

FROM DATA SCARCITY TO DIGITAL TWINS: BUILDING RESILIENCE IN AFRICAN ROAD NETWORKS

ABSTRACT Road authorities in developing countries often struggle to manage extensive road networks with limited budgets, fragmented data, and ageing infrastructure. Without reliable asset information, renewals become reactive, expensive, and vulnerable to climate shocks. This paper shares lessons from two pioneering digital Road Asset Management (RAM) initiatives in sub-Saharan Africa: Tanzania's District Roads Management System (DROMAS) and Malawi's Highway Management System (MAHMS), which demonstrate how lightweight digital tools can transform renewal planning and build resilience across the asset lifecycle.

Both systems use cost-effective smartphone-based road condition, inventory, and traffic data integrated with GIS to build reliable digital road databases. These datasets were processed through tailored analytical tools (occasionally using HDM-4, often simplified deterioration models for low-volume networks). These "fit-for-purpose digital twins" allowed authorities to simulate maintenance backlogs, prioritise renewals, and optimise investment strategies over 5–10-year periods. In Tanzania, institutionalisation of DROMAS under TARURA provided vital information aiding expansion of network coverage in planning from less than 50% to nearly 100%, while also enabling performance-based renewal contracts. In Malawi, MAHMS introduced systematic condition data, reducing budget uncertainty and guiding annual and multi-year planning programmes.

Findings show that even in data-scarce, resource-constrained settings, digital RAM systems deliver measurable resilience across lifecycle stages: more intelligent planning, adaptive renewals, and enhanced accountability. A contrasting example from Zambia, where a RAM system failed due to weak institutional support, underscores how digital tools can help authorities make broad, sustainable decisions guided by qualitative and quantitative data.

The paper concludes with practical recommendations for scaling transformative digital twins for planning and management of road networks. It demonstrates how data-driven asset management can strengthen institutions to support smarter renewal programmes and embed resilience for sustainable development and management of road infrastructure in developing countries.