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# Assessment of Environmental Safeguard Integration in Land Tenure Regularization Using GIS Suitability Analysis and Ground Verification: Evidence from Mbarali District, Tanzania

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**ABSTRACT**

This study assessed the extent to which environmental safeguards were integrated into the implementation of the Land Tenure Improvement Project in Mbarali District, Mbeya Region, a semi-arid ecosystem bordering the Ruaha National Park and encompassing the Usangu wetland system. The study employed GIS-based suitability analysis using the Analytical Hierarchy Process, field verification through physical observations and Key Informant Interviews, and legal document review. Findings reveal significant discrepancies between GIS model classifications and field-verified environmental conditions across seven study wards. Several sites classified as moderately suitable by the GIS/AHP model were identified as environmentally hazardous through ground verification, including waterlogged areas in Igurusi, erosion-prone gullies in Rujewa and Ubaruku, and floodplain areas in Kongolo Mswiswi. Rujewa, Igurusi, Kongolo Mswiswi, and Ubaruku wards exhibited higher concentrations of environmentally sensitive land compared to Lugelele, Mapogoro, and Madibira. The study concludes that GIS suitability modeling alone is insufficient for environmental safeguard compliance in land regularization and must be complemented by systematic field verification, legal compliance assessment, and stakeholder engagement. Strengthened institutional capacity, inter-agency coordination, and integration of climate resilience considerations are essential for sustainable Land Tenure Improvement Project Implementation.

**Keywords**: Land tenure improvement, Environmental safeguards, GIS suitability analysis, hazardous land

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## INTRODUCTION

Land Tenure Improvement (LTI), as the formal process of adjudicating, surveying, and documenting land rights through cadastral and titling processes, has gained traction as a means of enhancing land market functioning, land use productivity, conflict reduction, women's empowerment, and general governance (Ali *et al.*, 2014). Environmental safeguards-policy measures, legal requirements, and procedural safeguards established under Tanzania's Environmental Management Act (2004), Land Act (1999), and the World Bank Environmental and Social Framework (2017), are designed to mitigate LTI's risks when integrated systematically from the land use planning stage through to title issuance (FAO, 2016). However, the relationship

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between land formalization and environmental outcomes is complex. For long-term sustainability of LTI, environmental protections must be purposefully incorporated into each phase of the regularization of land tenure (Kironde, 2019; Deininger and Alemu, 2012; Burns et al., 2007; Ricci and Lehfeld, 2025). Globally, accelerating rural and urban expansion driven by population growth has increased pressure on environmentally sensitive land, generating demand for land-based investments, housing, and infrastructure that intersect with fragile ecosystems (Robinson *et al*., 2014). While lack of formal tenure may incentivize unsustainable land use through over-exploitation of common resources, formal regularization can equally trigger land conversion, subdivision of ecologically sensitive areas, and encroachment on wetlands, forest reserves, and water catchments (Ghatak and Mookherjee, 2014; Delville *et al*., 2002; Toulmin, 2009).

There have also been discussions about the formalization of land tenure regularization in Africa, the recent increase in demand for land and the scarcity of available land highlight how crucial it is to protect the rights to permit land-related investment that would reduce the productivity gap while also guaranteeing that rising land values benefit local land users rather than posing a threat of dispossession (Pacheco and Benatti, 2015). In Ethiopia, land regularization and certification have been done at the expense of soil conservation and reforestation. This implies that there is an integration of environmental considerations and land tenure security (Teklemariam et al., 2016). Similarly, Rwanda has made headway in integrating the environmental safeguards in their LTI programs (Sagashya and English, 2010). In Tanzania, as land tenure reform picks up speed, equitable and resilient land governance will depend on striking a delicate balance between environmental sustainability and tenure security. Rapid land regularization can lead to greater land fragmentation and unsustainable agricultural intensification (Kombe and Kreibich, 2006). Tanzania's larger pledges to environmental sustainability under national policies like the Environmental Management Act (EMA) of 2004 and the National Environmental Policy (2021) may be jeopardized by this tendency. However, village land-use planning has inherently been integrating the environmental considerations through environmental zoning and associated conservation strategies (United Republic of Tanzania, 2019). The existing Urban Planning (Planning Space Standards) Regulation of 2018 has considered and provided some measures to protect sensitive lands; however, its compliance is somehow challenging when it comes to the regularization process due to capacity and resource constraints, planning design shortcomings, institutional fragmentation, and social-legal complexities of informal settlements and land acquisition barriers (URT, 2024).

Existing research on land tenure improvement has largely focused on socio-economic outcomes, including impacts on property rights, land markets, credit access, and equity (Markussen and Tarp, 2014; World Bank, 2017). While some studies from Ethiopia (Teklemariam et al., 2016) and Rwanda (Sagashya and English, 2010) have examined the relationship between land certification and environmental outcomes, the specific challenge of integrating formal environmental safeguard frameworks into operational land tenure regularization processes remains underexplored. In particular, no study has systematically examined how GIS-based suitability analysis, field verification, and legal compliance review interact to determine environmental safeguard outcomes within an ongoing land titling project in Tanzania. This gap is significant given the complex ecological conditions characterizing many LTIP implementation areas and the legal obligations established under Tanzania’s Environmental Management Act (2004), Land Act (1999), and the World Bank Environmental and Social Framework. Against this background, this study assesses the integration of environmental safeguards in LTIP implementation in Mbarali District, Mbeya Region, Tanzania, with specific focus on: (i) the concordance between GIS suitability analysis outcomes and field-verified environmental conditions; (ii) the application of legal and regulatory compliance criteria in regularization decisions; and (iii) governance and institutional factors affecting safeguard integration.

## METHODOLOGY

### Case Study Selection and Sampling

This study was done in Mbarali District, Mbeya Region, in the South-Western Part of Tanzania. Mbarali has a total population of 446,336 (217,280 males and 229,056 females) with 112,139 households at an average size of 4 people (URT 2022). Mbarali District was purposively selected based on three criteria: (i) its ecological sensitivity as a semi-arid ecosystem encompassing the Usangu wetland and bordering Ruaha National Park; (ii) the intensity of LTIP implementation, with seven wards undergoing concurrent cadastral survey and titling; and (iii) the diversity of land use pressures including rice irrigation, pastoralism, and peri-urban expansion that create a range of environmental safeguard challenges. The LTIP Initiative in Mbarali District was implemented in seven (7) townships/wards namely Madibira, Ubaruku, Rujewa, Lugelele, Mabadaga, Igurusi, and Kongolo as shown in Table 1 and Figure 1.

**Table 1: Townships/Wards where LTI initiatives are Implemented; Source: URT, 2022**

| Townships/Wards | | | | Villages |
|---|---|---|---|---|
| **Name** | **Population** | **Number of households** | **Household size** | |
| Rujewa | 42,013 | 11058 | 3.8 | Mbuyuni, Ihanga, Mlimani, Isisi and Mabanda |
| Lugelele | 15,810 | 4,358 | 3.6 | Igawa, Lugelele ‘A’ and Lugelele ‘B’ |
| Mabadaga | 37,753 | 9,610 | 3.9 | Madadaga |
| Igurusi | 27,878 | 7,947 | 3.5 | Ilolo, Igurusi, Lusese, Lunwa, Majenje, and Rwanyo |
| Kongolo Mswiswi | 14,079 | 3,852 | 3.7 | Kongolo Mkola and Kongolo Mswiswi |
| Madibira | 38,120 | 9,359 | 4.1 | Mkunywa, Mahango, Chalisuka and Ikoga |
| Ubaruku | 46,318 | 13,294 | 3.5 | Mwakaganga, Mbarali, Ubaruku, Mkombwe Mpakani and Majengo |

The selection of these seven wards for active implementation and consequently for this study was based on the intensity of ongoing land transactions, readiness for cadastral survey, and the presence of documented environmental sensitivities, including proximity to rivers, wetlands, and erosion-prone terrain. The study therefore adopts a full coverage approach with respect to LTIP implementation, encompassing all wards in which formalization activities were conducted, which represents approximately 64% of the LTIP-identified wards in the district. The selected wards collectively represent a diversity of ecological and land tenure conditions, ranging from wetland-adjacent and flood-prone areas (Igurusi, Kongolo Mswiswi) and erosion-affected zones (Rujewa, Ubaruku) to relatively stable peri-urban land (Lugelele, Mapogoro), thereby adequately capturing the range of environmental safeguard challenges present within the LTIP study area.

### Data Collection Methods

Primary data were collected through five sequential stages. The first stage involved face-to-face key informant interviews which were conducted with 3 representatives from approximately 14 institutions purposively selected based on their technical relevance to land administration, environmental management, and infrastructure planning, including District Council departments, NEMC, TANESCO, TANAPA, Rufiji Basin Water Board, OSHA, TARURA, TANROADS, and the Ministry of Lands, yielding an estimated 42 key informants in total. Interviews followed an open thematic approach covering five themes: LTIP environmental compliance awareness, observed safeguard practices, inter-agency coordination, community engagement, and implementation gaps.

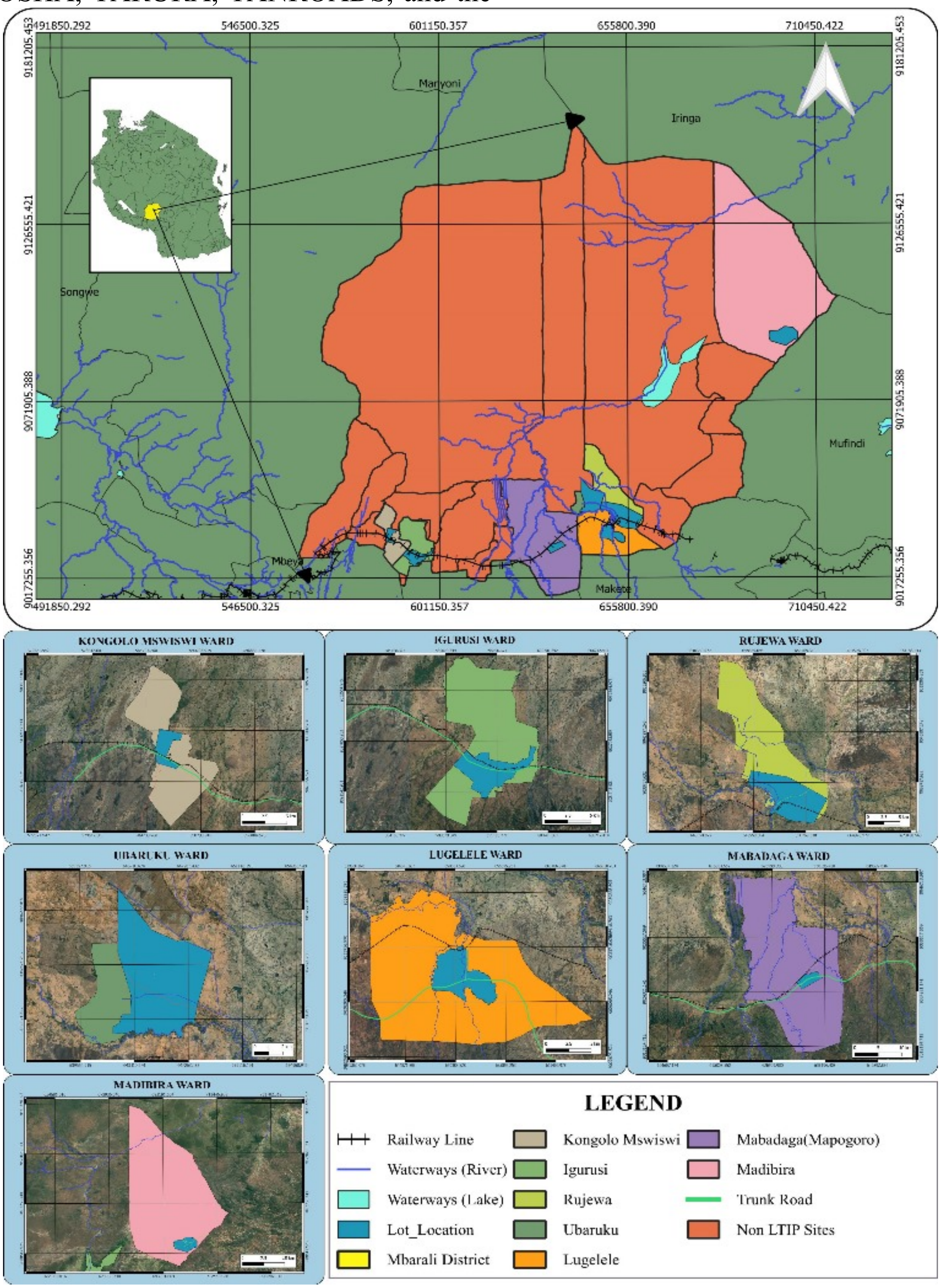


**Figure 1: Townships/Wards where LTI initiatives are Implemented**

A total of 52 community sensitization sessions were conducted across seven wards, reaching 3,391 participants (54% men and 46% women). In addition, 6,792 people were reached through awareness campaigns implemented by 26 social experts from nine Civil Society Organizations (CSOs). Participants were mobilized through ward and village leaders, and feedback was captured through grievance register books distributed to all 52 hamlets, through which 179 grievances were formally logged and resolved. Third, a validation meeting was held with selected technical and community representatives to review and confirm preliminary findings. Fourth, physical site observations were conducted by the LTIP Environmental Technical Team using a standardized assessment checklist across 12 environmentally sensitive sites, recording parameters including drainage, slope stability, erosion, flooding indicators, and proximity to sensitive features.

Secondary data comprised a structured review of documents selected for their direct relevance to LTIP implementation, including the LTIP ESMP, World Bank Environmental and Social Framework, and applicable Tanzanian legislation. To ensure reliability, triangulation was applied throughout by systematically cross-validating findings from interviews, community consultations, field observations, GIS analysis, and document review. Where discrepancies arose between data sources, particularly between GIS outputs and field-verified conditions; findings were reconciled through legal compliance assessment and the judgment of the LTIP Environmental Technical Team, strengthening the credibility and defensibility of all assessment outcomes.

**Assessment of compliance of LTIP on environmental safeguards**

The compliance assessment was conducted in three sequential steps, beginning with a GIS-based Analytical Hierarchy Process (AHP) implemented in ArcGIS Pro for suitability analysis. Eight criteria were used to evaluate susceptibility to flood, waterlogging, and erosion hazards: Digital Elevation Model (DEM), slope, Land Use/Land Cover (LULC), Topographic Wetness Index (TWI), flow accumulation, valley depth, profile curvature, and watershed characteristics. SRTM 30 m DEM and Landsat 2023 imagery were used as primary datasets. All spatial layers were projected to a common coordinate system, WGS 84 / UTM Zone 37S, to ensure spatial consistency and reduce geometric distortion. The datasets were resampled to 30 m resolution and standardized into a uniform suitability scale of 1 (not suitable), 2 (moderately suitable), and 3 (suitable) prior to weighted overlay analysis.

AHP was applied using expert judgment from specialists in hydrology, geomorphology, and environmental management. Pairwise comparisons followed Saaty's (1980) scale to determine relative importance of criteria. The resulting weights were: DEM (28.6%), slope (21.1%), LULC (15.9%), TWI (11.7%), flow accumulation (8.6%), valley depth (6.3%), profile curvature (4.7%), and watershed (3.1%). Higher weights for DEM and slope reflect their dominant influence on runoff generation and terrain-driven hydrological processes, while lower weights for curvature and watershed reflect secondary influence. The consistency ratio (CR) was 0.017, indicating strong logical consistency and reliability of expert judgments. Model validation was conducted using field observations and spatial accuracy assessment techniques, including confusion matrix analysis, overall accuracy, and Kappa coefficient. In addition, ROC curve analysis and Area Under Curve (AUC) were used to evaluate predictive performance, with higher values indicating stronger model reliability. A sensitivity analysis was performed by varying criterion weights by ±10–20% to test model stability. Results showed that DEM and slope had the greatest influence on hazard zonation, while curvature and watershed variables had minimal impact. Overall, the model demonstrated strong robustness and stable performance underweight perturbation scenarios

The second step involved field verification through physical site inspections conducted by the LTIP Environmental Technical Team using a standardized checklist. Observed parameters included drainage patterns, slope stability, erosion evidence, vegetation cover, flooding indicators, and proximity to rivers and wetlands. Community meetings and validation sessions at ward and village levels complemented site inspections by capturing residents' historical knowledge of site conditions. The third step was a legal and regulatory compliance review assessed against the Land Act (1999), Environmental Management Act (2004), Urban Planning Regulations (2018), the World Bank Environmental and Social Framework, and the LTIP ESMP. Hazardous land was defined operationally per Land Act 1999, Cap 113, Part III, Section 7(i). Where GIS outputs conflicted with field findings, field verification and legal compliance assessment took precedence. Only plots satisfying all three steps were qualified for regularization.

## RESULTS

Results related to the environmental protection compliance assessment carried out in seven wards in Mbarali are presented in this section. Twelve environmentally vulnerable regions, waterlogged sites, marshy areas, erosion-prone areas, flood plain areas, and hazardous areas were the focus of the study. Six of the twelve sites had contentious issues that required several evaluations in order to be eligible for regularization.

### Environmental Safeguards Integration in water lodged areas

Twenty plots in Jipe Moyo hamlet, Majenje Village (Igurusi Ward), were under consideration for regularization. A discrepancy was observed between the GIS/AHP model outputs and field-verified conditions. The model classified the area as moderately suitable (Figure 2), whereas field assessments indicated environmental concerns related to inadequate drainage and potential flood risk. On-site observations revealed localized temporary water retention, slow surface runoff, and predominantly light brown to beige clay soils. Additionally, a hand-dug water storage dam for rainwater harvesting was identified within the area. Community consultations indicated a recurrent history of seasonal flooding, particularly during periods of intense rainfall.

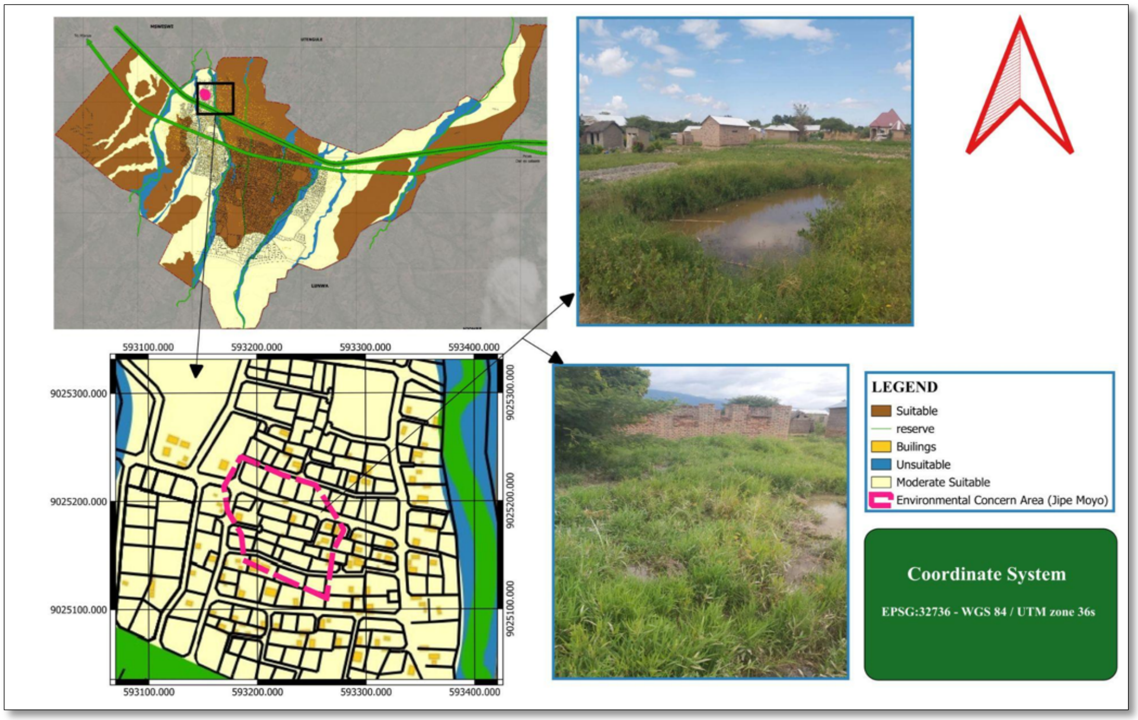


**Figure 2: Suitability Map of Igurusi Ward, Majenje Village, Jipe Moyo Hamlet**

However, in applying the legal compliance framework, the area does not meet the statutory definition of hazardous land as stipulated under the Land Act, 1999 (Cap. 113), Part III, Section 7(i), the Environmental Management Act, 2004, or the Environmental and Social Management Plan (ESMP) safeguard criteria for project site selection. Although flood susceptibility was confirmed, the LTIP Environmental Technical Team determined that the associated risks are manageable through appropriate engineering and drainage interventions and do not constitute an irreversible threat to life, infrastructure, or the environment. The area was approved for regularization subject to the following conditions: land must be set aside for a drainage system to direct water toward residents were observed, primarily diverting water from a river along the western boundary of the settlement.

Community consultations revealed recurrent waterlogging during the rainy season, with some residents attributing the condition to the presence of underground springs. The adjacent paddy farming areas; urban agriculture is the preferred land use to reduce impervious surface cover and maintain water infiltration; and housing development that blocks water infiltration should be discouraged. These measures will reduce flood risk and enhance long-term infrastructure stability (Ma et al., 2024).

**Environmental safeguards Integration in swampy areas**

Jangwani A hamlet, located in Rwanyo Village, Igurusi Ward, was identified as an area of environmental concern. Field observations indicated that the site is characterized by a flat, low-lying topography with clay-dominated soils, where the relative elevation compared to surrounding areas promotes water accumulation and retention. Informal drainage channels constructed by absence of a properly engineered drainage system limits the effective conveyance of excess surface and subsurface water away from the area. In addition, the prevailing clay soils exhibit relatively low water storage capacity compared to loam and sandy soils, and are associated with reduced infiltration rates (Kuok et al., 2023; Mesele et al., 2024).

The interaction between poor drainage infrastructure and low-permeability soils exacerbates the waterlogging conditions in the area. The suitability analysis model classified the area as moderately suitable (Figure 3).

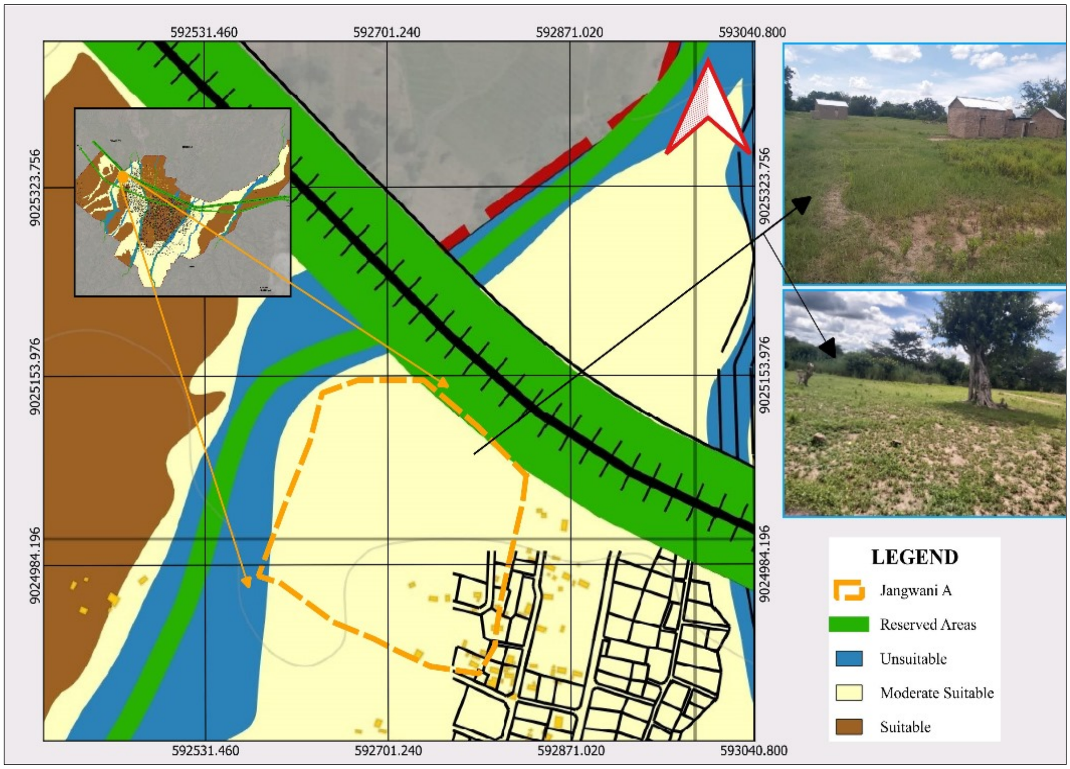


**Figure 3: Area of Environmental Concern in Rwanyo village, Jangwani A hamlet**

Unlike Jipe Moyo, no discrepancy was found between the GIS output and field verification; both indicated moderate environmental sensitivity. Under the Land Act 1999, Cap 113, Part III, Section 7(i), the area does not qualify as hazardous land, as waterlogging is attributable to drainage deficiencies rather than irreversible terrain or environmental conditions. The area therefore has merit for regularization, provided mitigation measures are implemented. Regularization was approved under the conditions of allowing the construction of drains to drain excess water to the river, greening of the land to improve water absorption, and a 15-meter stream buffer zone. Title deeds may be issued for residential use when all of these conditions are met.

**Environmental safeguard integration in erosion-prone areas**

Jangwani B hamlet in Rwanyo village, Igurusi ward, contained five houses situated near the base of a scree slope. The area was characterized by clay soil, gentle but erodible upper edges, and a relatively flat lower section where the houses are located. A perennial stream without embankments serves as the main drainage outlet and is subject to meandering during heavy rainfall. Community consultations confirmed that rainwater actively erodes the cliff edges of the upper land during the rainy season. The AHP model classified the area (Figure 4) as moderately suitable, while field assessment identified active erosion risk and flood hazard.


**Figure 4: Environmental Concern Area at Rwanyo Village, Jangwani B Hamlet**

A significant discrepancy existed between the GIS classification and field-verified conditions. The model underestimated risk because slope instability, stream meandering, and active erosion at the scree edge are not adequately captured at 30-meter raster resolution. Field assessment confirmed that the area is prone to soil erosion from runoff and flooding, as it lies at the same elevation as the unembankened stream. Under the Environmental Management Act 2004, Part V, Section 51, the area qualifies as a sensitive area, encompassing land prone to soil erosion, slopes, and fragile terrain. Furthermore, the LTIP ESMP directs that regularization should not be carried out in areas meeting the Land Act 1999 definition of hazardous land. The site meets this definition, as development would pose a danger to life and lead to environmental degradation on contiguous land. The area was therefore excluded from residential regularization. Urban agriculture is recommended as the appropriate land use, as cultivating the land will stabilize the soil matrix, manage surface runoff, and reduce erosion risk (Xia et al., 2022; Mainuri et al., 2013). No title deeds should be issued for residential purposes.

**Environmental safeguard integration in flood plain areas**

Mshikamano Hamlet in Kongolo Mswiswi village was classified as moderately suitable (Figure 5) by the AHP model. Site verification confirmed a gentle slope and proximity to a seasonal river whose banks lack embankments. During the dry season, the river has minimal flow; however, community consultations revealed that during peak rainy seasons parts of the area function as a floodplain. The main environmental concern was the proximity of surveyed plots to the river channel and the absence of engineered flood protection.

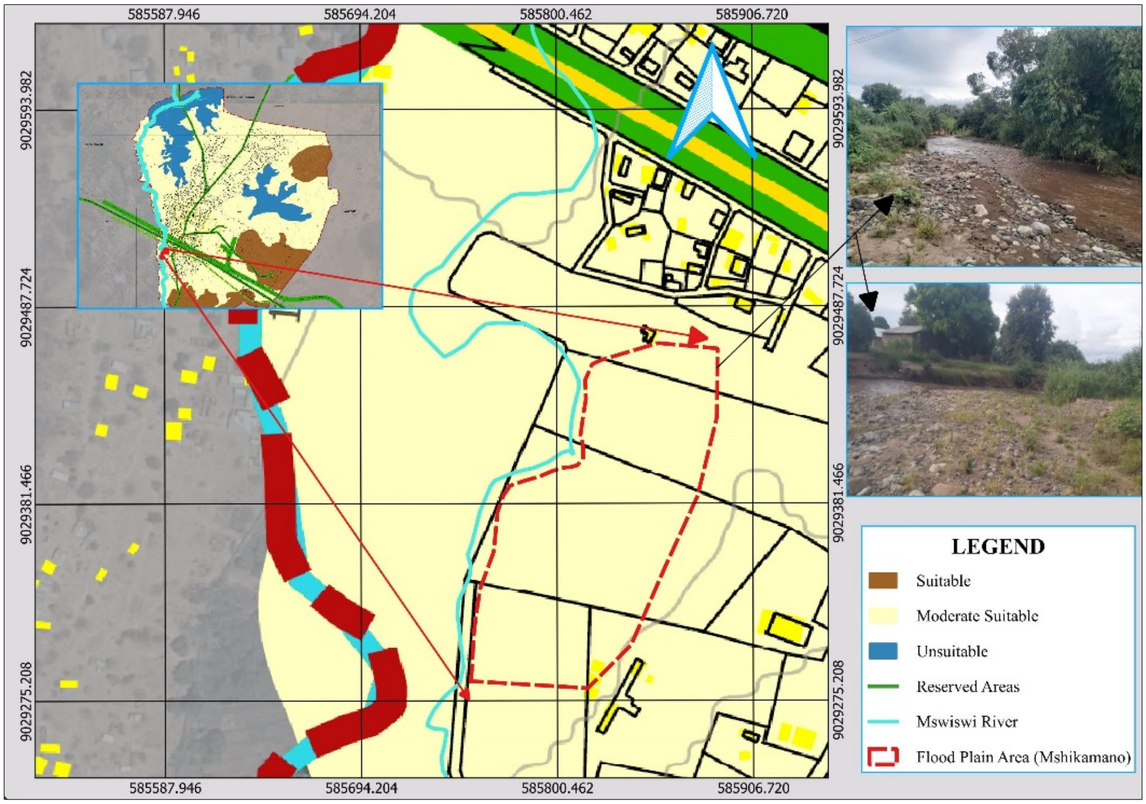


**Figure 5: View of an Area Identified as a Floodplain during Peak Rainy Seasons**

This implies that there is a partial discrepancy between the GIS classification and field findings. While the model correctly identified the area as moderately sensitive, it did not capture the seasonal floodplain function or the absence of riverbank protection. Following legal compliance assessment against the Land Act 1999, Cap 113, Part III, Section 7(i), Environmental Management Act 2004, Part V, Section 51, and the ESMP directives, the area was determined to be manageable and does not meet the threshold for hazardous land classification. The flood risk is seasonal, localized, and addressable through standard engineering mitigation. Regularization was recommended for plots situated beyond the approved river reserve boundary. A mandatory 30-meter buffer zone must be maintained from each side of the riverbank. River embankments integrated with nature-based infrastructure, including trees and grasses, must be constructed to prevent overflow into the regularized area and improve the river's flood retention capacity (Xia and Chen, 2021; Radhakrishnan et al., 2018; Stark et al., 2016).

**Environmental safeguard considerations in flood prone area**

Flooding was reported at Jangurutu Primary School in Jangurutu hamlet, Kanisani B village, Rujewa ward. Field assessment revealed that flooding originates from an outfall canal designed to divert excess water from an investor's irrigation canal to the Jangurutu River (Figure 6). Physical inspection of the canal identified the following conditions: the canal is constructed but unpaved; banks are composed of silt soil; the surveyed canal section covers approximately 1,153.93 m² with a length of 225.39 m, canal width is non-uniform throughout; and sediment accumulation was observed in localized deposits within the channel, restricting flow capacity. The AHP model classified the surrounding land as non-hazardous, as flooding occurs only during heavy rainfall and is concentrated in the mid-section of the canal near the primary school, while the upper section remains unaffected.

A partial discrepancy existed between the model output and observed conditions, indicating that flooding is seasonal and localized rather than permanent or life-threatening but did not capture the sediment management and canal maintenance deficiencies contributing to overflow. Following assessment against the Land Act 1999, EMA 2004, and ESMP directives, the area does not qualify as hazardous land. The flooding risk is attributable to canal management failures rather than inherent terrain hazard and is therefore addressable through targeted engineering intervention.


**Figure 6: Irrigation Canal at Jangurutu**

The land along the canal should be planned, surveyed, and registered. However, initiatives to heighten the outfall canal embankments by 0.5 m - 1 m are crucial to expand its capacity, ensuring it can accommodate a larger volume of water and prevent overflow into surrounding areas. Furthermore, the nature of the soil used is silt, which is somehow easy to be eroded by rainwater due to its particle size, which are detached when exposed to water or runoff (Chen et al., 2023). Therefore, embankments should be constructed by using a mixture of silt and clay soil or only clay soil. In addition, there is a need to dredge the outfall canal to eliminate the soil pile that restricts water flow from the main canal to the river and lining unpaved areas to reduce soil deposits (Hasan, 2024). Sediment accumulation has formed irregular deposits within the channel, reducing its effective depth and restricting water flow. Clearing these deposits will help restore its capacity. Furthermore, the embankments need to be compacted to enhance their strength and stability. Also, some sections of the channel are significantly narrower than others, restricting water movement and increasing the risk of overflow. Expanding these sections will create a more uniform width, allowing the channel to hold and direct water more efficiently.

**Environmental Safeguards integration in hazardous areas**

Two sites were identified as hazardous: Shimo la Mchanga in Wameri hamlet, Isisi village, Rujewa ward, and a gully in Mpakani village, Ubaruku ward. At Shimo la Mchanga, the site is actively used for sand extraction within human settlements, resulting in large gullies with depths ranging from approximately 1.3 to 3 meters. Field observations characterized the site as having mixed sand, clay, and loam soil; a depressed landform; scarp slopes in most areas; steep edges where farming occurs; and a total gully area of 37,082 m². Vegetation consists of shrubs, grasses, and swamp plants. Some community members farm within the gully despite known risks. The Mpakani gully originates from Majengo village's irrigation scheme, passes through Ubaruku ward, and joins a larger gully in Songwe ward. It is characterized by seasonal water inundation, illegal sand and soil mining, informal dumping, and soil instability. The AHP model classified both sites as moderately suitable (Figure 7).

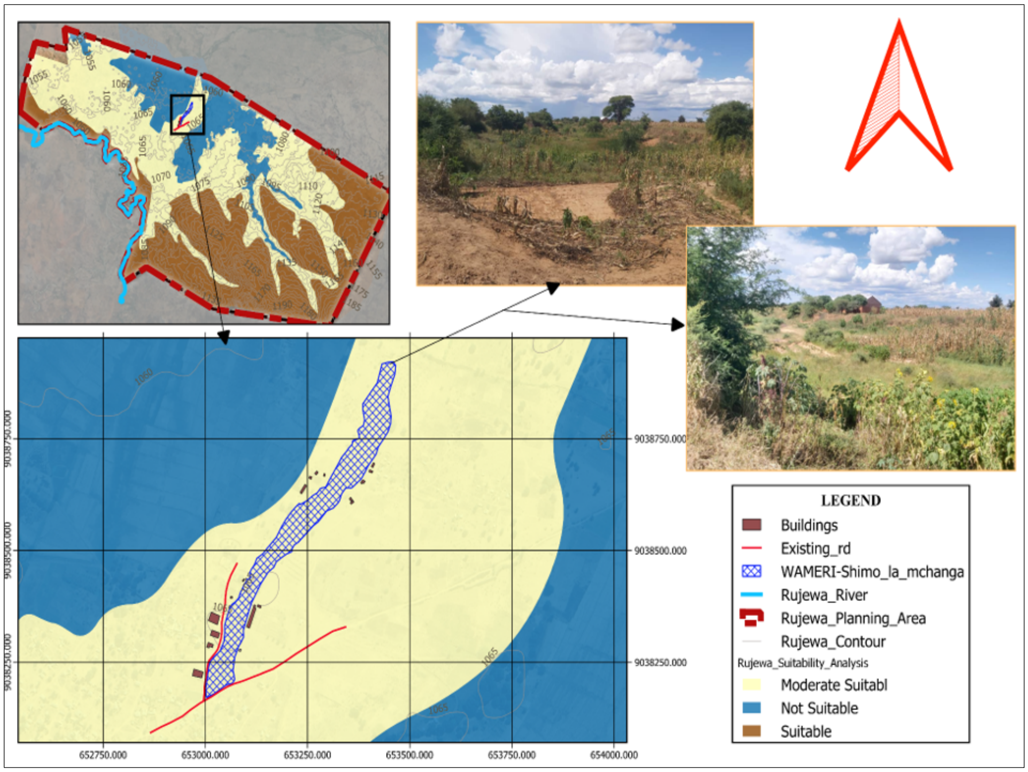


**Figure 7: A Map Showing Discrepancy in Suitability Before and After Ground Truthing**

The model's moderate suitability classification failed to capture active gullying, scarp instability, and ongoing hazard-generating activities. Under the Environmental Management Act 2004, Part V, Section 51, both areas qualify as sensitive land encompassing erosion-prone, fragile, and environmentally significant terrain. Under the Land Act 1999, Cap 113, Part III, Section 7(i), both sites meet the definition of hazardous land, as continued development would pose a danger to life and lead to further environmental degradation on contiguous land. The LTIP ESMP further directs that regularization must not be carried out in such areas. Both sites were excluded from regularization. Environmental education and sustained community engagement are required to address ongoing sand mining and farming within the gullies. Ward and village authorities should enforce existing prohibitions on sand extraction and implement monitoring mechanisms to prevent recurrence.

## DISCUSSION

The findings suggest that GIS/AHP-based screening may underestimate certain site-specific environmental risks of regularization sites. This has important implications for the environmental screening required in land tenure programme. In five of the six sites assessed, field verification either qualified or directly contradicted the model's classification, with the most critical discrepancies at Jangwani B and Shimo la Mchanga, both classified as moderately suitable despite active hazard conditions confirmed on the ground. This finding is consistent with the work of Robinson et al. (2014), which found that spatial modelling tools have consistently failed to capture the dynamic site conditions proven to be determinative for hazard classifications, and the guidance provided by the World Bank (2017), which recommends that GIS screening be conducted in combination with ground-based verification. What this study contributes beyond existing evidence is an operationalized three-step compliance framework which combines AHP suitability analysis, standardized field verification, and legal compliance review, demonstrates how such integration can be structured within an active land titling project, offering an indicative transferable methodological model for comparable LTIP contexts across Tanzania and Sub-Saharan Africa.

The findings also expose a structural gap between policy intent and operational practice in safeguard implementation at district level.

Tanzania's legal frameworks provide adequate definitional guidance for hazardous land identification, yet their translation into regularization decisions requires levels of technical competence, multi-agency coordination, and enforcement capacity that are inconsistently available locally. This aligns with Kironde (2019), Kombe and Kreibich (2006), and Burns et al. (2007), who documented institutional fragmentation and capacity deficits as persistent barriers to regulatory compliance across Tanzanian and Sub-Saharan African land administration contexts. Strengthening the ESMP alone is insufficient; what is needed is explicit embedding of environmental screening protocols including mandatory field verification and legal compliance sign-off into LTIP operational procedures, supported by formal inter-agency coordination between land administration, environmental management, and urban planning authorities. The climate resilience dimension equally demands attention: several sites approved as currently manageable, particularly Jipe Moyo, Jangwani A, and Mshikamano were assessed against present-day hydrological conditions without accounting for projected changes in rainfall intensity in the Rufiji basin under climate change scenarios (Ricci and Lehfeld, 2025). Incorporating climate risk screening into LTIP environmental compliance assessments would significantly improve the long-term defensibility of regularization decisions, particularly given Mbarali's position within the ecologically sensitive Usangu wetland system (Table 2).

Finally, several methodological limitations qualify the interpretation of these findings. The AHP model's weighting, while internally consistent (CR = 0.017), was derived from a single pairwise comparison exercise without sensitivity analysis to test output stability under alternative weighting scenarios, potentially introducing classification uncertainty across ecologically distinct wards. Field observations, though conducted using a standardised checklist by trained technical teams, involved inherent professional judgement in interpreting site conditions. The findings are also derived from a single case study district, limiting direct generalizability to other LTIP areas; however, the three-step assessment framework and the institutional patterns identified reflect conditions documented across multiple Tanzanian and regional land administration contexts, supporting broader applicability of the study's methodological and policy conclusions.

**Table 2: Cross-site Summary of Environmental Safeguard Compliance Assessment Outcomes**

| Site/ Ward | GIS/AHP Classification | Field Verification | GIS–Field Discrepancy | Legal Compliance | Conclusion |
|---|---|---|---|---|---|
| Jipe Moyo/ Igurusi | Moderately suitable | Waterlogging, clay soil, flooding history | Yes | Not hazardous — Land Act 1999, EMA 2004, ESMP | Approved with conditions |
| Jangwani A/ Igurusi | Moderately suitable | Waterlogging, clay soil, low-lying terrain | No | Not hazardous — Land Act 1999 | Approved with conditions |
| Jangwani B/ Igurusi | Moderately suitable | Active erosion, scree slope, unembankened perennial stream | Yes | Hazardous — EMA 2004 s.51; Land Act 1999 s.7(i) | Excluded — urban agriculture recommended |
| Mshikamano/ Kongolo Mswiswi | Moderately suitable | Gentle slope, seasonal river, seasonal floodplain function | Partial | Not hazardous — Land Act 1999, EMA 2004, ESMP | Approved with conditions |
| Jangurutu/ Rujewa | Non-hazardous | Seasonal canal flooding, silt banks, sediment accumulation | Partial | Not hazardous — flooding attributable to canal management | Approved with conditions |
| Shimo la Mchanga/Rujewa | Moderately suitable | Active gullying, scarp slopes, illegal sand mining, soil instability | Yes | Hazardous — EMA 2004 s.51; Land Act 1999 s.7(i) | Excluded from regularization |

## CONCLUSION AND RECOMMENDATIONS

This study assessed the integration of environmental safeguards in the Land Tenure Improvement Project (LTIP) implemented across seven wards in Mbarali District, Tanzania, using a three-step compliance assessment framework combining GIS/AHP suitability analysis, systematic field verification, and legal compliance review. The principal finding is that GIS-based suitability modelling, while a useful initial screening tool, is insufficient for reliable environmental hazard identification in the context of land tenure regularization. These findings demonstrate that sustainable regularization requires the sequential integration of technical suitability analysis, on-site verification, stakeholder engagement, and legal compliance assessment as a unified decision framework rather than as separate or optional steps.

The study recommends the following: formally embedding a standardized three-step compliance protocol within LTIP operational guidelines; strengthening environmental assessment capacity within district-level teams and inter-agency coordination between land administration, environmental management, and urban planning authorities; incorporating community environmental education as a sustained component of project implementation; and integrating climate risk screening into suitability assessments to account for areas that may deteriorate under future climate scenarios. The study acknowledges that the single case study design and reliance on qualitative field assessments limit direct generalizability; however, the methodological framework and governance implications are transferable to other LTIP implementation areas in Tanzania and comparable land tenure programs in sub-Saharan Africa and provide a foundation for future longitudinal research on long-term safeguard compliance outcomes.

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