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The Restoration of Degraded Lands by Local Communities and Indigenous Peoples

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One of Earth's foremost ecological challenges is the degradation of land habitats. This degradation is often caused by deforestation and desertification resulting from the unsustainable management of natural resources. Land restoration seeks to reverse this trend and repair ecosystems to better health. Indigenous peoples and local communities have a key role in realizing long-term, sustainable land restoration. Local and indigenous communities often have intimate knowledge of the local ecosystems and an interest in preserving ecosystem services. Areas managed by indigenous peoples and local communities especially overlap with remaining intact ecosystems and suffer from less deforestation than unprotected areas. Here, we discuss how the knowledge and engagement of local communities can improve the management, implementation, and monitoring of habitat restoration. However, there are also challenges to land restoration, and scientists and policymakers that can align restoration outcomes with community benefits gained from environmental stewardship and knowledge, are more likely to achieve long-term sustainable restoration success.

Keywords: conservation and restoration, land degradation, deforestation, desertification, local and indigenous communities, ecosystem functions

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INTRODUCTION

Land degradation is an environmental process wherein the chemical, physical and biological quality of land and soil becomes progressively worse. This loss may be caused by erosion, deforestation, salinization, soil compaction, and the loss of organic soil content (Cowie et al., 2018; Keesstra et al., 2018). Degradation often results from the unsustainable management of natural resources and is often driven by agricultural over-exploitation (Barbier and Hochard, 2018). These impacts may be further exacerbated by climate change, including drought and desertification (Webb et al., 2017; Han et al., 2021). Ultimately, land degradation reduces biodiversity, ecosystem integrity, and productivity, and can release soil carbon into the atmosphere which contributes to climate change (Davidson and Janssens, 2006).

Land degradation is one of our most pressing ecological challenges, with more than 75% of land worldwide currently impacted. These losses affect an estimated 3.2 billion people that are dependent on degraded land for food, water, and other essential ecosystem services (IPBES., 2019). Together with climate change, land degradation is undermining the livelihood of local communities, displacing populations from traditional lands, and causing rapid and widespread loss of biodiversity (Hermans and McLeman, 2021).

Given the urgent concern of land degradation, the United Nations declared 2021–2030 the "Decade on Ecosystem Restoration" with the Sustainable Development Goal to achieve Land Degradation Neutrality, wherein the amount and quality of land ecosystems remains stable and do not decrease further (Cowie et al., 2018; Chasek et al., 2019; **Figure 1**). To achieve these goals and reverse land degradation will require sustainable informed land management. Here, we discuss how the knowledge and engagement of local communities can improve the management, implementation, and monitoring of habitat restoration. We also discuss the challenges to integrate indigenous knowledge into land restoration projects.

LAND RESTORATION

Restoration aims to initiate and accelerate the recovery of land. Restoration strategies vary according to the affected ecosystem and the cause of degradation. Re-forestation within natural or plantation sites can restore forest ecosystems (Gastauer et al., 2020). Re-seeding can provide vegetation cover and prevent the erosion and desertification of rangelands (Stock et al., 2020). Conservation tillage, nutrient, and organic replenishment can restore poor soils, whilst wetland restoration aims to recover the natural hydrology of rivers and lagoons (Santini et al., 2019).

Despite these efforts, the restoration of ecosystems is difficult. Effective restoration strategies are often specific to a site, and successes in one region or ecosystem may not be easily transferred to another location. Restoration requires committed and concerted efforts over many years and depending on the goals, successful restoration requires decades to centuries with ongoing management often needed (Yang et al., 2020). For example, organic carbon restoration within soil layers may take many years longer to recover than aboveground grassland biomass (Moreno-Mateos et al., 2012; Hu et al., 2018).

LAND MANAGEMENT BY INDIGENOUS PEOPLES AND LOCAL COMMUNITIES

Indigenous and local communities are resident populations that identify with the original inhabitants of a region. There are at least 370 million people who define themselves as indigenous and retain social, economic, cultural, and political connections to the original populations who inhabited a country before conquest or colonization (Shawoo and Thornton, 2019).

Indigenous peoples are stewards to over a 15% of the land around the world. This overlaps with 40% of terrestrial protected areas and ecologically intact landscapes (Garnett et al., 2018; Sze et al., 2022). Granting tenure rights and management of these lands with conservation value to local communities is often preferred to establishing large uninhabited vast sanctuaries. In these cases, indigenous and local communities sustainably manage the land according to traditional practices. For example, the Australian government recently recognized the importance of aboriginal communities to safeguard the lands, and returned 160,000 hectares of rainforest within the Daintree National Park to the Eastern Kuku Yalaji community (Queensland Government., 2021).

Lands managed by local communities were found to have lower rates of deforestation (Sze et al., 2022). With the exception of the Americas, indigenous lands have ∼26% lower rates of deforestation than protected forests. For example, in Nepal, deforested lowland regions have improved since the devolvement of state forests to local community management slowed deforestation, and restored communal forests and watersheds (Nagendra, 2007). In addition to keeping forests intact with higher levels of biodiversity, indigenous communities have a measurable impact in reducing forest carbon emissions and mitigating climate change (Sze et al., 2022).

There are numerous reasons why local communities are well-positioned to manage restoration efforts. Local communities often harbor intimate knowledge from thousands of years of observation, experience, and management of the land (Wehi and Lord, 2017; Robinson et al., 2021). This ecological knowledge informs restoration efforts and effective management practices.

Local communities also harbor an interest in restoring ecosystems from which they benefit. Community-based institutions are often more successful than government policies or institutions, given they are closely engaged and respond quickly to environmental changes or threats. For example, local fishing communities from the Selkie village quickly identified damage to the Jukajoki river in Finland caused by the release of iron and other minerals by a state-owned peat mine. The village with a local cooperative (Snowchange) subsequently led a successful community project to restore the watershed and closed the mine (Mustonen, 2014).

Indigenous and local communities often express deep spiritual and cultural ties to their land that is an integral part of their cultural and social identity, and reflect millennia of ecological stewardship (Wehi and Lord, 2017). These cultural and social ties encourage local communities to value and manage their lands sustainably. For example, the spiritual views of the Guarani people from Paraguay, Argentina, Bolivia, and Brazil forbids farming and forestry in sacred hills with natural freshwater springs (Yvyawate) and forests (Kagũy ete) where medicinal plants are found (Frainer et al., 2020). This wholistic appreciation that essential ecosystem services, such as the provision of food, water, and clean air, are dependent on healthy working ecosystems motivates effective conservation and restoration, and ensures the benefits of agriculture and resources are balanced by responsibilities to manage the land sustainably.

Recognizing cultural institutions can promote an understanding of restoration efforts and increase local engagement. For example, the creation stories of the White Mountain Apache Tribes highlight the importance of water bodies within the landscape (Long et al., 2020). These cultural traditions aligned with efforts to restore rivers and watersheds, and engaged community support. Conversely, the loss of lands and natural resources is linked to the loss of cultural values and responsibilities and provides another incentive for community-based conservation.

Degraded lands in Nevado de Toluca National Protected Area.

Land degradation

Causes:
Agricultural land use.
Farming.
Grazing.
Forestry.
Urbanisation.
Industrial land use.

Impact:
Loss of soil quality (organic matter, acidification).
Loss of biodiversity.
Loss of ecosystem services.

United Nations
Decade On Ecosystem Restoration
2021-2030

Ongoing restoration (reforestation) of degraded lands.

Land restoration

Restoration of degraded land:
Consideration of local communities and indigenous welfare.
Use of traditional knowledge.
Cultural and social values.
Informed land-management.
Economic incentives and compensation.

Sustainable land-use.
Sustainable resource-use.
Ongoing management and monitoring.
Benefit sharing.

FIGURE 1 | Effective land restoration requires integrating scientific and local knowledge.

ENGAGING LOCAL AND INDIGENOUS COMMUNITIES IN LAND RESTORATION

Coupling the goals of ecological restoration with the participation of local communities is needed for successful, long-term restoration of ecosystems (Robinson et al., 2021). These communities often directly rely on the ecosystem services for their livelihood and are particularly vulnerable to land degradation. Therefore, restoring degraded habitats is often critical for the well-being of these communities, who are well-positioned with an interest in restoring the land upon which their livelihood depends.

The knowledge of indigenous and local communities can inform and guide effective restoration. Traditional knowledge can identify keystone species or sites that are foundational to restoration efforts (Raymond et al., 2010; Tengö et al., 2014). The historical continuity of local communities with the land can help define natural baselines for species recovery, watershed management and define the aims and targets of restoration efforts (Mustonen, 2013).

The use of traditional knowledge is becoming increasingly appreciated in managing fire-prone regions. Indigenous peoples have been effectively managing fire for millennia to reduce fuels and manage wildlife and plants. The Australian Aborigines have maintained a complex system of land management using fire and native plant life cycles to ensure food abundance throughout the year (Bardsley et al., 2019). These indigenous fire regimes and traditional knowledge are being increasingly used to recover native biodiversity and ecosystem functions in restoration efforts (Russell-Smith et al., 2015).

Local communities also have experience with successional regeneration processes that occur during habitat restoration. The land management practices of local communities, such as rotational farming, agroforestry and exclosures have been developed over thousands of years and are effective strategies to prevent environmental degradation. For example, forest restoration in Thailand using traditional knowledge of the Karen and Lawa ethnic groups in the Mae Chaem watershed, Chiang Mai, has informed and improved forest restoration with the

rotation of swidden cultivation systems (Mertz et al., 2009; Tongkoom et al., 2021).

LOCAL AND INDIGENOUS COMMUNITIES MONITORING RESTORATION

Local communities can also actively monitor ecosystem health and restoration success, and collect data on species and ecological trends, particularly in remote sites and over long time periods (Eicken et al., 2021). The indigenous communities in the semipolar regions of the United States and Canada have collaborated with the Local Environmental Observer Network to collect diverse observations on wildlife sightings, climate, and ecological features. Similarly, the Bayaka pygmies monitor forestry and biodiversity in the Congo Basin (Grantham et al., 2020).

Local communities have played a key role in monitoring oil spills within the Niger Delta, which is the third-largest wetland in the world and has Africa's largest expanse of mangroves. The contamination of the delta's diverse resources by oil spills is commonplace, and local communities have been widely recruited to monitor and report oil spills, which is then used to require companies to immediately clean and restore oil spills, and inform regulatory decisions (Zabbey et al., 2021). Furthermore, local communities are increasingly leading environmental assessments and management that were previously the exclusive preserve of scientists.

IMPROVING BIODIVERSITY WITH LOCAL AND INDIGENOUS COMMUNITIES

Indigenous and local communities often manage their lands in ways that can restore biodiversity. They often cultivate endemic and wild species in small plots that are more diverse and species-rich than industrial agricultural landscapes (Pautasso et al., 2013). Local farmers can also store and exchange seeds that maintain genetic diversity, and breed crops that adapt to changing climates, pathogens, and environmental conditions (Bellon et al., 2019).

Traditional knowledge has also given rise to thousands of traditional crop species and varieties that local farmers have domesticated, improved, and conserved over generations. For example, Mexican farmers or "campesinos", who grow maize in small-hold family farms have developed native maize varieties by saving and storing seeds (Bellon et al., 2019; McLean-Rodríguez et al., 2021). This constitutes the greatest store of genetic diversity for this staple crop which is increasingly important in developing strains capable of growing under changing climatic conditions, altitudes, and resistance to pathogens. Similarly, local farmers' communities of the Potato Park in Cusco, Peru, have developed more than a quarter of the 4,000 or so potato varieties found in the country (Lüttringhaus et al., 2021).

RESTORING FORESTS AND GRASSLANDS

Deforestation is a primary cause of land degradation, particularly in tropical regions. This deforestation is often the result of expanding agricultural practices such as in Indonesia and Malaysia, where oil palm has replaced many of the natural forests, while soy plantations are a principal cause of primary forest loss in Brazil and Argentina (Nagendra, 2007; World Resources Institute., 2021).

In both developed and developing countries, forests are being restored through state and national programs that are increasingly engaging local communities (World Resources Institute., 2022). Forest rehabilitation projects in the Philippines, Indonesia, China, Vietnam, Peru, and the Brazilian Amazon promote community organization and improvement of rural livelihoods (Bos et al., 2020). Local knowledge of tree characteristics, planting of diverse species of ecological and economic importance, and integration of rehabilitation programs with regional development strategies are essential elements of restoration success.

The Amazon jungle has undergone massive deforestation in recent decades due to livestock farming, logging, and soybean cultivation. In response, the Brazilian government has pledged to support the restoration of 12 million hectares of the deforested Amazonian jungle by 2030 through the National Restoration Policy (Brando et al., 2013). However, in the absence of community knowledge, re-forestation efforts may use inappropriate non-native species and simple monocultures. Despite the ecological advantages of native species, non-native wood species that can be sold at higher prices are often given priority and cultivated at the expense of native forests. For example, restoration of the Upper Xingu Basin has been primarily achieved by planting nursery-raised tree seedlings. The common use of seedlings of riparian forest species from central Brazil due to their availability and fast initial growth rates ignores the original vegetation structure and composition of the Upper Xingu forest and has undermined restoration success (Schmidt et al., 2019).

Grasslands and rangelands can include annual and perennial grasslands, shrub and dry woodlands, savannah, tundra, and desert. Grasslands often form catchment areas and their sustainable management is needed to ensure the hydrological cycle and watershed protection. Rangelands provide many key ecosystem services to local communities, including pastoral grazing and livestock feed. However, grasslands are under increasing pressure from over-grazing and must be managed sustainably to prevent erosion and desertification. For example, to exclude persistent grazing of degraded land, small-hold farmers in Ethiopia have increasingly adopted enclosures that prevent persistent grazing and enable recovery of degraded grasslands (Yayneshet et al., 2009; Adem et al., 2020). These efforts have been complemented by re-forestation efforts using native seedlings grown in nurseries by local communities (Worku et al., 2017).

ENGAGEMENT OF LOCAL AND INDIGENOUS COMMUNITIES IN GOVERNMENT POLICIES

Globally, governments have committed to conserving 17% of terrestrial environments (UNEP-WCMC IUCN., 2021). These commitments often involve local or global conservation agreements that prioritize the conservation and restoration of sites with ecologically and biodiversity value. Local community representation and engagement is essential when drafting these conservation agreements.

There are numerous examples of restoration processes that do not sufficiently recognize the local community value systems (Guibrunet et al., 2021). Top-down restorations conducted with little participation from local communities often do not consider differences between restoration efforts and local communities' interests that ultimately undermine success (Armitage et al., 2012; Kohler and Brondizio, 2017).

There are numerous successful frameworks for involving local communities in conversation and restoration efforts. Collaborative agreements, such as the Akwe Kon Guidelines, Tkarihwaiéri Code of Ethical Conduct and Whakatane mechanism involve indigenous people in restoration efforts whilst respecting local rights and institutions (Secretariat of the Convention on Biological Diversity, 2011; Freudenthal et al., 2012). These policy tools also help negotiate and define sustainable sharing and exploitation of resources in restored ecosystems. The inclusion of local communities as partners can also support their land rights and provide access to social services and economic opportunities.

Engagement in restoration efforts and the use of indigenous knowledge can empower local communities. Combining restoration efforts within local development initiatives has been increasingly promoted by governments, Non-Governmental Organizations, and some development agencies. Leading the environmental restoration of land can support broader claims of stewardship, governance and sovereignty (Bohensky and Maru, 2011).

The UN Convention on Biological Diversity's Aichi targets set goals to protect roughly 15% of the world's area (Convention on Biological Diversity., 2021). These protected areas have been largely able to reduce the rate of deforestation and improve restoration. However, their creation may cause communities to be evicted, or limit livelihoods, and local communities should be compensated when conservation or restoration goals are prioritized over community interests. These economic incentives can also encourage local participation in restoration outcomes. For example, the Mexican *Abies religiosa* fir forests in the state of Michoacán are the wintering sites of the monarch butterfly that migrate from across the United States and Canada. Given their iconic importance, a global fund was established to support local communities to diversify livelihoods from forestry industries, and restore the forests in which the monarch butterfly winters (Vidal et al., 2014).

CHALLENGES TO INTEGRATING INDIGENOUS KNOWLEDGE IN LAND RESTORATION

Despite the advantages of indigenous knowledge to improve land restoration, engaging local communities in restoration activities does not always lead to successful ecosystem restoration nor benefit for local communities. Much work remains to identify the factors that support successful restoration that is beneficial to local communities. In Mexico, the *La Malinche* National Park was established to protect over 45,000 ha of highly diverse temperate forests. Under this protection, only research, conservation, and sustainable tourism are allowed, with forestry and farming prohibited. However, the National Park has undergone extensive deforestation by local communities, and forests have rapidly been replaced by arable land and for cattle pastures (Tellez et al., 2019). Urgent discussions are needed to resolve differences between the conservation of the National Park and the rapid deforestation for agriculture.

Restoration projects often involve the multiple academic, governmental and community participants and non-academic actors with contrasting knowledge, interests and goals. Engaging multiple participants can lead to potential conflicts that should be discussed at the early stages of each restoration project. Some challenges in addressing these conflicts include defining stakeholders' selection criteria, integrating systematically stakeholders' viewpoints, and communicating desired restoration outcomes. Collaborative planning frameworks (both inter-and trans-disciplinary) can help mediate conflicts and build consensus among participants while fostering learning and engagement (Metzger et al., 2017). Participants are not only expected to contribute their expertise to informed decision-making but also reflect upon their own motivations when designing and monitoring restoration activities.

Indigenous stewardship and local knowledge often derive from thousands of years of experience and are deeply embedded within the economics, politics, and culture of the community. Given this knowledge is developed through an understanding of the local environment, this knowledge may be difficult to transfer to other sites or apply in different contexts. By contrast, scientific knowledge aims to identify generalizable principles that can be applied to achieve restoration success in different sites (Bohensky and Maru, 2011). While this highlights a key distinction between indigenous and scientific knowledge, this also demonstrates how each process can complement and support each other. Scientific approaches to land restoration can be informed by localized knowledge, employ established institutions and empower local communities. Conversely, scientific processes can inform local land restoration efforts, and provide clear working frameworks and quantitative metrics to assess success. Restoration efforts must pragmatically incorporate both sources of knowledge that are continually re-worked, often in highly innovative ways.

CONCLUSIONS

Despite the advantages of engaging local communities, restoration should not assume local and indigenous communities are willing to support restoration efforts. Local communities harbor diverse political, cultural, and economic aspirations that can diverge from the goals of land restoration. Local communities may object to limits on the exploitation of natural resources, or new land management regimes, such as regular fires (Costa et al., 2018). Projects that involve local communities only for labor or land are often economically unsustainable due to the high opportunity costs and delayed benefits from land restoration and are often not locally accepted.

Restored and rehabilitated land that promises to provide sustainable agriculture and pastoral grazing, food, medicine, and tourism can provide long-term benefits to local communities. However, to achieve restoration, these ecosystems must be managed sustainably and not over-exploited. This sustainable use may contrast with expectations, and local communication must be invested to recognize the legitimacy of the restoration efforts to ensure these long-term sustainable solutions. This recognition of local communities' value systems requires strengthening collaborative governance through institutional collaborations and citizens participation (Guibrunet et al., 2021).

Land restoration is a key method to reverse the degradation of land habitats and restore ecosystem health, however, restoration is a challenging and lengthy process. Restoration requires a close engagement with local and indigenous communities that share an interest in conserving and restoring lands. Local communities harbor traditional knowledge and cultural values that can inform land management, monitor restoration progress and improve recovery and greater biodiversity (IPBES., 2019). However, to realize this success requires close alignment between scientists, governments, and local and indigenous communities to ensure incentives and benefits are shared.

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NS researched and drafted the manuscript. YM researched and reviewed the manuscript. All authors contributed to the article and approved the submitted version.

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