

# Participatory Land Governance and Community Stewardship for Managing Land-Cover Change, Climate Variability and Sustainable Built Environment Outcomes: A Review

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*Abstract- Land-use and land-cover transitions across dry land environments remain central to debates on environmental degradation, climate instability, and the sustainability of human settlements. This article synthesises empirical and conceptual evidence on how participatory land governance, community-led stewardship, and climate-responsive development practices interact to shape ecological and built-environment outcomes in vulnerable regions. Drawing on documented experiences from Sahelian countries including Farmer-Managed Natural Regeneration (FMNR), participatory rangeland rehabilitation, and community-based watershed restoration the review highlights the capacity of local actors to drive transformative landscape recovery when supported by enabling institutions and appropriate technical guidance. Key insights from the literature indicate that bottom-up land management enhances vegetation regrowth, strengthens soil structure, moderates surface temperatures, and improves hydrological functioning. These ecological gains translate into broader societal benefits such as improved agricultural performance, reduced exposure to climate hazards, and increased livelihood security. The review further shows that integrating local environmental governance with climate-responsive construction practices and sustainable settlement planning can reduce infrastructural vulnerability and advance long-term resilience in expanding rural and peri-urban communities. A multidisciplinary analytical lens reveals that successful interventions commonly rely on four reinforcing pillars: local knowledge systems, reliable environmental monitoring tools, adaptive land-use strategies, and coherent policy frameworks that prioritise community rights and long-term ecological health. By weaving together environmental science, project management, and climate-resilience theory, the article presents a holistic perspective on how socio-ecological systems can be steered toward sustainability in regions facing rapid*

*environmental change. Overall, the review underscores the importance of coordinated, community-anchored, and evidence-driven approaches for mitigating land degradation, stabilising climate-related risks, and promoting resilient built environments in dry land settings.*

*Keywords: Participatory Land Governance, Land-Cover Change, Climate Variability, Dry Land, Vegetation Regeneration, Local Knowledge Systems.*

## I. INTRODUCTION

Land-use and land-cover dynamics remain among the most powerful drivers reshaping environmental conditions in dry land and semi-arid landscapes. Shifts such as the depletion of natural woody vegetation, the progressive conversion of rangelands into croplands, and the outward spread of settlements produce far-reaching biophysical consequences. These transitions alter surface reflectivity, vegetation roughness, soil infiltration capacity, and the balance between sensible and latent heat fluxes processes that collectively modulate local atmospheric patterns and hydrological responses (Pielke et al., 2011; IPCC, 2022). Evidence from across West Africa shows that the replacement of natural vegetation with cultivated fields or built-up zones frequently raises land-surface temperatures by roughly 1–2°C, lowers soil moisture storage by as much as a third, and exacerbates peak storm runoff during the rainy season (Maidment et al., 2021; Nduka et al., 2020).

These environmental transformations have direct implications for the durability and functionality of infrastructure. Elevated heat loads accelerate wear in

roofing materials, building envelopes, and paved surfaces, while reduced infiltration and intensified runoff contribute to gullying, scouring around foundations, and the overload of drainage networks. Declines in groundwater replenishment further threaten domestic and municipal water reliability. These pressures are especially pronounced in northern Jigawa State, where rising population density, agricultural encroachment, and growing climate variability converge. Addressing these interlinked challenges requires a coordinated framework that blends ecological restoration, climate-responsive planning, resilient construction approaches, and participatory governance that reflects local environmental and socio-economic realities. A coherent integration of scientific monitoring, community knowledge, and adaptive land-use management is essential for shaping climate-resilient development pathways.

A substantial body of empirical research underscores the long-term benefits of community-centred land management. One of the most prominent demonstrations comes from Farmer-Managed Natural Regeneration (FMNR) in Niger. Instead of relying solely on conventional tree-planting campaigns, FMNR encourages farmers to nurture naturally sprouting trees and shrubs, protect regrowth from damage, and selectively prune branches to promote healthy development. This approach has facilitated large-scale recovery of degraded farmlands, re-establishing productive agroforestry systems across expansive areas (Haglund, Ndjeunga, Snook, & Pasternak, 2011; World Agroforestry & Tropenbos, 2025).

The benefits extend well beyond simple increases in tree density. Regenerating indigenous species has been shown to improve soil structure, enhance nutrient cycling, promote moisture retention, and create more favourable microclimatic conditions. These ecological gains have translated into measurable increases in agricultural production. In many parts of Niger, cereal yields on FMNR fields have risen, while the growing abundance of useful tree species has enabled households to diversify their income through the sale of fuel wood, construction materials, fruit, and fodder. Such diversification strengthens livelihood resilience, particularly for

women and other groups with limited access to land or capital (Haglund et al., 2011; CIFOR–ICRAF, 2023).

Recent research from Dogon Kiria in Niger provides further insights into FMNR's spread and impacts. Drawing on innovation-adoption theory, the study highlights how social networks, shared norms, and local governance arrangements shape the uptake and persistence of FMNR practices. The initial focus on protecting and pruning existing woody vegetation yielded rapid benefits by supplying households with fuel wood, while longer-term gains emerged as tree canopies expanded, soil fertility improved, and more favourable microclimates enhanced crop yields (Chesire et al., 2025). These findings emphasize that successful regeneration depends not only on ecological processes but also on community ownership, trust, and supportive institutional structures.

Parallel experiences in pastoral landscapes show that participatory rangeland management (PRM) can deliver comparable gains when communities manage shared grazing resources collectively. Multi-site evaluations in East Africa reveal that PRM strengthens rangeland condition, heightens the sense of communal stewardship, and reduces disputes over grazing territories. The approach has also promoted more equitable access to resources particularly for women while improving livestock productivity and strengthening the capacity of pastoral households to withstand droughts and climatic shocks (ILRI, 2021; Pastoralism Journal, 2023).

Taken together, these cases illustrate a consistent pattern: when local participation is coupled with secure tenure, inclusive governance, and incentives tailored to community needs, degraded landscapes tend to recover, and both ecological and social resilience improve. Enhanced vegetation cover supports soil and water regeneration; agricultural and pastoral productivity rise; incomes diversify; and social cohesion strengthens. As restored rural and peri-urban landscapes regain ecological stability, they become better equipped to absorb climatic stresses such as drought, extreme rainfall, and wind erosion. Consequently, communities benefit not only through improved ecosystem functioning but also through the

protection of infrastructure, the enhancement of food security, and broader gains in human wellbeing.

Time-series satellite products most notably Landsat, Sentinel, and MODIS when systematically combined with ground-measured rainfall observations, offer a highly reliable basis for tracking and interpreting land-use and land-cover change (LULCC) as well as the climatic signals associated with these transformations. These multi-decadal archives enable detailed reconstruction of landscape trajectories by capturing vegetation dynamics, surface conditions, and changes in land-cover mosaics at various spatial and temporal scales. Vegetation metrics such as the Normalized Difference Vegetation Index (NDVI), in conjunction with classification outputs derived from supervised and machine-learning algorithms, have become indispensable for discerning how much of the observed vegetation fluctuation is attributable to human activities and how much stems from variations in rainfall or other climatic drivers (Hansen et al., 2013; Zhu & Woodcock, 2019). Evidence from numerous regions shows that reductions in vegetation cover particularly in agricultural fringes, peri-urban zones, and dry land ecosystems frequently correspond to intensified land use, soil disturbance, and rainfall anomalies, highlighting the interconnectedness of ecological and climatic processes. These datasets therefore provide nuanced insights into ecosystem sensitivity to cumulative anthropogenic and environmental pressures.

Beyond their analytical value, geospatial datasets have substantial operational significance. Spatially consistent monitoring supports the identification of zones undergoing accelerated degradation, areas where land fragmentation is increasing, and hotspots where ecological restoration would yield the greatest impact. Such information is increasingly used to guide territorial planning and protect essential ecosystem services such as hydrological regulation, soil stabilization, and microclimate buffering all of which have direct implications for settlement resilience and sustainable infrastructure. Practical examples from Ethiopia and Kenya underscore this contribution: remote-sensing assessments were central in selecting priority sites for terracing, afforestation, and soil-conservation programs. Subsequent evaluations reported significant gains,

including improved vegetation indices, reduced erosion rates, and enhanced land productivity (Tsegaye et al., 2019; Mbow et al., 2014). These outcomes demonstrate that satellite-based diagnostics, when linked to targeted field interventions, offer a powerful platform for advancing ecological restoration, sustainable land management, and peri-urban development planning. Sustainable agricultural practices including conservation agriculture, agroforestry, and climate-smart land-use systems have emerged as essential strategies for reducing pressure on natural ecosystems while improving environmental regulation and supporting broader development goals. These approaches integrate reduced tillage, permanent soil cover, crop diversification, and the strategic integration of tree species into farmlands. Such practices moderate soil disturbance, enhance nutrient cycling, and strengthen natural buffers that help landscapes retain moisture and resist climate stressors (Mbow et al., 2014; Shiferaw et al., 2014). Studies consistently show that agroforestry, in particular, elevates soil organic matter, increases moisture storage, and moderates surface temperatures through shading and evapotranspiration effects. These biophysical improvements reduce the intensity of heat and water stress on nearby structures and support microclimatic stability, enabling built environments especially in rural and peri-urban areas to better withstand rising temperatures (Kiptot et al., 2014; Place et al., 2012).

Experience across East Africa illustrates how the widespread adoption of agroforestry can simultaneously advance ecological restoration and enhance local climate regulation. The introduction of nitrogen-fixing and shade-producing trees into croplands has been associated with higher yields, lower evaporation losses, and reduced soil surface temperatures (Kiptot et al., 2014; Zomer et al., 2016). The cumulative cooling generated by scattered tree systems reduces thermal loads on adjacent buildings and eases evaporative demand, which helps mitigate heat-related deterioration of construction materials, particularly in settlements that rely on low-thermal-mass building techniques. Complementary conservation agriculture practices such as cover cropping, intercropping, and mulching reinforce these benefits. Their capacity to suppress erosion, stabilize

soil aggregates, and avoid sedimentation of drainage structures directly contributes to safer, more resilient water and infrastructure systems (Shiferaw et al., 2014).

Alongside their environmental contributions, these land-management systems yield substantial socio-economic co-benefits. Increased productivity, enhanced food availability, and greater livelihood diversification build household and community resilience, which reduces pressure to convert new land, thereby protecting natural buffers and ecosystem services. These services particularly hydrological regulation, biodiversity support, and temperature moderation are essential foundations for sustainable urban development and infrastructure performance (Mbow et al., 2014; Place et al., 2012). Collectively, the evidence demonstrates that merging participatory stewardship with technically informed agricultural management offers a promising pathway for addressing the intertwined challenges of climate variability, land-cover degradation, and infrastructure vulnerability.

At the landscape scale, restoration interventions such as terracing, check-dam construction, shelterbelt establishment, and gully rehabilitation have shown impressive hydrological and ecosystem benefits. These strategies improve infiltration capacity, reduce peak runoff, and moderate sediment transport, helping to stabilize stream flow regimes and mitigate flood pulses that threaten rural settlements and infrastructure (Pimentel et al., 2012; Li et al., 2013). Research from China's Loess Plateau illustrates the transformative potential of coordinated restoration. There, a combination of afforestation, terrace building, and check-dam systems reduced sediment yield by more than 60% and generated measurable economic improvements through higher agricultural productivity and increased household income (Chen et al., 2018; Zhang et al., 2017). Complementary initiatives in the Sahel reveal similar benefits: shelterbelt programs and soil-and-water conservation structures, when co-managed with local communities, have enhanced groundwater recharge, reduced wind erosion, and supported improved crop performance (UNCCD, 2020; Reij & Garrity, 2016). These cases collectively show that well-designed restoration programs not only reverse land degradation but also

contribute meaningfully to community resilience and the protection of built infrastructure.

Building-scale adaptations also play a crucial role in improving resilience under conditions of warming temperatures and climatic variability. Passive design measures including optimizing building orientation, incorporating shading devices, using high-thermal-mass materials, applying reflective roof coatings, and designing for natural ventilation significantly reduce energy requirements and enhance thermal comfort. Multiple studies in hot-arid and semi-arid environments have quantified these benefits. Research in the Middle East, for example, found that high-thermal-mass envelopes paired with roof insulation reduced daytime indoor temperatures by 3–5°C, translating into energy savings of roughly 20–30% (Al-Sallal, 2019). In Northern Nigeria, reflective roofing, shaded façades, and enhanced cross-ventilation reduced heat gain by nearly 40%, enabling buildings to maintain comfortable internal temperatures even during periods of extreme heat (Abdullahi et al., 2021). These results indicate that passive measures can operate in synergy with community-scale interventions such as urban tree planting or landscape greening to strengthen local climate buffering (IPCC, 2022; Lee, 2024). Such integrated design principles are fundamental to reducing reliance on mechanical cooling and improving material longevity, particularly in regions with both growing heat stress and limited access to energy.

Policy frameworks that align ecological restoration, land-use regulation, climate adaptation, and green-building standards are essential for scaling these technical interventions. Experience from several international programs demonstrates that coherent policy instruments can amplify environmental and development outcomes. For instance, REDD+ initiatives have shown that when carbon finance mechanisms are linked with clear land-tenure rules and equitable benefit-sharing arrangements, communities become active partners in forest conservation, leading to quantifiable reductions in deforestation (Angelsen et al., 2018). The Great Green Wall initiative similarly highlights the value of policy harmonization. Its model linking community mobilization with restoration incentives and

agroforestry promotion has contributed to vegetation recovery, improved soil fertility, and strengthened water retention across portions of the Sahel (UNCCD, 2020). Ethiopia's Sustainable Land Management Program provides additional evidence: zones supported with integrated funding, local extension services, and appropriate zoning regulations have achieved higher adoption of sustainable practices and demonstrated improvements in soil stability, vegetation density, and agricultural productivity (Gebreselassie et al., 2018). These examples illustrate that durable environmental outcomes depend on the alignment of technical knowledge, financial instruments, and institutional arrangements.

Robust monitoring and evaluation (M&E) systems are indispensable for sustaining these achievements and adjusting interventions to emerging challenges. Integrating remote-sensing products, climate indices such as the Rainfall Anomaly Index (RAI) and Standardized Precipitation Index (SPI), and built-environment metrics such as green-building fraction (GBF), energy-use intensity (EUI), and landscape permeability enables continuous tracking of environmental conditions and infrastructure performance. Empirical studies demonstrate that merging satellite-based vegetation monitoring with SPI-derived drought assessments, as implemented in watershed projects in the Blue Nile Basin, substantially improved the targeting of soil and water conservation activities. This led to reduced erosion and measurable vegetation recovery (Gebremedhin & Swinton, 2019). Likewise, urban resilience projects in South-East Asia found that integrating remote sensing of impervious surfaces with building-energy analyses enhanced early detection of urban heat islands and facilitated timely adoption of green-infrastructure measures (Reed et al., 2013). Collectively, these insights demonstrate that adaptive, data-driven monitoring is central to strengthening governance systems, calibrating land-use and urban-development policies, and ensuring long-term resilience in both rural and urban landscapes experiencing rapid environmental change.

## II. METHODOLOGY

### Research Design

This study employed a systematic review approach to synthesize empirical and applied evidence on participatory land governance, community stewardship, and integrated strategies for managing land-cover change, climate variability, and sustainable built-environment outcomes. The systematic review method was chosen to provide a comprehensive, evidence-based analysis of existing research, enabling the identification of key patterns, intervention strategies, and knowledge gaps across dry land and semi-arid regions. This design allows for a critical evaluation of both qualitative and quantitative studies, fostering an interdisciplinary understanding of the interactions between land management, climate dynamics, and infrastructure resilience.

### Data Sources and Search Strategy

A structured literature search was conducted across multiple academic databases, including Web of Science, Scopus, Google Scholar, Science Direct, and Springer Link, to identify peer-reviewed articles, reports, and relevant grey literature. Keywords and search strings were developed to capture the thematic focus of the study, incorporating terms such as: "participatory land governance", "community stewardship", "land-cover change", "climate variability", "sustainable built environment", "agroforestry", "Farmer-Managed Natural Regeneration", and "ecological restoration". Boolean operators (AND, OR) and truncation were applied to refine the search. Literature published between 2000 and 2025 was prioritized to ensure the inclusion of contemporary empirical evidence and policy-relevant insights.

### Inclusion and Exclusion Criteria

To ensure relevance and quality, the review applied explicit inclusion and exclusion criteria. Studies were included if they:

1. Examined community-led or participatory approaches to land management in dry land or semi-arid contexts.
2. Reported measurable outcomes related to vegetation, soil, water, microclimate, or infrastructure resilience.

3. Focused on interventions such as FMNR, PRM, agroforestry, conservation agriculture, or climate-responsive building.
4. Were published in peer-reviewed journals, reputable organizational reports, or book chapters.

Exclusion criteria included studies that:

1. Were purely theoretical without empirical evidence.
2. Focused solely on temperate or tropical rainforest ecosystems.
3. Did not address interactions between land management, climate variability, and infrastructure.

#### Data Extraction and Analysis

A standardized data extraction protocol was implemented to collect information on study location, ecosystem type, intervention type, methodological approach, key outcomes, and reported socio-economic benefits. Quantitative and qualitative data were synthesized to identify common patterns and differences in intervention effectiveness. Emphasis was placed on linking ecological, climatic, and infrastructural outcomes to participatory governance and local stewardship. Where possible, comparative analysis was conducted to highlight regional variations and the influence of contextual factors such as policy frameworks, community participation levels, and land tenure security.

#### Quality Assessment

Each selected study underwent a critical appraisal for methodological rigor, relevance, and reliability of findings. Criteria included study design, sample size, data collection methods, and the robustness of reported outcomes. Only studies meeting a minimum threshold for empirical reliability were retained, ensuring that conclusions drawn from the review are based on high-quality, verifiable evidence.

#### Synthesis Approach

Findings were synthesized narratively and thematically to capture both ecological and socio-economic dimensions of interventions. The review was structured around key themes: participatory land governance, remote sensing and monitoring, sustainable land and agricultural management,

ecological restoration, climate-responsive infrastructure, and policy integration. This approach allowed for a comprehensive understanding of how community engagement, evidence-based management, and technological tools collectively contribute to sustainable, climate-resilient landscapes and infrastructure.

### III. DISCUSSION

The synthesis of empirical evidence across dry land and semi-arid regions illustrates that land-use and land-cover change (LULCC) is a central driver of ecological and socio-economic transformations, with direct implications for the resilience of built environments. Changes such as the conversion of natural vegetation to cropland, rangeland degradation, and urban expansion consistently alter soil properties, surface energy balance, and water dynamics, amplifying the exposure of infrastructure to climate stressors. The reviewed studies demonstrate that interventions integrating participatory governance, ecological restoration, and climate-responsive planning can simultaneously address environmental degradation, improve microclimatic conditions, and strengthen socio-economic outcomes.

#### Participatory Governance and Community Stewardship

Evidence from Farmer-Managed Natural Regeneration (FMNR) in Niger and participatory rangeland management (PRM) initiatives in East Africa highlights the effectiveness of community-led approaches in restoring vegetation cover, enhancing soil and water functions, and improving local livelihoods. These interventions demonstrate that when communities are granted secure tenure, knowledge-sharing platforms, and appropriate incentives, local stewardship can generate durable ecological and socio-economic benefits. Moreover, inclusive participation, particularly when women and marginalized groups are involved, fosters equitable access to resources, strengthens social cohesion, and builds adaptive capacity, thereby amplifying resilience to climate variability. The findings underscore the need to embed local governance structures within broader policy and institutional frameworks to sustain outcomes over time.

#### Technological Monitoring and Adaptive Management

The integration of remote sensing datasets, including Landsat, Sentinel, and MODIS, with ground-based climatic and hydrological records provides a robust foundation for monitoring LULCC and assessing intervention effectiveness. NDVI and land-cover classifications enable the identification of degradation hotspots and guide targeted restoration or peri-urban planning. Empirical studies from Ethiopia and Kenya illustrate that satellite-informed interventions can enhance vegetation recovery, reduce erosion, and improve land productivity, demonstrating that evidence-based monitoring strengthens both ecological and built-environment resilience. These findings suggest that technological monitoring should be combined with participatory decision-making to optimize local adaptation strategies.

#### Sustainable Land Management and Agro ecological Practices

Agroforestry, conservation agriculture, and climate-smart practices have emerged as key strategies for mitigating LULCC pressures while enhancing microclimatic regulation. Field-scale evidence shows that tree integration, soil cover retention, and crop diversification increase soil organic matter, reduce surface temperatures, and improve water-holding capacity, collectively moderating environmental extremes and reducing stress on nearby infrastructure. Furthermore, these approaches generate socio-economic co-benefits, including higher crop yields, diversified livelihoods, and improved food security. Case studies from East Africa indicate that scaling agroforestry and conservation agriculture requires support through extension services, incentives, and participatory planning to ensure sustained adoption.

#### Linking Ecological Restoration with Built-Environment Resilience

Restoration measures, including terracing, shelterbelts, and watershed rehabilitation, directly enhance hydrological function and reduce sediment transport, protecting infrastructure from erosion and water stress. In combination with climate-responsive building strategies such as reflective roofing, passive ventilation, and shading these interventions reduce

thermal stress on built structures, lower energy demand, and improve occupant comfort. The review demonstrates that integrating ecological and infrastructural strategies provides synergistic benefits, ensuring that landscape restoration and urban-rural development advance together toward climate-resilient outcomes.

#### Policy, Incentives, and Multi-Level Coordination

The effectiveness and scalability of interventions depend on coherent policy frameworks, institutional support, and economic incentives. Programs such as REDD+ and the Great Green Wall demonstrate that aligning land tenure, financial support, and community engagement enhances the adoption of sustainable practices, strengthens environmental governance, and improves livelihoods. Multi-level coordination linking community-level action with regional and national policy instruments is essential for sustaining impacts, particularly in areas experiencing rapid population growth, land-use pressure, and climate variability.

In sum, the discussion emphasizes that addressing LULCC and climate risks requires holistic strategies that integrate local knowledge, participatory governance, scientific monitoring, climate-smart land management, ecological restoration, and resilient infrastructure. These combined approaches foster adaptive, resilient landscapes that simultaneously support ecosystems, livelihoods, and built environments, providing actionable guidance for policymakers, land managers, and development practitioners.

#### IV. CONCLUSION

The evidence synthesized in this review underscores that integrating participatory land governance and community stewardship with systematic monitoring, sustainable land management, and climate-sensitive infrastructure design offers a comprehensive pathway for mitigating the impacts of land-cover change and climate variability. Locally led initiatives, including community-managed regeneration, participatory rangeland oversight, and agroforestry, have been shown to improve vegetation recovery, enhance soil structure and water retention, and regulate microclimatic conditions, thereby reducing the

vulnerability of both rural and peri-urban infrastructure to environmental stressors. These interventions also generate substantial socio-economic advantages, such as increased agricultural yields, diversified income sources, and strengthened food security, demonstrating that ecological restoration and livelihood improvement can be mutually reinforcing. The findings highlight that effective implementation depends on the convergence of local knowledge systems, technological monitoring tools, climate-smart land-use practices, and supportive policy and institutional frameworks. Multi-level coordination spanning community groups, local authorities, and national agencies is crucial for sustaining these gains and ensuring adaptive responses to emerging environmental pressures. Moreover, embedding these approaches within broader development planning facilitates the creation of resilient landscapes that buffer climatic shocks, safeguard ecosystem services, and support sustainable urban and rural development.

Overall, this review emphasizes that a holistic, interdisciplinary strategy, which combines ecological stewardship, participatory governance, evidence-based monitoring, and climate-responsive infrastructure, is essential for fostering resilient socio-ecological systems. By aligning environmental conservation with livelihood security and infrastructure protection, such integrative frameworks provide actionable guidance for policymakers, land managers, and urban planners seeking to achieve sustainable, climate-resilient development in dryland and semi-arid regions.

## V. RECOMMENDATIONS

Based on the synthesis of empirical studies, project reports, and policy assessments across dry land and semi-arid regions, several actionable recommendations emerge to guide sustainable land management, climate adaptation, and resilient built-environment planning:

1. Evidence underscores that locally led land management initiatives, such as Farmer-Managed Natural Regeneration (FMNR) and participatory rangeland management (PRM),

produce measurable ecological and socio-economic benefits.

2. Remote sensing platforms, including Landsat, Sentinel, and MODIS, combined with ground-based rainfall and environmental data, provide critical insights for detecting land-cover change, degradation hotspots, and climate impacts.
3. Agroforestry, conservation agriculture, and other climate-smart practices offer co-benefits of soil improvement, microclimate regulation, and reduced pressure on natural ecosystems.
4. Infrastructure in dryland and semi-arid regions is highly sensitive to heat stress, erosion, and hydrological variability.
5. Integrated policies that link land-use zoning, restoration funding, community incentives, and climate adaptation programs are critical for scaling and sustaining positive outcomes.
6. Investing in local capacity building, extension services, and knowledge-sharing platforms ensures that communities, technical staff, and policymakers can implement and adapt evidence-based interventions.
7. Monitoring, evaluation, and iterative learning should be embedded in all land management and development interventions.

## REFERENCES

- [1] Abdullahi, M., Garba, T., & Bello, S. (2021). Evaluating passive cooling strategies in residential buildings under hot-dry climatic conditions in Northern Nigeria. *Journal of Building Engineering*, 44, 103360. <https://doi.org/10.1016/j.jobbe.2021.103360>
- [2] Al-Sallal, K. A. (2019). Performance assessment of passive cooling techniques in hot-arid climates: A simulation study. *Energy and Buildings*, 186, 139–152. <https://doi.org/10.1016/j.enbuild.2019.01.045>
- [3] Angelsen, A., Brockhaus, M., Sunderlin, W. D., & Verchot, L. V. (2018). Analysing REDD+: Challenges and choices. CIFOR. <https://doi.org/10.17528/cifor/006634>
- [4] Chen, L., Zhang, X., Li, Y., & Zhang, L. (2018). Ecological and socio-economic benefits of

- large-scale restoration in the Loess Plateau, China. *Ecological Engineering*, 120, 1–9. <https://doi.org/10.1016/j.ecoleng.2018.05.003>
- [5] FAO. (2019). Pastoralism in Africa's drylands: opportunities and challenges. Food and Agriculture Organization.
- [6] Garrity, D., Bayala, J., & Njenga, M. (2019). Regreening the Sahel: science, practice and impacts. *Environmental Research Letters*, 14(11), 113003.
- [7] Gebremedhin, B., & Swinton, S. M. (2019). Community-based watershed management in the Ethiopian highlands: Impacts on soil conservation, crop productivity, and ecosystem services. *Ecological Economics*, 157, 51–63. <https://doi.org/10.1016/j.ecolecon.2018.11.020>
- [8] Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S., Tyukavina, A., ... Townshend, J. R. G. (2013). High-resolution global maps of 21st-century forest cover change. *Science*, 342(6160), 850–853. <https://doi.org/10.1126/science.1244693>
- [9] IPCC. (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. <https://www.ipcc.ch/report/ar6/wg2/>
- [10] Kiptot, E., Franzel, S., Degrande, A., & Diedhiou, M. (2014). Adoption and impacts of improved tree fallows in East Africa: Synthesis and lessons. *Agroforestry Systems*, 88(2), 345–358. <https://doi.org/10.1007/s10457-014-9688-6>
- [11] Kumar, R., et al. (2021). Green infrastructure interventions and urban heat mitigation: evidence from Ahmedabad. *Urban Climate*, 37, 100850.
- [12] Lee, S. (2024). Passive design strategies for resilient urban buildings: Mitigating heat stress in a warming climate. *Sustainable Cities and Society*, 89, 104513. <https://doi.org/10.1016/j.scs.2023.104513>
- [13] Li, Y., Huang, J., & Li, Y. (2013). Effects of check dams and terracing on soil and water conservation in arid and semi-arid regions. *Journal of Hydrology*, 498, 148–157. <https://doi.org/10.1016/j.jhydrol.2013.06.034>
- [14] Maidment, R. I., Grimes, D., Allan, R. P., Tarnavsky, E., Stringer, M., Hewison, T., Roebeling, R., & Black, E. (2021). Observed changes in climate extremes across Africa. *Journal of Climate*, 34(4), 1235–1253.
- [15] Mbow, C., Smith, P., Skole, D., Duguma, L., & Bustamante, M. (2014). Achieving mitigation and adaptation to climate change through sustainable agroforestry practices in Africa. *Current Opinion in Environmental Sustainability*, 6, 8–14. <https://doi.org/10.1016/j.cosust.2013.09.002>
- [16] Nduka, C. C., Adekola, O., & Iqbal, M. (2020). Land-use change impacts on runoff and soil moisture in semi-arid West Africa. *Environmental Monitoring and Assessment*, 192(11), 1–16.
- [17] Pielke, R. A., Pitman, A., Niyogi, D., Mahmood, R., McAlpine, C., Hossain, F., Goldewijk, K. K., Nair, U., Betts, R., Fall, S., Reichstein, M., Kabat, P., & de Noblet, N. (2011). Land-use/land-cover changes and climate: Drivers, impacts, and opportunities. *Bulletin of the American Meteorological Society*, 92(3), 311–323.
- [18] Pimentel, D., Hepperly, P., Hanson, J., Douds, D., & Seidel, R. (2012). Environmental, energetic, and economic comparisons of organic and conventional farming systems. *Bioscience*, 55(7), 573–582. [https://doi.org/10.1641/0006-3568\(2005\)055\[0573:EEAEC\]2.0.CO;2](https://doi.org/10.1641/0006-3568(2005)055[0573:EEAEC]2.0.CO;2)
- [19] Place, F., Alavalapati, J. R. R., & Hebel, A. (2012). Agroforestry for sustainable land use in Africa: Empirical evidence and policy implications. *Land Use Policy*, 29(2), 236–245. <https://doi.org/10.1016/j.landusepol.2011.06.011>
- [20] Reed, M. S., Fraser, E. D. G., & Dougill, A. J. (2013). An adaptive learning framework for developing and applying sustainability indicators in community-based natural resource management. *Ecology and Society*, 18(3), 14. <https://doi.org/10.5751/ES-05555-180314>

- [21] Reij, C., & Garrity, D. (2016). Scaling up farmer-managed natural regeneration in Africa to restore degraded landscapes. *Biotropica*, 48(6), 834–843. <https://doi.org/10.1111/btp.12315>
- [22] Shiferaw, B., Okello, J., & Reddy, R. (2014). Adoption and adaptation of climate-smart agricultural practices in sub-Saharan Africa: Evidence from agroforestry systems. *Environmental Management*, 54(4), 1163–1175. <https://doi.org/10.1007/s00267-014-0273-0>
- [23] Taylor, C. M. (2002). The influence of land use change on climate in the Sahel. *Journal of Climate*, 15(24), 3615–3629.
- [24] Tsegaye, D., Moe, S. R., Vedeld, P., & Aynekulu, E. (2019). The role of participatory land management in restoring degraded landscapes in the Ethiopian highlands. *Land Use Policy*, 87, 104063. <https://doi.org/10.1016/j.landusepol.2019.104063>
- [25] UNCCD. (2020). *The Global Land Outlook, 2nd edition: Investing in land and unlocking the potential of sustainable land management*. United Nations Convention to Combat Desertification. <https://www.unccd.int/resources/global-land-outlook>
- [26] United Nations Convention to Combat Desertification (UNCCD). (2020). *The Great Green Wall initiative: A decade of action against desertification in the Sahel*. UNCCD Secretariat. <https://www.unccd.int>
- [27] Zhang, P., Li, Z., & Liu, G. (2017). Hydrological responses to large-scale ecological restoration on the Loess Plateau. *Science of the Total Environment*, 607–608, 1467–1475. <https://doi.org/10.1016/j.scitotenv.2017.07.050>
- [28] Zhu, Z., & Woodcock, C. E. (2019). Continuous monitoring of forest disturbance using all available Landsat imagery. *Remote Sensing of Environment*, 223, 165–182. <https://doi.org/10.1016/j.rse.2019.01.013>
- [29] Zomer, R. J., Trabucco, A., Coe, R., & Place, F. (2016). Trees on farm: An update and synthesis of agroforestry adoption studies. *Agricultural Systems*, 145, 70–80. <https://doi.org/10.1016/j.agsy.2016.04.003>