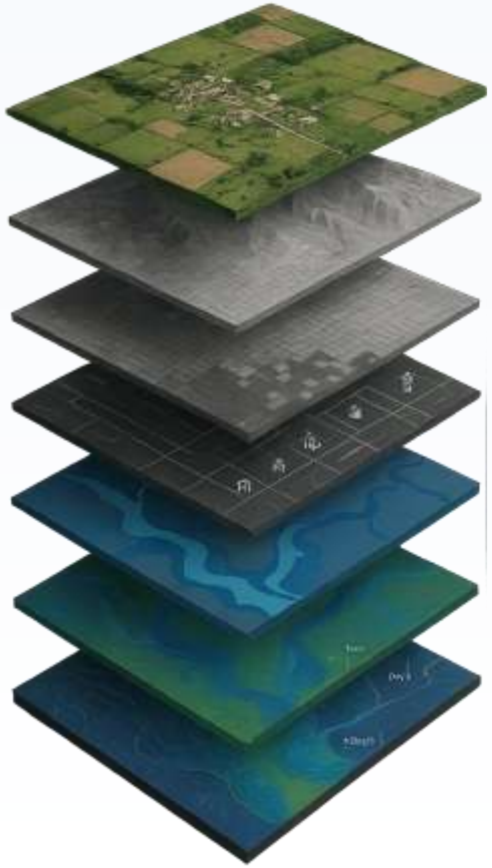
At RIIS, we use the PIE model — People, Infrastructure, Environment — to understand disaster risk as an interconnected system:

- **P**eople: households, schools, clinics, and gathering places.
- **I**nfrastructure: roads, bridges, power lines, pump stations, mining facilities.
- **E**nvironment: rivers, wetlands, farmland, and soils.

Disasters rarely hit one dimension alone. A washed-out bridge halts evacuation. A contaminated river poisons farmland. A damaged clinic leaves people without care.

The overlap is where risk turns into crisis — and where foresight matters most.

High-resolution data gives decision-makers the clarity to act when every minute counts

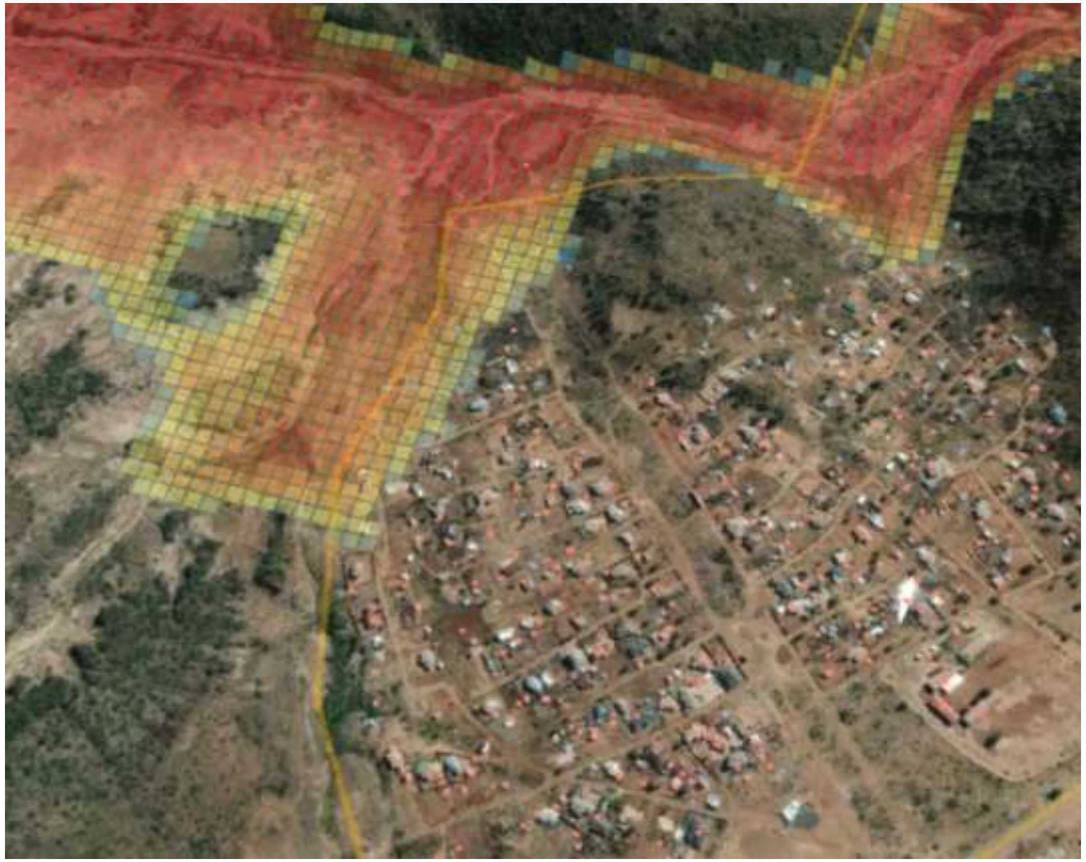


Our approach combined multiple streams of intelligence to make the Sekhukhune simulation more than just a flood map.

- Drone surveys gave 10 cm detail on settlements, tailings walls, and access roads.
- High-resolution EO imagery captured land cover and topography changes across the broader landscape.
- Hydrological and engineering models projected flow velocity, arrival times, and inundation depths.
- Population and infrastructure datasets revealed where people lived, moved, and depended on critical services.

By integrating these into a layered model, we could move from “where water flows” to “who is at risk, how fast, and what to do”.

Sunny or rainy, small breach or large - each possibility alters who and what is at risk

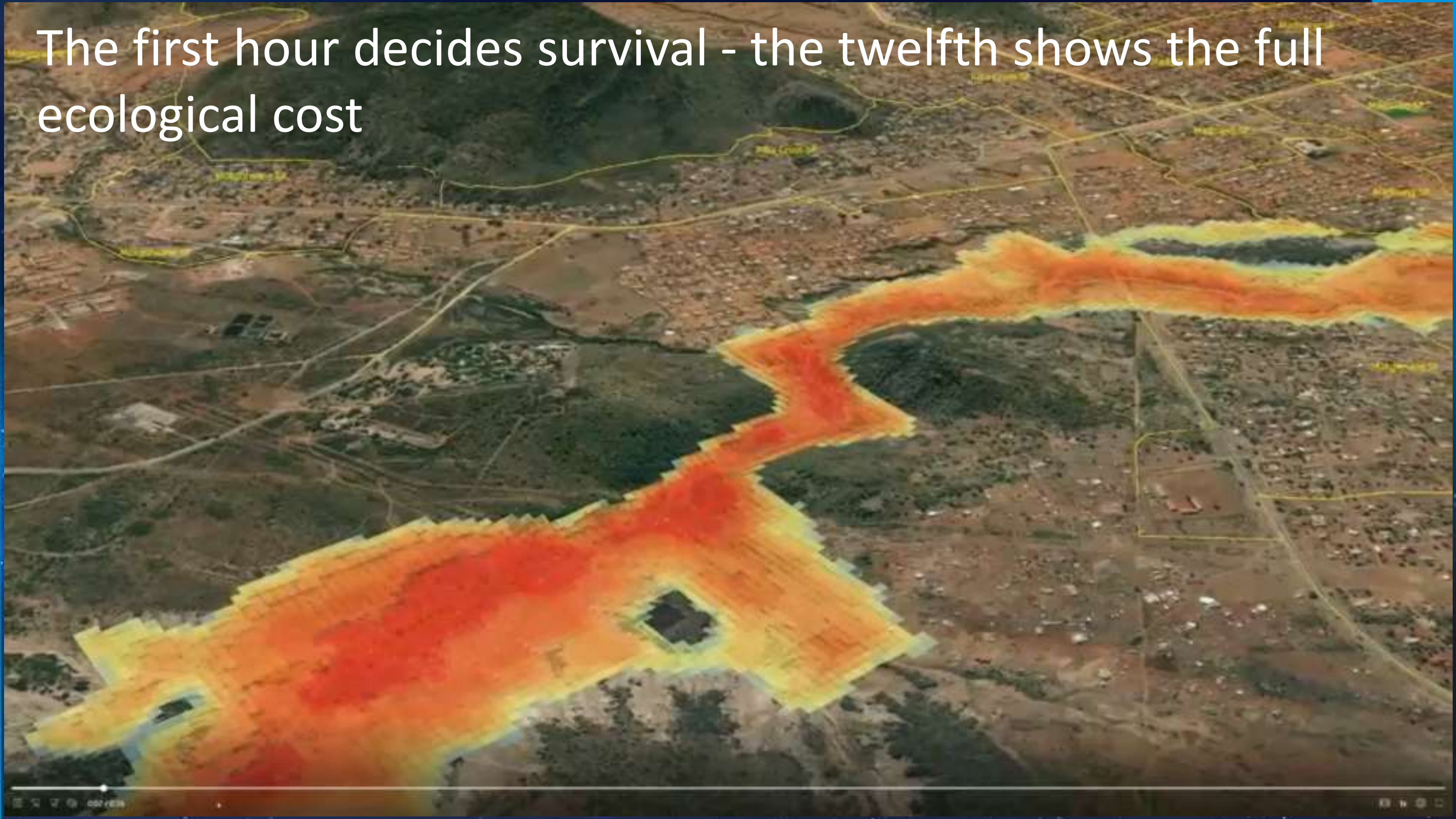


- Reactive = delayed sirens, rushed evacuations, preventable losses.
- Proactive = scenario foresight, safe design, informed evacuation planning.

Different rainfall + breach conditions change depth, arrival, velocity, exposure.

Our scenario modelling tested eight distinct cases, including new infrastructure that appeared after the initial baseline—captured through EO change detection.

The first hour decides survival - the twelfth shows the full ecological cost



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From data to resilience - transforming foresight into African-led preparedness

Key insights from the simulation

🛰️ EO-based hydrological models showed widespread flood + contamination risk.
👥 Community mapping revealed exposure, housing types, evacuation routes.
🏗️ Critical infrastructure mapped for reinforcement and redundancy.

Practical actions from the simulation

- Flood-proofing infrastructure.
- Pre-agreed assembly points and signage.
- Evacuation drills with clear routes.

This is not just for Sekhukhune — it is a scalable playbook for Africa.
African institutions can lead globally in context-specific EO resilience solutions.

Lessons scale beyond mining → national and continental resilience.
African-led EO + AI → predictive governance, inclusive resilience.

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