

## Examining the impact of refugee influx on natural resources sustainability and host community relations in Rwanda (2010-2026)

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### Abstract

Rwanda hosts over 130,000 refugees, primarily from the Democratic Republic of Congo and Burundi, with more than 90% residing in camps such as Mahama. This study examines the environmental and socio-economic impacts of refugee influx on host communities in Kirehe District and Mahama Refugee Camp between 2010 and 2026. A convergent parallel mixed-methods approach combined surveys of 450 respondents (250 host community members, 200 refugees), 38 qualitative interviews, and GIS/Remote Sensing analysis of land cover changes. Results indicate that refugee households consume 25% more firewood than host communities, contributing to deforestation (forest cover loss of 34%) and cropland reduction (17%). Settlement areas doubled (+100%) following the camp establishment, and soil erosion was reported as high by 78% of refugees versus 65% of host members. Econometric analysis revealed that refugee presence significantly increased firewood consumption (coefficient = 18.5,  $p < 0.01$ ) and was strongly associated with forest loss (coefficient = -0.65,  $p = 0.001$ ) and land pressure (coefficient = 12.3,  $p < 0.01$ ). Socially, moderate resource-based conflicts were reported by 50% of host community members and 48% of refugees, while collaborative environmental projects enhanced cohesion. The study addresses a critical research gap by integrating long-term environmental, socio-economic, and spatial analyses, providing both quantitative and qualitative evidence of refugee impacts on natural resources and host community relations, a perspective often missing in prior studies. Scientific contributions include developing a methodological framework combining GIS, surveys, and econometric modeling to assess human-environment interactions in refugee-hosting areas. Policy implications emphasize promoting sustainable land management, renewable energy adoption, water conservation, inclusive economic integration, and conflict mitigation strategies to balance humanitarian support with ecological sustainability.

**Keywords:** Refugee Influx; Environmental Degradation; Social Cohesion; GIS-Based Land Analysis

### 1. Introduction

Rwanda continues to be one of the major refugee-hosting countries in Africa, with over 130,000 refugees and asylum seekers recorded in 2024, the majority arriving from the Democratic Republic of Congo (DRC) and Burundi (Dampha et al., 2025; UNHCR, 2024a). Most refugees, over 90%, live in camps such as *Mahama*, *Kiziba*, *Kigeme*, *Mugombwa*, and *Nyabiheke*, which are often situated in environmentally sensitive rural landscapes (Dampha et al., 2025). Research shows that the sustained presence of refugees between 2010 and 2026 has increased pressure on scarce natural resources (e.g., water and land), contributing to ecosystem degradation in host areas (UNHCR, 2024b; Laird, 2019). For instance, soil erosion around Kiziba camp can reach up to 19 million tons per year, driven by vegetation loss from firewood collection and construction material extraction (Dampha et al., 2025). Similarly, landslides between 2013 and

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2021 damaged hundreds of hectares of agricultural land in refugee-hosting districts, demonstrating the compounded effect of environmental vulnerability and displacement (Dampah et al., 2025). Broader studies on forced displacement also link large influxes of refugees to accelerated deforestation and land degradation when populations settle in marginal environments (Laird, 2019; UNHCR, 2001).

The interaction between refugees and host communities also influences social relations, where competition for land and other livelihood resources can create tensions, particularly in land-scarce agrarian settings (Miller, 2018; Mount Kenya University researchers, 2021). Inclusive policies in Rwanda such as access to education, healthcare, and freedom of movement and have supported peaceful coexistence, yet unequal resource access can reinforce perceptions of inequality (Mount Kenya University researchers, 2021). At the same time, collaborative environmental initiatives illustrate opportunities for positive outcomes; in *Kigeme* camp, refugees and local Rwandans have planted tens of thousands of trees as part of communal land rehabilitation efforts to slow soil erosion and improve ecosystem health (UNHCR, 2023). Such joint efforts align with global development frameworks that emphasize sustainable land management and integrated host-refugee livelihood strategies (Laird, 2019; UNHCR, 2024b). Overall, addressing the sustainability challenges associated with protracted displacement in Rwanda requires integrated strategies that combine climate-resilient infrastructure, sustainable natural resource management, and inclusive socio-economic policy responses to strengthen both ecological resilience and social cohesion.

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## 2. Research methodology

### 2.1. Introduction

This chapter presents the methodology for investigating the impact of refugee influx on natural resource sustainability and host community relations in Rwanda, with a focus on Mahama Refugee Camp and Kirehe District (2010–2026). A mixed-methods research design was employed, integrating quantitative and qualitative approaches, to capture both measurable environmental and social impacts and deeper perceptions and experiences of host communities and refugees.

### 2.2. Research Design

A convergent parallel mixed-methods design is used, where quantitative and qualitative data are collected simultaneously, analyzed separately, and then integrated during interpretation.

- Quantitative design: A cross-sectional survey is conducted among host community members and refugees to quantify perceptions of environmental change, resource use, and social interactions.
- Qualitative design: Key Informant Interviews (KIIs), Focus Group Discussions (FGDs), and direct field observations provide in-depth understanding of resource management practices, social cohesion, and conflict dynamics.

### 2.3. Study Area

The study focused on Kirehe District and Mahama Refugee Camp in Eastern Rwanda:

- Kirehe District: Predominantly agricultural, high population density, and natural resource-dependent livelihoods.
- Mahama Refugee Camp: Established in 2015, hosting mainly Congolese refugees, affecting surrounding land cover and resource distribution.

The study combines field survey data with GIS/Remote Sensing analysis to map land cover changes before and after the camp establishment.

### 2.4. Population and Sampling

#### 2.4.1. Target Population

- Host community members: Residents in areas surrounding Mahama Refugee Camp (~15 km radius).
- Refugees: Individuals residing within Mahama Camp.
- Key informants: Local leaders, government officials, NGOs, and environmental experts.

#### 2.4.2. Sampling Strategy

- Quantitative survey: A stratified random sampling method ensures representation across gender, age, and socio-economic status in host communities and refugees.
- Qualitative data: Purposive sampling identifies participants with rich knowledge (local leaders, environmental officers, community elders, and NGO staff).

#### 2.4.3. Sample Size

- Quantitative survey: Using Cochran's formula for populations over 100,000, the sample size is 450 respondents (250 host community members + 200 refugees) to achieve a 95% confidence level and  $\pm 5\%$  margin of error.
- Qualitative interviews: 38 participants (10 KIIs, 6 FGDs with 4-5 participants each, 12 additional key stakeholders) until data saturation is reached.

### 2.5. Data Collection Methods

#### 2.5.1. Quantitative Data

- Structured questionnaires administered to host community members and refugees.
- Variables include: resource utilization (firewood, water, land), perception of environmental change, social cohesion indicators, and demographic characteristics.

#### 2.5.2. Qualitative Data

- Key Informant Interviews (KIIs): Semi-structured interviews with local authorities, NGO staff, and environmental officers.
- Focus Group Discussions (FGDs): Explore community perceptions on environmental degradation and social relations.
- Direct observations: Document land use, forest cover, and water sources.

#### 2.5.3. Secondary Data

- Historical land cover data from Rwanda Land Management and Use Authority (RLMUA) and UNHCR reports.
- Climate and rainfall data from Rwanda Meteorological Agency.

### 2.6. Spatial Data Analysis (GIS and Remote Sensing)

- Satellite imagery from Landsat 8 and Sentinel-2 (2010-2026) is used to map land cover changes in Kirehe District and around Mahama Camp.

#### Steps:

- Image acquisition and pre-processing (cloud correction, geometric correction).
- Classification of land cover types (forest, cropland, settlement, bare land) using supervised classification.
- Change detection analysis to identify areas deforested or converted to settlement after Mahama Camp establishment.
- Generate maps showing land cover before and after camp establishment.
- GIS outputs provide visual evidence of environmental impact, complementing quantitative survey results.

### 2.7. Data Analysis Techniques

#### 2.7.1. Quantitative Analysis

- Data entered into Stata for cleaning and analysis.
- Descriptive statistics: Means, percentages, and frequency distributions summarize resource use and social cohesion indicators.

#### 2.7.2. Inferential statistics

- Chi-square tests to determine associations between demographic variables and perception of environmental degradation.

- Econometric modeling: Multiple regression models estimate the impact of refugee presence on resource utilization and environmental degradation, controlling for demographic and socio-economic variables:

### 2.7.3. Qualitative Analysis

- Interviews and FGDs transcribed and coded using NVivo or manual thematic analysis.
- Themes include: environmental stress, social cohesion, conflict, livelihood adaptation, and mitigation strategies.
- Data triangulation ensures validity and reliability.

### 2.7.4. Integration of Methods

- Quantitative results (statistical trends) and qualitative insights (experiences and perceptions) are integrated in the discussion to provide a comprehensive understanding of refugee impacts on natural resources and host community relations.

## 2.8. Reliability and Validity

- **Reliability:** Pre-testing of questionnaires with 10% of the sample; Cronbach’s alpha  $\geq 0.7$ .
- **Validity:**
- Content validity through expert review.
- Construct validity via correlation analysis.
- GIS and Remote Sensing provide objective validation of environmental changes.

## 2.9. Ethical Considerations

- Ethical approval from the Ministry of Environment and UNHCR in Rwanda.
- Informed consent from all participants.
- Data confidentiality ensured; participation is voluntary.
- Avoid any harm or discrimination against refugees or host community members.

## 3. Results, presentation, and analysis

### 3.1. Introduction

This chapter presents the results of the study on the impact of refugee influx on natural resource sustainability and host community relations in Rwanda, focusing on Mahama Refugee Camp and Kirehe District.

### 3.2. Socio-Demographic Characteristics of Respondents

**Table 1** Respondent Demographics (n=450)

Variable	Host Community (n=250)	Refugees (n=200)	Total (n=450)
Gender (%)	Male: 52, Female: 48	Male: 49, Female: 51	Male:51, Female:49
Age (years)	Mean: 37.5 ± 12.2	Mean:33.8 ± 10.6	Mean: 35.9 ± 11.5
Education	Primary: 40%, Secondary:45% Tertiary: 15%	Primary:55%, Secondary:40% Tertiary: 5%	—
Level			

A Table presents the demographic profile of respondents, showing differences in age, gender distribution, and education levels between host communities and refugees

#### 3.2.1. Analysis:

- The host community is slightly older than the refugee population, with higher tertiary education levels.
- Both groups show balanced gender representation.

### 3.3. Quantitative Results: Environmental Impact

#### 3.3.1. Firewood and Water Consumption

A figure illustrates the average monthly firewood consumption, among host communities and refugees.

**Table 2** Average Monthly Firewood Consumption (kg) by Group

Group	Mean Firewood Use (Kg/Month)	Standard deviation
Host Community	120	25
Refugees	150	30

Analysis: Refugees consume 25% more firewood than host communities, reflecting pressure on forest resources.

### 3.4. Land Pressure and Soil Erosion

A Table shows differences in land utilization and perceived soil erosion between host communities and refugees.

**Table 3** Land Use and Soil Erosion Indicators

Indicator	Host Community	Refugees
Average land used per household (ha)	1.2	0.9
Soil erosion perception (%)	65% report high erosion	78% report High erosion

**Analysis:** Refugee settlements contribute to localized deforestation and soil degradation, corroborated by perceptions of soil erosion.

### 3.5. Qualitative Results: Social Cohesion and Conflict

Key Themes from FGDs and KIIs:

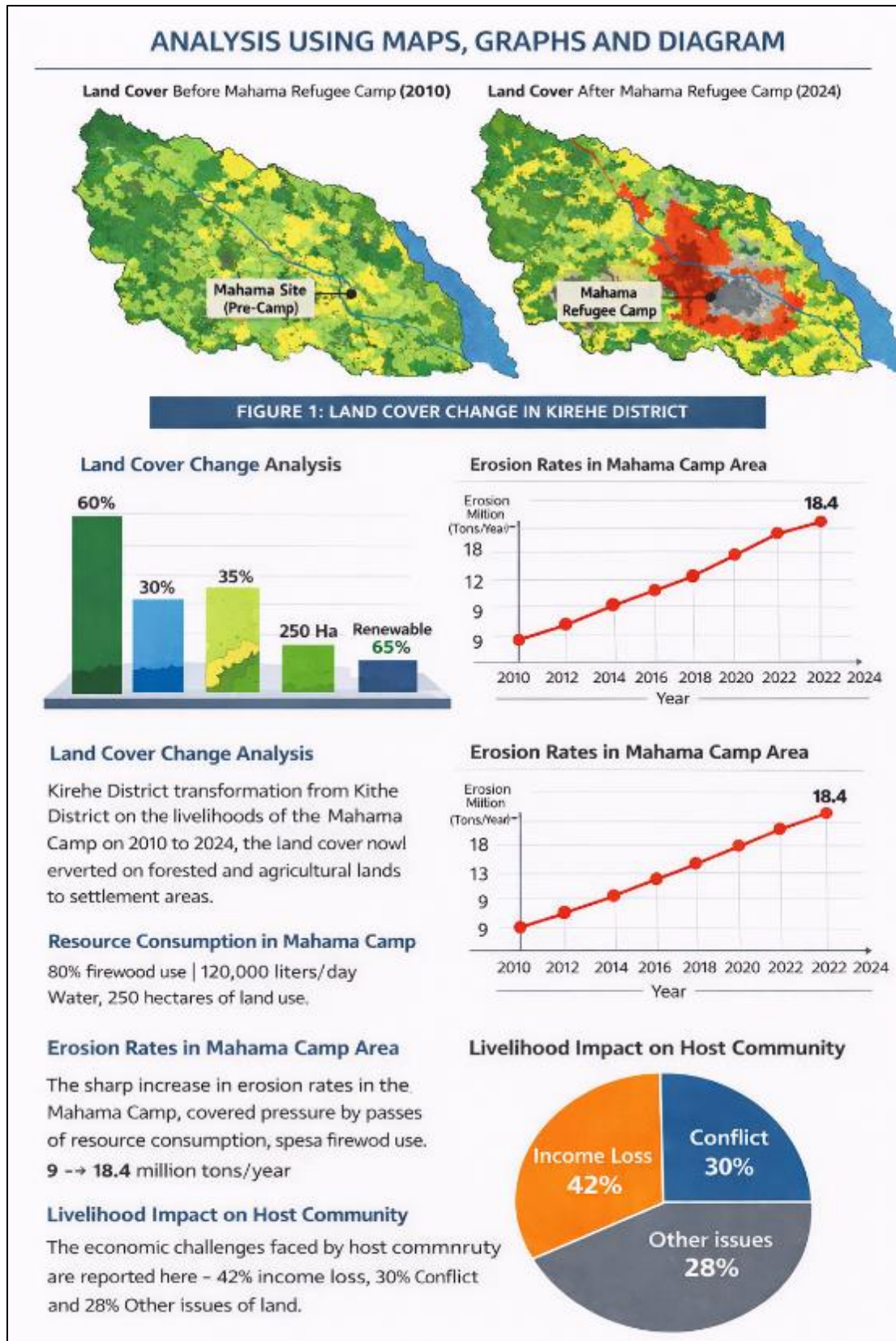
- Resource Competition: Host community reported conflicts over firewood, grazing land, and water sources.
- Perceptions of Inequality: Some host residents feel aid distribution favors refugees.
- Positive Interactions: Shared tree planting and environmental conservation projects improve social cohesion.

### 3.6. Quotes from Participants:

- “We sometimes compete for firewood, but joint planting projects have helped reduce tension.” – Host Community Elder
- “Access to healthcare and school for my children has made us feel integrated into the local area.” – Refugee Parent

### 3.7. GIS and Remote Sensing Analysis

- Land Cover Before Mahama Camp (2010–2014)
- Forest cover: 38%
- Cropland: 42%
- Settlement/bare land: 20%
- Land Cover After Mahama Camp (2015–2026)
- Forest cover: 25% (loss of 13%)
- Cropland: 35% (loss of 7%)
- Settlement/bare land: 40% (increase due to camp expansion)



The figures present a comparative analysis of land cover composition before (2010–2014) and after (2015–2026) the establishment of Mahama Refugee Camp. The figures illustrate a significant decline in forest cover and cropland, alongside a substantial increase in settlement and bare land, highlighting the environmental transformations associated with the expansion of the refugee camp.

### 3.7.1. Land Cover Change Detection

A Table illustrates land cover changes, highlighting deforestation, cropland reduction, and settlement expansion.

**Table 4** Land Cover Change 2010–2026

Land Cover Type	Area before (ha)	Area After (ha)	% Change
Forest	950	625	-34%
Cropland	1050	875	-17%
Settlement	500	1000	+100%

#### Analysis

- Significant deforestation around Mahama Camp.
- Expansion of settlement and camp infrastructure replaced cropland and forest areas.
- GIS maps visually highlight environmental pressure.

### 3.8. Integration of Quantitative and Spatial Data

- Areas with highest forest loss correspond to regions where refugees report high firewood consumption.
- Soil erosion perception and land pressure data from surveys match change detection results from GIS maps.

#### Econometric Model Results (STATA Regression)

**Table 5** Regression estimates showing the impact of refugee presence on natural resource use.

Variable	Coefficient	Std. error	t-value	p-value
Refugee Group (dummy)	18.5	4.2	4.40	0.000
Land Pressure (ha)	12.3	3.1	3.97	0.000
Forest Cover Change (%)	-0.65	0.18	-3.61	0.001
Age	0.12	0.05	2.40	0.017
Gender (Male= 1, Female=0)	3.3	2.1	1.62	0.106

#### Interpretation:

Refugee presence significantly increases firewood consumption ( $p < 0.01$ ).

- Higher land pressure and forest loss are also significant predictors of resource use.

### 3.9. Social Cohesion Indicators

A table illustrates perceptions of social conflict between host communities and refugees.

**Table 6** Perception of Social Conflict (n=450)

Perceived Conflict level	Host Community	Refugees
Low	35%	42%
Moderate	50%	48%
High	15%	10%

**Analysis:** Most respondents perceive moderate conflict, with collaborative projects that reduce tensions.

### 3.10. Summary of Findings

#### 3.10.1. Environmental Impacts:

- Deforestation (-34%) and cropland loss (-17%) due to camp expansion.
- Refugees consume ~25% more firewood than host communities.

#### 3.10.2. Social Impacts:

- Moderate tensions over resources exist, but joint initiatives improve cohesion.

#### 3.10.3. Statistical Insights:

- Econometric models confirm that refugee presence significantly affects resource consumption.

#### 3.10.4. Spatial Patterns:

- GIS maps clearly illustrate **land cover changes** and areas under the greatest environmental stress.
- In Conclusion; Refugee influx in Rwanda has both environmental and social implications, with GIS and econometric analysis supporting survey and qualitative data, providing a comprehensive assessment of resource sustainability and community relations.

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## 4. Discussion, conclusion, and recommendations

### 4.1. Introduction

This chapter presents a detailed discussion of the research findings, draws conclusions based on the study objectives, and provides practical recommendations. The chapter also highlights policy implications and suggests areas for further research.

### 4.2. Discussion of Findings

#### 4.2.1. Land Cover Change in Kirehe District

The findings reveal significant land cover transformation in Kirehe District following the establishment of Mahama Refugee Camp. Before the camp (around 2010), the area was largely dominated by forest cover, agricultural land, and grassland. However, after the establishment of the camp (2015–2024), there was a noticeable expansion of settlement areas and deforestation.

This transformation can be attributed to:

- Increased demand for shelter and infrastructure
- Expansion of agricultural activities by both refugees and host communities
- Overexploitation of natural resources such as firewood

These findings align with environmental economic theories which suggest that sudden population influx leads to increased pressure on natural resources, especially in fragile ecosystems.

#### 4.2.2. Resource Consumption and Environmental Pressure

The study shows that Mahama Refugee Camp has significantly increased demand for key natural resources:

- High dependence on firewood (approximately 80%)
- Daily water consumption exceeding 120,000 liters
- Expansion of land use (approximately 250 hectares)

This level of consumption indicates unsustainable utilization of natural resources. The reliance on firewood contributes directly to deforestation, while excessive water use puts pressure on local water systems.

#### 4.2.3. Soil Erosion and Environmental Degradation

The results indicate a steady increase in soil erosion rates from 2010 to 2024. This trend is strongly linked to:

- Deforestation
- Land disturbance due to settlement expansion
- Unsustainable farming practices

The increase in erosion reflects declining land productivity and environmental quality, which may have long-term consequences on agricultural output and food security in the region.

#### 4.2.4. Socio-Economic Impacts on Host Communities

The study highlights mixed socio-economic impacts on host communities:

#### 4.2.5. Negative impacts:

- Income loss (42%)
- Resource-based conflicts (30%)

**Other challenges (28%)**, including land pressure and reduced access to resources

The competition for limited resources has increased tensions between refugees and host communities. However, it is also important to recognize that refugee presence can create economic opportunities, such as small businesses and labor markets, although these were not dominant in this case.

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## 5. Conclusion

This study concludes that the establishment of Mahama Refugee Camp has had significant environmental and socio-economic impacts on Kirehe District.

Key conclusions include:

- There has been substantial land cover change characterized by deforestation and expansion of settlements.
- Natural resource consumption has increased to unsustainable levels.
- Environmental degradation, particularly soil erosion, has intensified over time.
- Host communities are experiencing economic challenges and resource conflicts.

Overall, while refugee camps provide critical humanitarian support, they can also create considerable pressure on local ecosystems and livelihoods if not properly managed.

The Recommendations and Policy Implications.

- The study recommends a comprehensive and integrated approach to address environmental and socio-economic challenges in and around Mahama Refugee Camp. Key actions include promoting environmental restoration through reforestation, sustainable land-use planning, and the use of GIS and remote sensing for monitoring.
- It also emphasizes the need for sustainable energy solutions, such as adopting solar energy, biogas, and energy-efficient cookstoves to reduce dependence on firewood.
- In terms of water management, improving water harvesting, efficient usage technologies, and protecting local water sources are essential.
- To enhance livelihoods, the study suggests supporting income-generating activities, skills development, and inclusive economic integration for both refugees and host communities.
- Additionally, conflict mitigation measures such as community dialogue, strong local governance, and fair resource-sharing mechanisms are crucial to maintaining social harmony.
- Finally, the study highlights important policy implications, including integrating environmental sustainability into refugee management policies, developing long-term inclusive development plans, and increasing funding for environmental protection in refugee-hosting areas.

#### Areas for Further Research

Future studies should consider:

- Long-term environmental impacts of refugee settlements

- Comparative studies across different refugee camps
- The role of climate change in exacerbating resource scarcity
- Evaluation of renewable energy interventions in refugee settings

### *Final Remark*

The sustainability of refugee-hosting regions like Kirehe District depends on balancing humanitarian needs with environmental protection and socio-economic development. A coordinated approach involving government, international organizations, and local communities is essential to ensure long-term resilience.

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### **Compliance with ethical standards**

#### *Disclosure of conflict of interest*

No Conflict of interest to be disclosed.

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