

BIODIVERSITY SURVEY ON THE DISTRIBUTION OF INVASIVE ALIEN PLANT SPECIES (IAS) IN PUGU-KAZIMZUMBWI NATURE FOREST RESERVES

Overall Technical Report



**Prepared for
Tanzania Forest Service Agency (TFS)**

**Authors
Ezekiel E. Mwakalukwa, Sami D. Madundo, and Canisius J. Kayombo**

June 2025

This report fulfils the Terms of Reference for the task assigned by Tanzania Forest Services Agency (TFS) on “Biodiversity Survey on the Distribution of Invasive Alien Plant Species (IAS) in Pugu & Kazimzumbwi Nature Forest Reserves.” All findings, interpretations and conclusions are those of the authors and do not necessarily reflect the views of TFS.

Cover image: Photograph showing part of the landscape of Kazimzumbwi Nature Forest Reserve.

ACKNOWLEDGEMENTS

The authors would like to sincerely thank the Tanzania Forest Service Agency (TFS) for commissioning and supporting this important study. We are especially grateful to the management team of Pugu-Kazimzumbwi Nature Forest Reserve for their logistical assistance, guidance during field activities, and valuable insights into local forest dynamics.

We extend our appreciation to the local village leaders, forest rangers, and community members who shared their knowledge of the landscape and provided invaluable support during the reconnaissance and field inventory phases.

Special thanks are due to our field assistants and casual labourers whose dedication, hard work, and perseverance made it possible to complete the fieldwork under often challenging conditions.

Finally, we acknowledge the contribution of previous researchers and conservation practitioners whose work in Pugu-Kazimzumbwi NFR provided a foundation for this study. Their earlier efforts remain key in advancing the understanding and conservation of Tanzania's coastal forests.

EXECUTIVE SUMMARY

This consolidated report presents the findings of a biodiversity and invasive alien plant species (IAS) survey conducted across two coastal forest ecosystems—Kazimzumbwi Nature Forest Reserve (KNFR) and Pugu Nature Forest Reserve (PNFR)—located in the eastern zone of Tanzania. The study was commissioned by the Tanzania Forest Services Agency (TFS) as part of a broader effort to document the extent of IAS in priority forest reserves and guide adaptive management planning.

Across both forests, a combined total of 13 IAS species were recorded. IAS were observed to occur primarily in areas of past disturbance such as former logging trails, built-up encroachment zones, old mining corridors, and charcoal extraction paths. Notable invasive species included *Lantana camara*, *Manihot carthaginensis* subsp. *glaziovii*, and *Senna siamea*. While some differences existed in spatial distribution and dominance between the two forests, the general trend indicated early- to moderate-stage invasions.

Findings underscore the importance of early intervention through targeted removal, restoration planting with native species, and community engagement. The study provides spatial insights, plot-level metrics, and species-specific importance values that form the basis for practical recommendations for managing and preventing IAS spread.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS	i
EXECUTIVE SUMMARY	ii
TABLE OF CONTENTS	iii
1.0 INTRODUCTION	1
1.1 Background Information.....	1
1.2 Purpose of the Task.....	1
1.3 Approach Taken	1
2.0 METHODOLOGY.....	2
2.1 Study Location.....	2
2.2 Methods.....	2
2.2.1 Desktop Review and Reconnaissance Survey.....	2
2.2.2 Plot Layout and Sampling Design	2
2.2.3 Data Collection Protocols	2
2.2.4 Data Analysis and Processing.....	2
3.0 RESULTS	4
3.1 Vegetation Types and Plot Attributes	4
3.2 Species Composition	4
3.3 Diversity and Dominance Metrics	4
3.4 Spatial Distribution of Alien/Invasive Alien Plant Species.....	4
3.5 Observed Ecological Impacts and Disturbances	4
4.0 MANAGEMENT RECOMMENDATIONS	5
REFERENCES	6

1.0 INTRODUCTION

1.1 Background Information

Invasive alien plant species (IAS) are among the most significant drivers of biodiversity loss in tropical forest ecosystems. These species disrupt native flora and fauna by outcompeting indigenous species, altering soil chemistry, and modifying fire regimes and hydrological cycles (Rai, 2022; van Kleunen et al., 2015). In Tanzania's coastal forests, where biodiversity is already under pressure from human encroachment, the establishment and spread of IAS represent a growing threat to conservation goals.

Kazimzumbwi and Pugu Nature Forest Reserves are two such ecosystems situated near the rapidly urbanizing region of Dar es Salaam. Despite their protected status, both forests have experienced anthropogenic pressure including logging, farming, settlement expansion, and infrastructure development. These disturbances create conditions favorable for IAS establishment and spread.

1.2 Purpose of the Task

Responding to the Tanzania Forest Service Agency (TFS) call for action, this task set out to fulfil the following specific objectives:

1. Map the current distribution and coverage of IAS within Pugu- Kazimzumbwi NFR, identifying hotspots and invasion corridors;
2. Quantify IAS composition and density across distinct vegetation types, comparing their diversity and dominance to indigenous plant communities;
3. Assess potential ecological impacts, including suppression of native regeneration, alteration of fuel characteristics, and interactions with disturbance regimes;
4. Provide spatially explicit management recommendations to guide rapid response, restoration, and long-term monitoring.

1.3 Approach Taken

The assignment combined a desktop review and reconnaissance with a systematic plot inventory which recorded all trees, shrubs, herbs, and identified IAS. Field observations were then integrated with location data to produce spatial maps of IAS hotspots to pinpoint the areas where management action is most urgently needed.

2.0 METHODOLOGY

2.1 Study Location

Pugu Nature Forest Reserve (PNFR) and Kazimzumbwi Nature Forest Reserve (KNFR) are coastal forest remnants located in Kisarawe District, within the eastern administrative region of Tanzania. KNFR covers approximately 4,000 ha, while PNFR spans roughly 2,410 ha. Both reserves are part of the coastal vegetation forests of Tanzania and host unique species assemblages.

2.2 Methods

2.2.1 Desktop Review and Reconnaissance Survey

A targeted literature scan (Frontier 1993, 2002; TFCG 2013; Mdemu & Burra 2016) and stakeholder discussions with TFS personnel and village scouts provided baseline information on likely IAS hotspots and access routes. A 14-day reconnaissance survey was conducted in December 2024. The survey team assessed plantation patches of exotic trees, identified visible IAS, and conducted 300-meter transect walks in four cardinal directions from identified IAS sites. The aim was to confirm spread patterns, inform sampling layout, and detect additional disturbance factors (Palys, 2008).

2.2.2 Plot Layout and Sampling Design

A systematic sampling design was used, with plots spaced at 600–700-meter intervals. In total, 80 and 60 plots were planned in KNFR and PNFR respectively. Due to encroachment and inaccessibility, 77 plots were surveyed in KNFR and 55 in PNFR. Each plot measured 15 m radius and was georeferenced using UTM coordinates.

2.2.3 Data Collection Protocols

Within each sampling plot the team recorded:

- Dominant vegetation type.
- Trees ≥ 1 cm DBH – species, DBH (cm), status (alien/indigenous), life-form, count.
- Understorey (< 1 cm) – seedling counts by species inside the 2 m sub-plot.
- Photographs of alien plants for pictorial representation of the existing alien taxa.
- Plot attributes: UTM coordinates (in EPSG 21037), elevation (m asl), slope ($^{\circ}$), canopy cover (% - spherical densiometer), litter depth (cm), disturbance category (Undisturbed, Low, Moderate, High).

Botanical determinations to the species level were conducted with the aid of a botanist; doubtful taxa were photographed for additional expert verification.

2.2.4 Data Analysis and Processing

Field data were entered into Microsoft Excel and cleaned. All further analyses used R version 4.4.2 (R Core Team, 2025):

- Vegetation summaries – number of plots, total individuals, mean canopy cover, slope, elevation.
- IAS metrics – per vegetation type: stem totals, plot incidence, Shannon–Wiener (H'), Simpson (1-D), and relative abundance (%).
- Hotspot mapping – presence/absence mapping overlaid within the forest.
- Statistical comparisons – Wilcoxon rank-sum for invasion status influence on forest diversity (Shannon diversity and Simpson dominance metrics).

All GIS operations were completed in QGIS 3.42.1 (QGIS.org, 2025) with field-collected UTM coordinates.

3.0 RESULTS

3.1 Vegetation Types and Plot Attributes

Kazimzumbwi had a broader range of vegetation types (8 total), dominated by Bushland, Wooded Grassland, and Thicket. PNFR had 7 types, with Coastal Forest and Bushland being most common. Built-up plots were recorded in both forests. Mean canopy cover was highest in Coastal Forests and lowest in built-up and grassland areas.

3.2 Species Composition

Across both forests, more than 40 IAS species were recorded. KNFR recorded 26 species, while PNFR had 42. IAS were more spatially concentrated in Kazimzumbwi, particularly in disturbed Wooded Grassland and Bushland zones. *Lantana camara* was the most dominant species in KNFR, while *Manihot glaziovii* dominated PNFR.

3.3 Diversity and Dominance Metrics

Shannon and Simpson indices showed slightly higher values in invaded plots across both forests. However, Wilcoxon tests indicated these differences were not statistically significant ($p > 0.05$). Diversity in Pugu was generally lower than in Kazimzumbwi, likely due to spatial fragmentation and edge effects.

In Kazimzumbwi, *Lantana camara* had an IVI of 41.9, substantially outcompeting other IAS. In Pugu, *Manihot glaziovii* had an IVI of 33.3, followed by *Lantana camara* (21.7). Several fruit tree species (e.g., *Psidium guajava*, *Mangifera indica*) were found in built-up plots, indicating ornamental or subsistence planting.

3.4 Spatial Distribution of Alien/Invasive Alien Plant Species

Spatial analysis of invasive alien plant species (IAS) presence in each Nature Forest Reserve showed a clustered invasion pattern. IAS were recorded in approximately 40% of the surveyed plots with hotspots most apparent along forest borders, ridge disturbances, and near forest-settlement boundaries. The distribution suggests that IAS spread in the reserves is primarily associated with legacy disturbance zones, previous border tree planting and ongoing peri-urban pressure. Species-specific distribution maps for key invaders were prepared to support site-specific management planning.

3.5 Observed Ecological Impacts and Disturbances

In both reserves, IAS were associated with canopy gaps, former charcoal kilns, and edge encroachment. In KNFR, *Lantana camara* was observed to suppress native seedling growth. In PNFR, riparian zones were threatened by *Syzygium cumini*, which could alter stream flow and bank stability.

4.0 MANAGEMENT RECOMMENDATIONS

1. Prioritize IAS removal in hotspot zones: Targeted eradication campaigns should focus on plots with high IVI scores for dominant species such as *Lantana camara* and *Manihot glaziovii*. Manual uprooting, chemical treatments, or a combination of methods may be employed depending on the infestation severity and terrain.
2. Implement native species restoration post-removal: Once IAS are removed, native tree and shrub species should be reintroduced to occupy the niche vacated by invasives. This reduces the likelihood of re-invasion and promotes natural ecosystem regeneration.
3. Establish a routine IAS monitoring program: Long-term monitoring is essential for early detection and rapid response. Permanent plots and periodic surveys should be instituted to track changes in IAS spread, especially in high-risk vegetation types.
4. Strengthen community awareness and boundary enforcement: Local communities should be sensitized on the ecological impacts of IAS and discouraged from introducing exotic species. Additionally, forest boundaries must be clearly demarcated and patrolled to prevent illegal activities that create openings for invasives.
5. Promote research and training in IAS control: Investment in local research and capacity building will ensure that forest managers and conservation personnel are equipped with the skills and knowledge to tackle emerging IAS challenges using evidence-based methods.

REFERENCES

- Boussougou, G. B., Brou, T. and Valimba, P. (2018). Vulnerability of Pugu and Kazimzumbwi Forest Reserves Under Anthropogenic Pressure in Southeast Tanzania. DOI: 10.1007/978-3-319-95165-2_16. In book: Computational Science and Its Applications – ICCSA 2018 (pp.231-240).
- Frontier Tanzania (1993). Site description and evaluation: Kazimzumbwi forest, Kisarawe district, Tanzania. 19pp.
- Frontier Tanzania (2002). Kazimzumbwi Forest Reserve. A Biodiversity Survey. Hall, S.M., Staddon, S., Howell, K.M. and Fanning, E. (Eds.). Coastal Forest Research Programme Technical Report No. 26.
- Lyimo, J. G., Kangalawe, R. Y. M. and Liwenga, E. T. (2017). Status, Impact and Management of Invasive Alien Species in Tanzania. Tanzania Journal of Forestry and Nature Conservation, 79 (2): 28-42.
- Mdemu, M.V and Burra, M. M. (2016). Drivers of Land Cover Dynamics for Pugu and Kazimuzumbwi Forest Reserves in Kisarawe, Tanzania. Open Journal of Forestry, 2016, 6, 348-360. <http://dx.doi.org/10.4236/ojf.2016.65028>
- QGIS.org (2025). QGIS Geographic Information System. QGIS Association. <http://www.qgis.org>
- Rai, P.K. (2022). Environmental Degradation by Invasive Alien Plants in the Anthropocene: Challenges and Prospects for Sustainable Restoration. Anthropogenic Science, 1:5–28. <http://dx.doi.org/10.1007/s44177-021-00004>
- R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <https://www.R-project.org/>.