Corresponding author(s): Philipo Jacob Mtweve*, Abraham Eustace, Qambemeda Masala Nyanghura, Vincent Moseti, Tanja Kramm, Pierre Ibisch, Lisa Biber-Freudenberger

Last updated by author(s): Aug 20, 2025

Reporting Summary

Nature Portfolio wishes to improve the reproducibility of the work that we publish. This form provides structure for consistency and transparency in reporting. For further information on Nature Portfolio policies, see our Editorial Policies and the Editorial Policy Checklist.

Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

n/a	Confirmed	
☐	☒	The exact sample size (*n*) for each experimental group/condition, given as a discrete number and unit of measurement
☐	☒	A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
☐	☒	The statistical test(s) used AND whether they are one- or two-sided *Only common tests should be described solely by name; describe more complex techniques in the Methods section.*
☐	☒	A description of all covariates tested
☐	☒	A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
☐	☒	A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
☐	☒	For null hypothesis testing, the test statistic (e.g. *F*, *t*, *r*) with confidence intervals, effect sizes, degrees of freedom and *P* value noted *Give P values as exact values whenever suitable.*
☐	☒	For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☒	☐	For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☐	☒	Estimates of effect sizes (e.g. Cohen's *d*, Pearson's *r*), indicating how they were calculated

Our web collection on statistics for biologists contains articles on many of the points above.

Software and code

Policy information about availability of computer code

Data collection	QGIS 3.22 for spatial data processing and visualization, Structured stakeholder workshops with standardized protocols, GPS units for field validation (Garmin eTrex series), AHP-OS software for pairwise comparison analysis
Data analysis	R version 4.2.0 with packages: bnlearn (structure learning), gRain (probabilistic inference), tidyverse (data manipulation), QGIS 3.22 for weighted overlay modeling and spatial analysis, Monte Carlo simulation implemented in R, Bootstrap analysis using R boot package, Statistical analysis using R stats package

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio guidelines for submitting code & software for further information.

Data

Policy information about availability of data

All manuscripts must include a data availability statement. This statement should provide the following information, where applicable:
- Accession codes, unique identifiers, or web links for publicly available datasets
- A description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our policy

Code availability: Analysis code will be deposited in GitHub repository upon acceptance. Custom algorithms for MCDA-BBN integration developed for this study.

Data availability statement: All spatial datasets, stakeholder workshop outputs, BBN conditional probability tables, MCDA weight matrices, and analysis code are available upon request from the corresponding author. Restrictions apply to stakeholder personal information to maintain confidentiality agreements. All geospatial datasets are derived from publicly available sources (NASA SRTM, ESA WorldCover, OpenStreetMap) or obtained through formal agreements with Tanzania government agencies. Public datasets used:NASA SRTM 30m Digital Elevation Model, ESA WorldCover 2021 (10m resolution), WorldClim version 2.1 climate data, Global Human Settlement Layer 2020OpenStreetMap road networks, Restricted data: Stakeholder workshop recordings and detailed preference matrices maintained confidentially as per ethics approval requirements.

Research involving human participants, their data, or biological material

Policy information about studies with human participants or human data. See also policy information about sex, gender (identity/presentation), and sexual orientation and race, ethnicity and racism.

Reporting on sex and gender	Not applicable - study focused on infrastructure planning decisions rather than sex/gender-specific outcomes. Stakeholder gender was not recorded to maintain anonymity.
Reporting on race, ethnicity, or other socially relevant groupings	Participants were Tanzanian nationals representing diverse professional backgrounds. Ethnicity not recorded to maintain participant confidentiality.
Population characteristics	30 regional experts and decision-makers: tourism operators (n=2), planning officers (n=4), field ecologists (n=2), road development specialists (n=4), community representatives (n=2), conservation NGO staff (n=2), plus 14 additional experts from initial consultation.
Recruitment	Systematic stakeholder identification using power-interest matrix analysis. Participants selected based on professional expertise and stake in Greater Serengeti infrastructure decisions. Recruitment through professional networks and institutional contacts.
Ethics oversight	Research permits obtained from Tanzania Commission for Science and Technology (COSTECH) and Tanzania Wildlife Research Institute (TAWIRI). Informed consent obtained from all participants. Confidentiality maintained through anonymization of individual responses.

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☐ Life sciences ☐ Behavioural & social sciences ☒ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see nature.com/documents/nr-reporting-summary-flat.pdf

Ecological, evolutionary & environmental sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	Four proposed road development routes (Northern, Serengeti, Eyasi, Mbulu) in the Greater Serengeti Ecosystem; 30 stakeholders representing affected sectors; 13 spatially-explicit evaluation criteria across engineering, biodiversity, socioeconomic, and political domains.
Research sample	Four proposed road development routes (Northern, Serengeti, Eyasi, Mbulu) in the Greater Serengeti Ecosystem; 30 stakeholders representing affected sectors; 13 spatially-explicit evaluation criteria across engineering, biodiversity, socioeconomic, and political domains.
Sampling strategy	Purposive sampling for stakeholder selection based on expertise and decision-making authority. Comprehensive spatial sampling using systematic 30m grid for geographic analysis. Literature sampling used systematic database searches with defined keywords.
Data collection	Three-phase approach: (1) Systematic literature review of 47 peer-reviewed publications; (2) Expert consultation at TAWIRI conference with 14 specialists; (3) Three-day participatory workshops with 16 primary stakeholders using structured facilitation protocols.
Timing and spatial scale	Field data collection December 2022 - January 2024. Spatial extent: 30,000 km² Greater Serengeti Ecosystem with 50km analysis buffer. Temporal projections: 30-year infrastructure impact modeling.
Data exclusions	No systematic exclusions applied. All stakeholder responses meeting consistency criteria (CR<0.1) included in analysis. Spatial data gaps (<1% of study area) addressed through interpolation.
Reproducibility	All analysis protocols documented with standardized procedures. Monte Carlo validation (n=1,000 iterations) and bootstrap analysis (n=500) demonstrate result stability. Cross-method validation confirms robustness.
Randomization	Monte Carlo parameter sampling used Latin Hypercube Sampling for efficient coverage. Bootstrap validation used random sampling

Randomization	with replacement. No experimental randomization required for observational case study design.
Blinding	Not applicable - study involved collaborative stakeholder engagement requiring transparent participation. Spatial data analysis objective and not subject to observer bias.

Did the study involve field work? ☒ Yes ☐ No

Field work, collection and transport

Field conditions	Dry season field work (December-January) in savanna and highland environments. Temperatures 15-35°C, minimal precipitation. Access via 4WD vehicles and foot surveys.
Location	Greater Serengeti Ecosystem, northern Tanzania (2-4°S, 34-36°E). Field sites across protected areas, community lands, and proposed route corridors.
Access & import/export	Research permits from Tanzania Commission for Science and Technology (COSTECH Permit #2021-687-NA-2021-256).
Disturbance	Minimal disturbance protocols followed. GPS validation points selected to avoid wildlife disturbance. Stakeholder workshops conducted at established conference facilities. No experimental manipulation of natural systems.

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

n/a	Involved in the study
☒ ☐	Antibodies
☒ ☐	Eukaryotic cell lines
☒ ☐	Palaeontology and archaeology
☒ ☐	Animals and other organisms
☒ ☐	Clinical data
☒ ☐	Dual use research of concern
☒ ☐	Plants

Methods

n/a	Involved in the study
☒ ☐	ChIP-seq
☒ ☐	Flow cytometry
☒ ☐	MRI-based neuroimaging

Plants

Seed stocks	*Report on the source of all seed stocks or other plant material used. If applicable, state the seed stock centre and catalogue number. If plant specimens were collected from the field, describe the collection location, date and sampling procedures.*
Novel plant genotypes	*Describe the methods by which all novel plant genotypes were produced. This includes those generated by transgenic approaches, gene editing, chemical/radiation-based mutagenesis and hybridization. For transgenic lines, describe the transformation method, the number of independent lines analyzed and the generation upon which experiments were performed. For gene-edited lines, describe the editor used, the endogenous sequence targeted for editing, the targeting guide RNA sequence (if applicable) and how the editor was applied.*
Authentication	*Describe any authentication procedures for each seed stock used or novel genotype generated. Describe any experiments used to assess the effect of a mutation and, where applicable, how potential secondary effects (e.g. second site T-DNA insertions, mosiacism, off-target gene editing) were examined.*