# A status report on Assisted Natural Regeneration: What, why, who, where, and how?

*A whitepaper by the Assisted Natural Regeneration Alliance*

**ASSISTED NATURAL REGENERATION**
ALLIANCE

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# Table of Contents

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# Executive **Summary**

Ecosystem restoration is urgently needed to mitigate and adapt to climate change; conserve and restore the planet's biodiversity, water, and soils; and to secure and enhance nature's contributions to people.

The United Nations Decade on Ecosystem Restoration (2021–2030) is a global movement to engage all sectors of society to participate in restoring ecosystems using a wide range of approaches and to achieve multiple objectives.

This document summarizes the current "state of the art" of one of these approaches — assisted natural regeneration (ANR) — with an emphasis on forest, woodland, and savanna ecosystems in the world's tropical and subtropical regions. It summarizes foundational literature, articulates regional perspectives on ANR and provides a conceptual framework for considering ANR practices within a broad set of nature-based solutions.

Our intended audience is broad, including restoration practitioners and implementers, policy makers and researchers.

Our aim is to present a common vocabulary to simulate collaborative activities among all stakeholders and to enable effective decision making and favorable conditions for implementation.

## The role, mission, structure and action modes of the Assisted Natural Regeneration Alliance

The ANR Alliance is a newly formed network with the mission to globally advance and amplify the practice and efficacy of ANR, fostering the recovery and vitality of natural and managed ecosystems for equitable and sustainable livelihoods and multiple socio-environmental benefits.

The main goals of the ANR Alliance are to:

1. stimulate wider awareness and knowledge regarding ANR practices;
2. support enabling policies and incentives for ANR implementation; and
3. facilitate access to evidence, technical support and monitoring capacity.

The ANR Alliance aims to strengthen and align local ANR efforts within the context of subnational, national and global agendas focused on nature-based solutions, ecosystem restoration, integrated landscape management and sustainable agriculture. Regional and global multi-sector platforms provide mechanisms to overcome barriers to ANR implementation, synthesize information, propose solutions and actions at subnational, national and international scales, and raise awareness of issues of common interest around the world.

**We advocate prioritizing consideration of ANR practices where and when they are feasible, while fully supporting responsible tree planting where and when it is required for socio-economic or environmental reasons.**

The Assisted Natural Regeneration Alliance was created in 2022 by the World Resources Institute, with support of WRI Brasil, Instituto Centro de Vida, Imazon and Suzano as an initial contribution of the project "Catalyzing and Implementing Assisted Natural Regeneration in Mato Grosso and Pará, Brazil."

Although ANR has strong links to agriculture, forestry, conservation and sustainable development (Figure 1), it is not formally integrated into these sectors and lacks adequate financial, political, and technical support from donors, investors, and governments to achieve its full potential.

Currently, the ANR "community" is highly fragmented across disciplines, sectors, and geographic regions, with no unifying platform. To bring this community together, the ANR Alliance aims to function as a multi-sector professional network and knowledge/technical facility among practitioners, researchers, implementing organizations, decision-makers, funders, and researchers.

The ANR Alliance began activities through establishing three regional networks in Asia-Pacific, Africa, and Latin America-Caribbean. Following regional surveys of practitioners, policy-makers, and researches, a series of virtual workshops were held in March and April 2023 to engage a diversity of ANR stakeholders, gathering 130 participants from 43 countries and 90 organizations. These regional workshops were followed by an in-person workshop with regional co-leaders in August 2023 to highlight priority activities and begin developing a Strategy and Short-term action plan. The ANR Alliance will initiate targeted outreach activities to foster wider adoption of ANR practices and to engage multiple regional and global actors and partners.

We invite engagement and partnership of individuals and organizations in these early steps of the Assisted Natural Regeneration Alliance.

Gabriel Mulenga/CIFOR

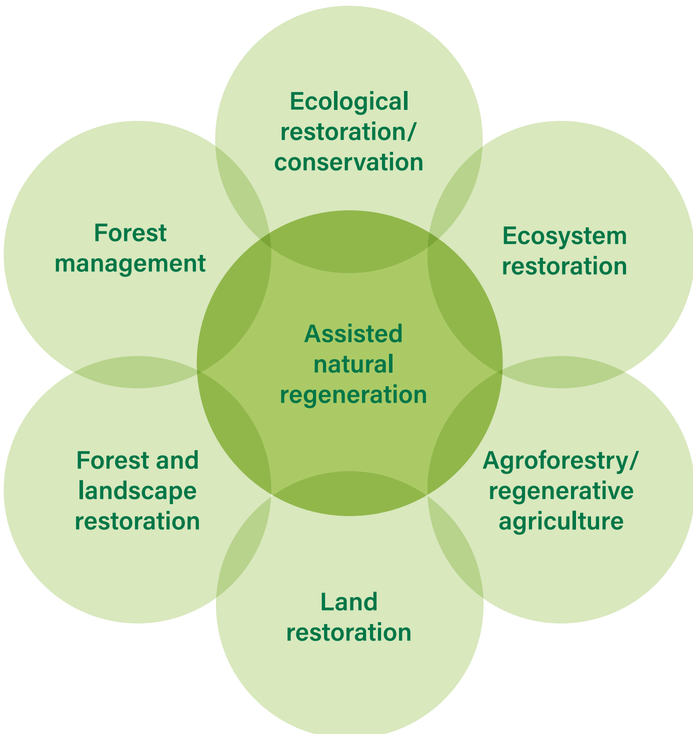
Assisted Natural Regeneration demonstration plot in Zambia

what

## What is Assisted Natural Regeneration?

**Assisted natural regeneration (ANR) is a set of practices and interventions designed to enhance and accelerate the recovery of natural and managed ecosystems.** These practices can be applied to ecological restoration, ecosystem restoration, land restoration, landscape restoration, forest management, agroforestry, and sustainable landscape management (Figure 1). Indigenous and traditional knowledge provide essential contributions to current ANR practices.[1]

**Figure 1.** Assisted natural regeneration practices can be applied to many nature-based solutions



ANR practices can be implemented in combination with other restoration and sustainable land-use practices at local and landscape scales. Enrichment planting and reintroduction can be appropriate elements of ANR practice if the primary emphasis of restorative actions is on promoting natural regeneration. Natural regeneration is a core component of conservation, restoration, and sustainable management efforts.

ANR approaches are inherently flexible, as they address conditions specific to sites and landscapes. The relatively low cost than other methods and multiple benefits offered make ANR a highly effective and economically viable restoration approach[2].

Assisted natural regeneration interventions can be implemented at different spatial scales and with different objectives:

- restoration of degraded forest, shrublands, pasturelands and grasslands, within the context of ecological and ecosystem restoration;
- forest regeneration and management for production and commercial value (including in post-logging forests); and
- regeneration of trees on farms and rangelands.

The first two of these modalities focus on regeneration at the stand or ecosystem level, whereas regeneration of individual trees or small patches of trees within farms and rangelands aligns closely with integrated landscape management and agroforestry.

The practice of ANR has tremendous promise in ecosystem restoration, sustainable land management, and forest and landscape restoration, the needs to be better utilized and appreciated by people on the ground, NGOs and government agencies, and high-level decision-makers.

Patrick Durst

ANR study tour.
Bohol, Philippines

Ruth Metzel_CI

Azuero Panama monitoring

why

## Why does ANR offer many benefits?

Satellite images and data shows that forests are regenerating naturally all over the world[3]. ANR harnesses the natural potential for recovery within ecosystems and landscapes. Biodiversity and ecosystem services are greatly enhanced during natural regeneration. Naturally regenerating forests offer rich opportunities for substantial recovery of biodiversity and carbon stocks within only a few decades, although complete recovery of native ecosystems can take centuries[4].

Compared to monoculture tree plantations, natural regeneration of forests is more effective for recovery of native biodiversity, regulatory ecosystem services, and for enhancing resilience to climate change impacts[5]. Naturally regenerating ecosystems are also important resources for ecotourism, environmental education, and recreation, helping to support local businesses, community-based enterprises, cultural practices, and local conservation efforts. ANR interventions can reduce soil erosion and improve water quality within a few years.

As natural forest regeneration is the most effective approach for long-term storage of carbon, ANR is of particular interest for its importance in mitigating global warming[6]. ANR practices are closely aligned with nature-based solutions for infrastructure, disaster-risk reduction and climate adaptation.

Nature-based solutions can be applied in the context of urban reforestation, wetland restoration and forest restoration, to reduce risks of flooding and soil erosion, stabilize water flows and improve water quality, and moderate local temperatures.

In agricultural landscapes ANR practices can reinforce the resilience of ecosystems in order to prevent, reduce, respond to, or adapt to existing or anticipated stressors, including climate change and extreme events[7].

who

## Who are the implementers of ANR?

The implementers and practitioners of ANR are the actors who provide the assistance that helps trees, ecosystems, and landscapes regenerate. ANR implementation provides a way to bring together local communities, farmers and land managers to engage intimately with restoration efforts, while building multiple components of community capital.

The tools and practices of ANR are relatively inexpensive and do not require extensive training or supply chains[8]. Weeding, thinning, pressing grasses, building exclosures, tree pruning, creating fire breaks, and watering or fertilizing trees can be done by individuals, families, community or church groups, smallholder farmers, and forest or reserve managers[9].

Jake Brennan

Clearing pasture grass for restoration, Ecuador

Practicing ANR involves a conceptual orientation toward evaluating the current state of degradation in the focal area and assessing options to promote a recovery trajectory based on promoting establishment and growth of native vegetation and species interactions. ANR approaches will require a change of mindset from business-as-usual tree planting schemes toward protecting, tending, and managing naturally regenerating trees to enhance recovery of ecosystem processes.

## Where are the best opportunities for ANR?

As an approach to restoring ecosystem functions, ANR is more viable and cost-effective where natural regeneration of forest, woodland and savanna ecosystems has a moderate- to high potential and where opportunity costs of land use are low, as in cases where land has been abandoned due to poor economic returns of farming or ranching. Where opportunity costs are higher, economic incentives can tip the balance toward adoption of ANR practices. Spatial predictive models can be used to identify suitable areas for assisted natural regeneration with high certainty, based on locations where natural regeneration has already occurred and persisted. Applying these methods across the Brazilian Atlantic Forest found that 21.8 million hectares, 30% of the entire restorable area, presented good opportunities for ANR[10].

**A recent global analysis using the same technique estimates that 215 million hectares of tropical and subtropical areas have potential for assisted natural regeneration.** The top three countries with highest potential for ANR are Brazil (43.7 Mha), Indonesia (29.3 Mha), and China (15.5 Mha)[11].

## How can ANR be integrated within forestry and agricultural production systems?

Enrichment planting of naturally regenerating forests with native and non-native tree species can increase their commercial value, biodiversity, and carbon stocks.

Forest management usig ANR approaches can be applied to promote regeneration of tree species in logged or degraded forest parcels or to promote timber species in naturally regrowing forests on formerly cleared land[12]. The practice of farmer managed natural regeneration (FMNR) is based on the selection of tree stumps and rootstocks of particular species used for food, fuel, or fodder. **FMNR practices have been introduced in 27 countries and extend over an estimated 18.2 million hectares worldwide[13].**

ANR approaches can also be applied in shifting cultivation systems to manage fallows and to transition towards sustainable agroforestry systems.

Silvopastoral systems, which combine livestock raising with use of trees and shrubs, can also integrate ANR practices. Pastures can be managed to promote the natural regeneration of trees and shrubs, through protection of isolated remnant trees and use of living fences where seed dispersing animals forage and perch[14].

## What are the major barriers and challenges to ANR implementation?

In addition to biophysical barriers such as uncontrolled fires, invasive species, and excessive grazing, nurturing a forest transition through ANR approaches presents immense policy and institutional challenges. The policy context of ANR is complex, due to the varied nature of ANR interventions, their spatial scale, and livelihood contexts.

Major policy barriers to adoption of ANR are:

- lack of land or tree tenure;
- restrictions on harvesting and marketing timber from naturally regenerating forests on private or community-held land;
- uniform taxation policies for abandoned farmland; and
- reforestation or restoration policies that do not recognize ANR as an approved and viable method of reforestation or ecosystem restoration.

Strict conservation policies intended to protect vulnerable species or prevent forest loss and degradation can also have perverse outcomes for promoting ANR, as smallholders have difficulties complying with legal requirements for permits for tree harvesting[15].

In many countries, production and sale of timber and fuelwood products from regenerating forests face serious obstacles due to legal restrictions, lack of appropriate government incentives for timber production through ANR, and limited dissemination of information regarding the contributions of regenerating forests to sustaining rural livelihoods[16]. Sustainable harvest of products from ANR sites can enhance the value and persistence of regenerating forest ecosystems and provide an important economic incentive for people assisting natural regeneration.

If ANR is to fulfill its potential for providing a diversity of environmental goods and services, policies will need to foster multiple-use management of regenerating forests that support legal instruments for supply chains for timber and non-timber products.

It is important to overcome perceptions of policy makers and the general public that the only way to restore forests or degraded lands is through tree planting. Another misconception is that natural regeneration should not require assistance (as it will happen anyway), and therefore should not be incentivized or supported by payments. Farmers also have persistent beliefs that trees and shrubs compete with crops for water and soil nutrients and should be removed from their farms.

Monitoring the progress of natural regenerating vegetation apart from planted vegetation and its impacts on people's lives is also a challenge, as most monitoring programs focus only on tracking survival and growth of planted forests.

## How to finance ANR?

Data for modeling the costs, benefits and risks of ANR in different contexts are patchy at best, but are critical for developing effective incentives and financing arrangements.

**Implementation costs for ANR (including fencing and enrichment planting) in Brazil were 33% and 32% of costs of full-scale planting of native tree species in Atlantic Forest and Amazonia, respectively**[17].

The economic benefits of FMNR have been evaluated more than for other types of ANR practices. Trees on farms increase water infiltration into soils, reduce soil temperature, and protect crops from wind damage. In addition, non-timber forest products such as fruits, nuts, fuel wood, forage and thatch bolster the economies of rural households in sub-Saharan Africa. Farmers who adopt FMNR practices — intercropping with nitrogen-fixing trees, crop rotations, higher tree densities, tree pruning and exclusion of fire — have higher crop yields[18].

The economic value of regulating ecosystem services (carbon sinks and carbon stocks) provided by secondary tropical forests comes at the expense of provisioning ecosystem services (fodder and timber)[19].

The most commonly utilized approach for financing ANR initiatives is based on payments for environmental services (PES) to farmers and landowners. These payments have generally been used in programs managed by state or national governments.

If policy restrictions are removed and access to better markets and credit are improved, income from sustainably managed timber and non-timber products and agroforestry products can also lead to self-sustaining ANR projects.

A third avenue for financing ANR comes from direct payments to landowners or communities that generate sales of verified carbon credits. Although several initiatives are underway to market carbon credits through ANR, serious challenges face the use of ANR sites for verified carbon credits, including issues of additionality, leakage, and permanence[20].

what

## What factors enable ANR implementation and effective outcomes

When ANR practices are incorporated into forestry and agricultural production systems, more traditional sectoral policies can provide an enabling environment for implementation of a variety of approaches. Case studies of ANR show that important factors for motivating, enabling and implementing ANR are the environmental benefits for local communities. These benefits include improving forest and soil quality; enhancing local biodiversity; increasing and regulating water supplies and pollination services; reducing erosion; and storing carbon in naturally regenerating vegetation[21].

Economic incentives, effective coordination and governance within ANR projects are also important motivating factors. Clear assignment of roles and responsibilities and consideration of distinct needs of stakeholders involved led to more successful implementation of ANR. Additional enabling factors for ANR include: effective local and national leaders, community organizers and champions, broad community support, technical training on ANR practices, incentives and rewards for practicing ANR[22].

"Seeing is believing" remains the most compelling evidence for the effectiveness of ANR. The evidence base for effectiveness of ANR needs to grow and provide robust documentation of local and global benefits that will capture the interest of communities together with investors, donors, organizations, corporations, and decision makers. A concerted communications campaign is needed to build awareness of the potential of ANR, with dedicated resources for study tours to successful project sites, farmer-to-farmer and forester-to-forester exchanges, and production of awareness-raising videos, brochures, posters, and feature articles. These issues are central to the strategy of the ANR Alliance.

Robin Chazdon

A five-year old ANR site in Bohol, Philippines

# Introduction

Ecosystem restoration is urgently needed to mitigate and adapt to climate change; conserve and restore the planet's biodiversity, water, and soils; and to secure and enhance nature's contributions to people. In addition to making essential contributions to the United Nations Sustainable Development Goals, restoring ecosystems is at the heart of global commitments under the United Nations Framework Convention on Climate Change (UNFCCC), the post-2020 Global Biodiversity Framework of the Convention on Biological Diversity (CBD), and the United Nations Convention to Combat Desertification (UNCCD). The United Nations Decade on Ecosystem Restoration (2021–2030) is a movement to engage all sectors of society to participate in restoring ecosystems using a wide range of approaches and to achieve multiple objectives. These international efforts emphasize the urgency and importance of undertaking restorative actions at local, subnational, and national scales.

All ecosystems have some capacity to recover their structure, functions, and composition following disturbances. In many cases, however, local and landscape conditions impede recovery through spontaneous natural regeneration processes (Elias et al. 2020, Jakovac et al. 2021), requiring management interventions to recover vegetation structure and diversity of native species and to promote successional or functional groups (Holl and Aide 2011, Jakovac et al. 2014, Rezende and Vieira 2019). Assisted natural regeneration (ANR) is a set of restoration practices and interventions designed to enhance and accelerate the recovery of ecosystems by overcoming specific barriers (Shono et al. 2020, McDonald 2021). These strategies (Table 1) may include the control of invasive grasses, ferns or shrubs and targeted enrichment planting of native species that fail to regenerate on their own (Orsi et al. 2011, Brancalion et al. 2016, Palomeque et al. 2017). The most appropriate ANR interventions

Robin Chazdon


Community-based ANR project in Malatapi, Zambales, Philippines are tailored to particular natural and managed ecosystems, socio-economic conditions, and landscape contexts.

The landscape and socio-economic context of ANR is an important determinant of success. In landscapes where natural regeneration of forest, woodland and savanna ecosystems has a moderate to high potential, ANR approaches can be far more cost-effective than full-scale tree planting (Evans et al. 2015, Latawiec et al. 2016, Crouzeilles et al. 2020). Without regulation or subsidies, however, ANR generally cannot compete with high-value agriculture on a financial basis. As an approach to restoring ecosystem functions, ANR is most viable where opportunity costs are low, as in cases where farmland has been abandoned due to inadequate financial returns. ANR approaches are less likely to be effective on lands with high levels of degradation (Nunes et al. 2017, Carvalho Ribeiro et al. 2020, Nunes et al. 2020) or where alternative land uses have high financial returns for landowners.

Despite its tremendous promise and widespread application, the practice of ANR remains underutilized and poorly appreciated (Chazdon et al. 2020b). This document summarizes the current "state of the art" of ANR around the world, with an emphasis on forest, woodland, and savanna ecosystems in the world's tropical and subtropical regions. It summarizes foundational literature, articulates regional perspectives on ANR and provides a conceptual framework for considering ANR practices within a broad set of nature-based solutions.

Our aim is to present a common vocabulary and highlight collaborative opportunities for engaging partners and members in the Assisted Natural Regeneration Alliance leading to expanded and accelerated application of ANR globally. Sections focus on the relevance of ANR in the context of ecosystem restoration, sustainable development and integrated land management. We examine how a wide range of nature's contributions to people can be enhanced through ANR and explore how ANR is aligned with restoration and conservation goals and can support forestry, agroforestry, and regenerative agriculture. Further, ANR is an important component of nature-based solutions for climate mitigation, climate adaptation and disaster-risk reduction. The report examines how ANR is being implemented currently and by whom and explores the policies and governance arrangements that support ANR interventions. Later sections review evidence for the costs and benefits of ANR and mechanisms for financing ANR interventions and practices, and insights and key lessons learned from case studies. Each section highlights key gaps and directions for further inquiries.

## The mission, goals, and functions of the Assisted Natural Regeneration Alliance

The Assisted Natural Regeneration Alliance was created in 2022 by the World Resources Institute to stimulate implementation of ANR as a low-cost restoration practice that also can provide livelihoods and economic benefits to rural communities across the world. Although ANR has strong links to agriculture, forestry, conservation and sustainable development, it is not formally integrated into these sectors and lacks adequate financial, political, and technical support from donors, investors, and governments. The ANR "community" has become highly fragmented across disciplines, sectors, and geographic regions with no unifying regional or global platform.

The mission of the Assisted Natural Regeneration Alliance is to **globally advance and amplify the practice and efficacy of ANR, fostering the recovery and vitality of natural and managed ecosystems for equitable and sustainable livelihoods and multiple socio-environmental benefits.**

The main goals of the ANR Alliance are to:

- stimulate wider awareness and knowledge regarding ANR practices;
- support enabling policies and incentives for ANR implementation; and
- facilitate access to evidence, technical support and monitoring capacity.

The ANR Alliance aims to strengthen and align local ANR efforts within the context of subnational, national and global agendas focused on nature-based solutions, ecosystem restoration, integrated landscape management and sustainable agriculture. Regional and global multi-sector platforms provide mechanisms to overcome barriers to ANR implementation, synthesize information, propose solutions and actions at subnational, national and international scales, and raise awareness of issues of common interest around the world.

We advocate prioritizing consideration of ANR practices where and when they are feasible, while fully supporting responsible tree planting where and when it is required for socio-economic or environmental reasons.

The ANR Alliance will operate through regional and country-level multi-sector networks and knowledge/technical facilities involving practitioners, researchers, implementing organizations, decision-makers, funders, and researchers across Africa, Asia-Pacific, and Latin America-Caribbean. Together, we aim to strengthen and align local ANR efforts within the context of subnational, national and global agendas focused on nature-based solutions, ecosystem restoration, and sustainable agriculture.

Following regional surveys of practitioners, policy-makers, and researches, three virtual workshops were held in March and April 2023 to engage a diversity of ANR stakeholders, gathering 130 participants from 43 countries and 90 organizations. Based on input from these surveys and workshops together with future members, we will build a consensus regarding priority activities within each region and develop a short-term Strategic Plan. We will also interact with other networks that intersect in their focus on ANR, including the Global Evergreening Alliance and the newly formed Natural Regeneration Network of the Society for Ecological Restoration. We will also work with AFR100 and Initiative 20x20 to pursue common goals.

Activities organized by the ANR Alliance will include communications and targeted outreach through international, national and subnational conferences, workshops, training webinars, synthesis workshops, task forces, development of a website and document archive, publications including policy briefs and blogs, practitioner and research exchanges and study tours.

# What kind of practice is ANR?

Assisting natural regeneration is a general mode of practice that can include different interventions to promote natural regeneration that are fit to different purposes and ecosystem types (Table 1).

ANR approaches are inherently flexible, as they address obstacles to recovery that are specific to sites and landscapes (Shono et al. 2020), such as inadequate seed dispersal (Duncan and Chapman 2002, Reid et al. 2015), heavy competition from invasive species (Palomeque et al. 2017, Matos et al. 2023), repeated fires (Scheper et al. 2021), and excessive consumption or trampling of regenerating vegetation (Piiroinen et al. 2017). Selection of ANR interventions is based on an informal or formal assessment of the barriers and limitations of natural recovery within the site and surrounding landscape (Holl and Aide 2011, Chazdon et al. 2021b). These interventions can also incorporate the needs of local communities by promoting recovery of forest, dryland, and savanna ecosystems alongside productive land uses (Hoosbeek et al. 2016, Kelly et al. 2021). As a component of larger-scale landscape restoration and integrated landscape management, ANR can complement and enhance other approaches such as full tree planting, agroforestry systems, riparian zone restoration, and regenerative agriculture (Murgueitio 2018, Montagnini 2020).

In the context of ecological restoration, the role of planting in ANR remains a contentious issue. According to the National Standards for the Practice of Ecological Restoration in Australia, "facilitated natural regeneration" practices do not include any planting, whereas "combined regeneration/reintroduction" practices involve reintroduction (through planting) of species that fail to colonize or regenerate as expected (Standards Reference Group 2021). Many implementers, however, view applied nucleation and enrichment planting as components of ANR practices (Wilson et al. 2021), whereas others view ANR as a hybrid of natural regeneration and vegetation reintroduction approaches. Reintroduction may be important to recover key native species, support ecological functions or to enable local livelihoods and income generation. In more general usage, ANR practices promote ecosystem recovery without relying on full-scale planting (Brancalion et al. 2016, Chazdon et al. 2021b, Krishnan and Osuri 2022). Enrichment planting and reintroduction can be appropriate elements of ANR practice if the primary emphasis of restorative actions is to promote natural regeneration.

In the broader context of Forest and Landscape Restoration, ecosystem restoration and integrated landscape management, ANR interventions are used to accelerate ecosystem and landscape recovery with a variety of approaches that are not strictly focused on recovery of the structure and composition of the original ecosystem (Gray et al. 2016, Uriarte and Chazdon 2016, Kremen and Merenlender 2018, Stanturf and Mansourian 2020), placing ANR within the realm of rehabilitation or partial ecosystem recovery (Gann et al. 2019). Following the ten principles of ecosystem restoration, ANR approaches should aim to achieve the highest level of recovery for biodiversity, ecosystem health and integrity, and human well-being (FAO 2021).

**Table 1. Interventions used in the context of implementation of assisted natural regeneration (ANR) in forest, woodland and dryland ecosystems**

| Context | Intervention |
|---|---|
| Tree-based | Remove weeds and press grass around naturally regenerating tree saplings |
| | Prune regenerating root sprouts, stems and branches |
| | Dig half-moon trenches at base of trees to trap water run-off |
| | Protect trees from insect herbivores and grazers |
| | Fertilize and water trees |
| | Protect trees from premature harvesting |
| Site-based | Assess factors that may limit or prevent natural recovery processes |
| | Select trees, saplings and shrubs in fields or fallow vegetation to protect and tend |
| | Build fences or exclosures to restrict grazing or carefully restrict grazing activity |
| | Protect site from logging or excessive trampling, grass or fuelwood collection |
| | Thin and remove unwanted trees to favor selected species or to reduce fire risk |
| | Create firebreaks around restoration site, and immediately extinguish or control wildfires that threaten the site |
| | Remove weedy species and vines or lianas that impede tree growth |
| | Provide roosting structures for seed-dispersing birds and bats |
| | Strategically introduce seeds or seedlings of local native species that regenerate poorly |
| | Silvicultural interventions to assist recovery of logged or overharvested forests |
| Landscape-based | Prevent or control fires |
| | Regenerate vegetation in upland and riparian zones for watershed management |
| | Protect and restore existing patches of remnant vegetation and habitat fragments |
| | Create or protect vegetated corridors or "stepping stones" that link restoration site with existing fragments in surrounding landscape |

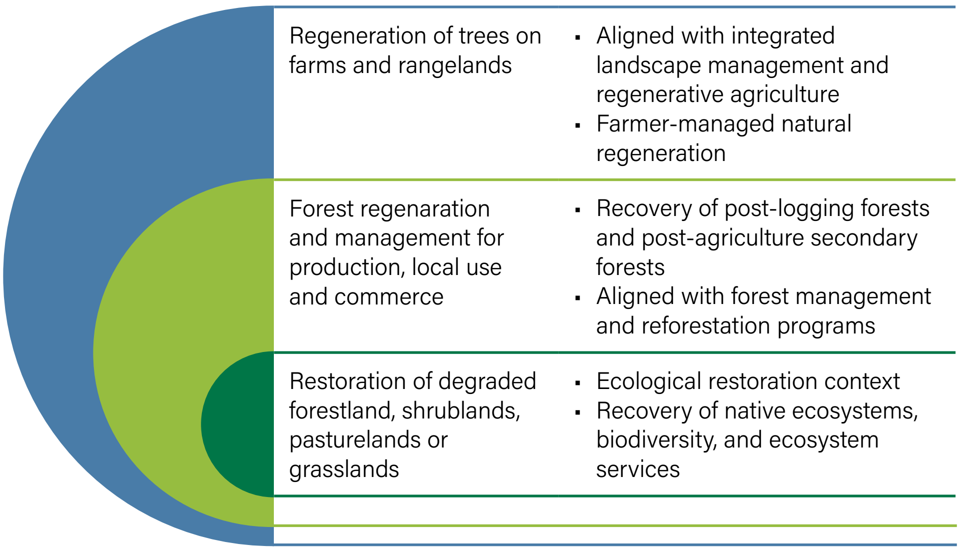
The flexibility, relatively low cost, and multiple benefits offered make ANR a highly effective and economically viable approach for restoring forests, grasslands, woodland, and dryland ecosystems at potentially large spatial scales. A rigorous study in Tigray, Northern Ethiopia compared outcomes of unassisted (open grazing land) regeneration with three exclosure treatments. Vegetation cover, woody species density and diversity of the three exclosure treatments were significantly higher than in adjacent open grazing areas (Araya et al. 2023). Assisted natural regeneration practices can enhance recovery in ways that (1) provide economic or livelihood benefits for local communities and farmers (Kpolita et al. 2022, Tougiani et al. 2023); (2) encourage establishment of native plant and animal species and key species interactions (Trujillo-Miranda et al. 2018); and (3) boost the production of ecosystem services such as carbon storage, improvement of local microclimates, supply of timber and non-timber products, or regulation of water supplies (Negewo et al. 2016, van Meerveld et al. 2021, Werden et al. 2022).

In many implementation contexts, ANR is an approach to ecosystem restoration or ecological restoration, where entire stands or ecosystems are restored as a unit. Shono et al (2020) describe three modalities of ANR: 1) restoration of degraded forest, shrublands, pasturelands and grasslands, within the context of ecological and ecosystem restoration; 2) forest regeneration and management for production and commercial value (including in post-logging forests); and 3) regeneration of trees on farms and rangelands (Figure 2). The first two of these modalities focus on regeneration at the stand or ecosystem level.

The third modality, when ANR is applied at the scale of individual trees or small patches of trees within farms and rangelands falls outside of the scope of ecological restoration, as the objectives and outcomes are more aligned with integrated landscape management and regenerative agriculture (Rey Benayas et al. 2008, Gray et al. 2016). Here, the goal is to assist the regeneration of native vegetation (trees, shrubs, or grasses) to improve agricultural production, for fodder reserves for livestock to reduce risks of erosion from wind and water, or to combine native trees with crop production in agroforestry or silvopastoral systems. The best example of this approach is farmer-managed natural regeneration (FMNR), where native trees and shrubs are protected and managed in fields and grazing lands (Chomba et al. 2020). FMNR is a low-cost, sustainable land regeneration system that can be used to rapidly and efficiently return degraded croplands and grazing lands to productivity (Francis et al. 2015, Reij and Garrity 2016). It is best practiced where soils have not been plowed and root stumps of trees remain underground. FMNR can also restore native biodiversity and increase resilience to severe weather events (Sendzimir et al. 2011). Within the context of integrated land management, FMNR is mostly viewed as an agroforestry practice that improves and diversifies livelihoods, increases crop production, and mitigates effects of droughts and high temperatures (Reij and Garrity 2016). Unfortunately, systematic comparisons of FMNR outcomes are limited by the lack of paired data from FMNR and non-FMNR sites (Chomba et al. 2020).

In other contexts, the focus of restoration is at the landscape or watershed scale (Paudyal et al. 2017a, Paudyal et al. 2017a,b). All three modalities of ANR (Figure 3) can be components of landscape-scale restoration initiatives such as Forest and Landscape Restoration (FLR) (Chazdon 2017). At the landscape scale, different interventions involving ANR in combination with other types of interventions can increase the extent and quality of vegetation cover to improve overall connectivity, watershed functions, biodiversity protection, increase food and fuel security, and improve livelihoods and human wellbeing (Besseau et al. 2018, Melo et al. 2021). For example, depending on the degradation level and landscape context, riparian forests can be restored using ANR, spontaneous natural regeneration or planting of native tree species (Meli et al. 2013, Calle and Holl 2019, Martens et al. 2019) with positive effects on water quality (Chavarria et al. 2021).

**Figure 2. Modalities of ANR. All modalities can be components of watershed- or landscape-scale restoration initiatives or sustainable landscape management**




Forest areas within a landscape can be restored using a combination of approaches such as Applied Nucleation (planting with clumps of trees) (Wilson et al. 2021a), together with ANR and active restoration interventions (Corbin and Holl 2012, Corbin et al. 2016, Barrera-Cataño et al. 2022; Table 2). In China, a long-held practice called Mountain Closure has been widely applied since the 1990s to assist natural regeneration in forest areas degraded by excessive logging or firewood harvest. Mountain Closure prohibits logging, industrial, and agricultural activities in the degraded region, allowing forest recovery through natural regeneration processes (Zhang et al. 2016).

**Table 2. Alignment of the spatial context of ANR with different modes of restoration and rehabilitation in forest or woodland biomes**

| | Mode of restoration or reforestation | | | | | |
|---|---|---|---|---|---|---|
| **Spatial context of assisted natural regeneration** | Agro-forestry | Forest Rehabilitation | Tree Plantations | Ecological restoration | Ecosystem restoration | Forest and landscape restoration |
| **Trees on farms and rangeland** | ✓ | ✓ | ⊘ | ⊘ | ✓ | ✓ |
| **Converted or degraded forest ecosystems** | ⊘ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Landscape matrix** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

Within a landscape, different forms of land-use interact spatially and temporally, and spatial planning can help to increase synergies and minimize negative ecological or socio-economic trade-offs created by these different land uses (Willemen et al. 2014)

## Why ANR help achieve socio-economic, ecological and management goals?

Assisted natural regeneration is not a new practice invented by modern-day restoration practitioners. For millennia, indigenous peoples around the world managed shifting cultivation fallows to enhance soil fertility, promote regeneration of species of economic and ecological importance, and to provide habitats for wildlife (Karthik et al. 2010, Junqueira, 2010a,b, Chazdon, 2014). Managed fallows provide multiple goods and services including food, resins, medicines, firewood and construction materials (Schmid-Vogt 1997, Cairns and Garrity 1999). Indigenous and traditional knowledge provide essential contributions to current management practices for ANR including management of invasive vegetation, tree pruning, and enrichment planting (Douterlungne et al. 2010, Wangpakapattanawong et al. 2010, Uprety et al. 2012). An important aspect of indigenous adaptive management in the Brazilian Amazon is the use of plants that have potential to promote natural regeneration of forest and recovery of biodiversity during the post-cultivation fallow period (Schmidt et al. 2021). Shifting cultivation fallows in Tanzania highlight the potential for natural regeneration to contribute to global and national climate and biodiversity goals and to sustainable, productive forest management (Doggart et al. 2023).

Practices of FMNR, involving coppicing and pollarding of naturally regenerating trees, draw upon traditional land management practices of farmers in dryland West Africa (Rinaudo 2007, Kandel et al. 2022). But this approach was new to many farmers in Niger who viewed trees on farmland as "weeds" that compete with food crops (Rinaudo 2007). Traditional *Ngitili* practices involving dry-season fodder reserves and woodlot protection are widely practiced within the context of ANR and community-based landscape restoration in Shinyanga, Tanzania (Wanjira et al. 2020).

In many traditional societies, land uses blended conservation, farming, and regeneration. In Northern Luzon, Philippines, the "muyong system" practiced by the *Ifugaos* for tending forests could be viewed as a forest conservation strategy, a watershed rehabilitation technique, a farming system or an assisted natural regeneration strategy (Butic and Ngidlo 2003, Camacho et al. 2009). Home gardens (Landreth and Saito 2014) and forest gardens (Ford and Nigh 2016) functioned as diverse agroforestry systems for harvesting timber and non-timber products, such as fruits, resins, medicinal plants, and game animals, in combination with assisted natural regeneration of native tree and shrub species (Michon et al. 2010). In the Northwestern Ghats of India, shifting agriculture practices support a high diversity of tree and shrub species, and swidden fallows provide numerous forest products, such as firewood, small timber, medicines, and food plants (Godbole et al. 2015).

Sacred forests in many regions are often composed of naturally regenerating forests, both assisted and unassisted, and have been managed and stewarded by local communities for many generations (Bhagwat and Rutte 2006, Yang et al.

2021). Protecting and enhancing the value of forests and other ecosystems is a cultural tradition that is strongly aligned with ANR practices (Constant and Taylor 2020, Baez Schon et al. 2022). Yet, assessments in West Africa indicate that sacred forest areas are being seriously degraded by human pressures (Padonou et al. 2019).

Different modalities of assisted natural regeneration can support a broad set of goals within the context of ecosystem restoration, landscape restoration, sustainable development and integrated land management. When conditions are suitable, spontaneous natural regeneration (often called "passive" restoration), can be an effective pathway to ecosystem recovery, requiring only site protection (Prach and del Moral 2015, da Silva et al. 2019, Barros et al. 2020, Jakovac et al. 2021, Poorter et al. 2021, Ssekuubwa et al. 2021).

Naturally regenerating forests offer rich opportunities for substantial recovery of biodiversity and carbon stocks within only a few decades, although complete recovery of native ecosystems can take centuries (Chazdon et al. 2009, Poorter et al. 2016, Crouzeilles et al. 2017, Barros et al. 2020, Matos et al. 2020). In the Atlantic Forest of southeastern Brazil, ANR implemented by local communities enhanced native biodiversity, particularly promoting species of cultural and economic importance (Souza et al. 2016). Compared to monoculture tree plantations, natural regeneration of forests is more effective for recovery of native biodiversity (Nichol and Abbas 2021, Hua et al. 2022, Tito et al. 2022), regulatory ecosystem services, and for enhancing resilience to climate change impacts (Petrokas et al. 2022, Santos et al. 2022). Many gaps remain in our understanding of how particular ANR practices influence outcomes, however, as assisted and unassisted natural regeneration treatments are usually combined in comparisons with other restoration or reforestation approaches.

Although the full recovery of ecosystems takes many decades or even centuries, it doesn't have to take 600 years to see the positive impacts of assisting natural regeneration (Box 1). In sites affected by grazing or invasive vegetation, ANR practices can promote ecosystem recovery and conservation, particularly in protected areas where obstacles to recovery are effectively mitigated and regrowing areas are able to persist. In the Numinbah Conservation Area in southeast Queensland, Australia, for example, protection from grazing and removal of invasive shrubs significantly promoted rainforest regeneration after 4–6 years (Uebel et al. 2017). ANR interventions can reduce soil erosion and improve water quality within a few years (Yang et al. 2018).

Several studies document how ANR can enhance a wide range of ecosystem services (Baretha et al. 2022). In an experimental study, Yang et al. (2018) found multiple ecosystem services were greater in ANR of secondary forests dominated by Chinese fir compared to monoculture plantations established at the same time. Young ANR forest had reduced surface runoff and sediment yield, reduced export of dissolved organic carbon, increased plant diversity, and increased aboveground biomass compared to young plantations (Yang et al. 2018). Fine root biomass and production increased rapidly in degraded forest stands six years after mountain closure in subtropical forests of eastern China (Feng et al. 2018).

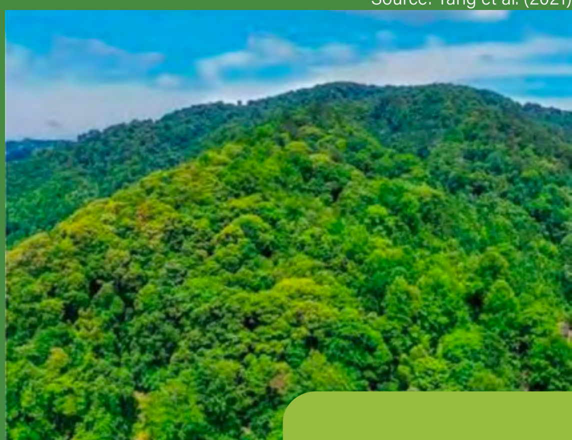
In eastern rain forests of Madagascar, young regenerating tropical forest vegetation can positively contribute to locally important hydrological ecosystem services. Regenerating forest fallows had reduced overland flow, increased infiltration, and higher total evapotranspiration than degraded land (van Meerveld et al. 2021). In the Panama Canal watershed, natural regeneration of tropical forests rapidly enhanced water quality and stream microbial diversity after only a few years of forest growth by improving river bank stability (Chavarria et al. 2021). Tropical dry forest on the Pacific Coast of Mexico showed rapid recovery of multiple forest resources including provision of timber and non-timber products, microclimate regulation and carbon storage within the first two decades of forest regeneration (Naime et al. 2020, Cortés-Calderón et al. 2021).

Naturally regenerating ecosystems are also important resources for ecotourism, environmental education, and recreation, helping to support local businesses and conservation efforts (Meadows et al. 2018, Adetola et al. 2021, Rafa et al. 2021). Benefits flow in both directions; in Costa Rica's Osa Peninsula, several ecolodges have contributed directly to reforestation and natural regeneration of tropical forests adjacent to Corcovado National Park (Almeyda et al. 2010, Hunt et al. 2015). In the Guanacaste Conservation Area of Costa Rica, large-scale forest regeneration assisted by controlling fires has contributed to conservation of wild biodiversity and expansion of protected areas that support environmental education and biodiversity research (Pringle 2017). The carbon storage potential of ANR is of particular interest for its importance in mitigating global warming. Lewis et al. (2019) claim that natural forest regeneration is the most effective

### Box 1. Converting a monoculture plantation to diverse native forest through ANR

The history of the Wanmulin Nature Reserve in Fujian Province, China illustrates how 600 years of natural regeneration transformed a Chinese fir (*Cunninghamia lanceolata)* plantation into a forest with high levels of biological diversity and many similarities to old-growth forest (Yang et al. 2021). The 189-hectare plantation was established on a graveyard in 1354 during a famine, when the owner gave a bushel of millet to suffering people if they planted a Chinese fir sapling. When the plantation was 31 years old, the owner's son donated approximately 30,000 trees for construction of a Temple, which were the only trees harvested. When the plantation was 45 years old, the land was declared a protected area by the provincial government, prohibiting development and logging. The site is now incorporated into the Nature Reserve system of Fujian Province and shows a diverse array of plant communities and dominant native tree species. Here, natural regeneration was assisted through active stewardship and protection of the former plantation across many generations and jurisdictions; nature took control over the recovery process. Ecosystem services currently provided by the Wanmulin Nature Reserve are valued at approximately USD$40 million annually, of which 41.4% is attributed to soil protection and improvement, 29.3% to air purification, and 13.5% to water resource protection (Yu 2001).

Source: Yang et al. (2021)



A visual overlook of the Wanmulin Nature Reserve.

approach for storing carbon. In Eastern Amazonia, however, aboveground carbon recovery after 30 years was higher in agroforestry systems than in naturally regenerating secondary forests (Cardozo et al. 2022). Another study found that forest biomass recovered at a rate of 2.25 Mg/ha per year during the first 20 years of succession (Lennox et al. 2018). It is important to note that assessments of carbon uptake in regenerating forests are highly uncertain and vary geographically (Cook-Patton et al. 2020, Junior et al. 2020). Despite the large area of naturally regenerating forests in the Brazilian Amazon (~129,000 km$^2$ by 2017), these forests are not achieving their full capacity to offset carbon emissions due to its low permanence and high rates of deforestation of primary forests (Junior et al. 2020, Smith et al. 2020).

Robin Chazdon

Managed second growth with Jucara Sertão do Ubatumirim, Brazil

In Brazil's Atlantic Forest, mixed species restoration plantations accumulated approximately 50% more aboveground carbon than naturally regenerating forests, but total cost-effectiveness for carbon accumulation was, on average, 60% higher for regenerating forests than for plantations (Brancalion et al. 2020a). Another Atlantic Forest study found higher rates of aboveground biomass accumulation in mixed young tree restoration plantings than in older stages of natural regeneration, but costs were not evaluated in this case (Manes et al. 2022).

Important biodiversity co-benefits are obtained alongside carbon recovery during forest regeneration (Chazdon et al. 2009, Poorter et al. 2021). In the Eastern Amazon, after 40 years, naturally regenerating forests recovered around 88% and 85% of species richness and composition from primary forests, respectively (Lennox et al. 2018). An accumulation of 75 Mg/ha of biomass was found as a benchmark for the influx of forest species (Lennox et al. 2018).

In Australia, ANR is preferred over full-scale tree planting in their voluntary carbon farming program for several reasons: 1) greater cost effectiveness and economies of scale; 2) co-benefits for native biodiversity; 3) increased ecosystem functions; 4) greater resistance to invasion by weeds and pests; resilience to climatic risks such as drought and fires (Evans 2018). Lowland naturally regenerating forests (1–60 yr old) in Latin America were estimated to potentially accumulate aboveground carbon stock of 31 Pg of carbon dioxide equivalents from 2008–2048 if they are left to regrow, equivalent to carbon emissions from fossil fuel use and industrial processes in all of Latin America and the Caribbean from 1993 to 2014 (Chazdon et al. 2016). Carbon accumulation varied widely across sites in the Eastern Amazon with differences higher than 90% among these and other sites in South America (Elias et al. 2022). A global study of annual rates of carbon storage in plant biomass (above- and belowground) during the first 30 years of natural regeneration showed 100-fold variation across forest biomes, with the highest accumulation rates in warm and wet tropical forest biomes (Cook-Patton et al. 2020).

More experimental research is needed across different ecosystems and biomes to evaluate the *additionality* of assisting natural regeneration for carbon storage and hydrological services as compared to unassisted natural regeneration: what is the additional payoff for assisting natural regeneration? A test of ANR techniques to improve slash-and-burn crop systems and enrich forest fallows clearly demonstrated that biodiversity and biomass in ANR-treated fallows were greater than in non-ANR fallows after 3.5 years (Peltier et al. 2014). A study in the Brazilian Amazon found that fertilization and planting nitrogen-fixing trees in an improved-fallow slash-and-mulch system can allow producers to harvest a merchantable timber species after just one crop-fallow rotation, while leaving slower-growing higher-value trees through subsequent crop-fallow rotations for future timber income (Joslin et al. 2016).

ANR practices are closely aligned with nature-based solutions for infrastructure, disaster-risk reduction and climate adaptation. Nature-based solutions can be applied in the context of urban reforestation, wetland restoration and forest restoration, to reduce risks of flooding and soil erosion, stabilize water flows and improve water quality, and moderate local temperatures (Seddon et al. 2020). But they also are critically important in agricultural landscapes where ANR practices can provide nature-based solutions that reinforce the resilience of ecosystems in order to prevent, reduce, respond to, or adapt to existing or anticipated stressors, including climate change and extreme events (Simelton et al. 2021). Similarly, ANR and other forms of forest restoration and reforestation can contribute to climate change adaptation and mitigation (Locatelli et al. 2015, Locatelli 2016). Mangrove restoration, largely through assisted natural regeneration, can be a strategy for disaster risk reduction and climate change adaptation (Fickert 2020, Menéndez et al. 2020, Gayathre et al. 2021).

Despite the multiple benefits that ANR practices can bring, changing land use is particularly challenging for smallholder farmers who face financial losses when they replace profitable enterprises with restoration interventions that may take decades to bring financial returns. For this reason, technical assistance and up-front compensation mechanisms are needed to promote sustainable land management practices that are aligned with ecosystem and landscape restoration. Investing in programs that provide technical, social, and financial support has huge returns for smallholders and rural communities that are seeking ways to achieve both socio-economic and environmental benefits.

Supporting farmers using ANR approaches is not as simple as providing tree seedlings, however, and requires strong awareness of the biocultural enrichment offered by assisting natural regeneration (Constant and Taylor 2020, Janzen and Hallwachs 2020).

# Who are the implementers and practitioners of ANR?

The implementers and practitioners of ANR are the actors who provide the assistance that helps trees, ecosystems, and landscapes regenerate. ANR implementation provides a way to bring together local communities and farmers to engage intimately with restoration efforts, while building multiple components of community capital (Chazdon et al. 2021a, Herbohn et al. 2022). The tools and practices of ANR are relatively inexpensive and do not require extensive training or supply chains. Weeding, thinning, pressing grasses, building exclosures, tree pruning, creating fire breaks, and watering or fertilizing trees can be done by individuals, families, community or church groups, smallholder farmers, and forest or reserve managers (Belem et al. 2017, Yirdaw et al. 2017).

The core of ANR practice is a conceptual orientation toward evaluating the current state of degradation in the focal area and assessing options to promote a better trajectory of outcomes based on promoting native tree and ecosystem recovery (Larwanou and Saadou 2011).

In the case of FMNR, farmers who have land tenure make the decisions

Source: https://regreeningafrica.org/photo-gallery/

Women tending trees in Senegal as part of the Regreening Africa Program regarding what they grow, and they become more empowered in the process (Francis et al. 2015, Moore et al. 2020). The right to practice FMNR on borrowed or leased land may be restricted depending on the land tenure systems and local practices in certain West African contexts (Kandel et al. 2021). While ANR extension services do not yet exist in many areas, holders of local knowledge (who are typically farmers) are often highly qualified to undertake such assessments themselves. Some projects led by research institutions and organizations also offer assistance and expertise (Rinaudo et al. 2019; Box 2).

For example, the Regreening Dodoma Program, jointly implemented by the organizations Justdiggit and LEAD Foundation, has been promoting FMNR in Tanzania since 2018 (Moore et al. 2020). Farmers are trained in the practice of FMNR based on four steps which are (1) selecting, (2) pruning, (3) marking, and (4) protecting woody regeneration. Farmers decide on which species to promote and participate in the program on a voluntary basis (Moore et al. 2020). Although the FMNR Hub provides many resources for capacity development, few resources focus on Assisted Natural Regeneration at regional or global scales (Alves et al. 2022, Wilson 2022b).

### Box 2. Scaling up land restoration in sub-Saharan Africa

The five-and-a-half year Regreening Africa program, funded by the European Union, aimed to reverse land degradation across 1 million ha in eight countries in sub-Saharan Africa: Ethiopia, Ghana, Kenya, Mali, Niger, Rwanda, Senegal and Somalia. Cumulatively, the Regreening Africa program reached out to 607,088 households across 954,440 ha. The main approach to reclaim Africa's degraded landscapes was to incorporate trees into croplands, communal lands and pastoral areas using Farmer- Managed Natural Regeneration, tree planting and other forms of agroforestry. In each country, the project is building multi-stakeholder partnerships with major international NGOs (World Vision, Oxfam Care International, Catholic Relief Services and Sahel Eco), research organizations (World Agroforesty Centre, Economics of Land Degradation), government ministries and agencies, and grassroots organizations (community-based organizations, women's groups and inter-faith networks). The Regreening Africa App is being used by more than 150,000 farmers and implementers farmers and implementers to capture data at the local and village level, facilitating monitoring of tree planting and farmer-managed natural regeneration (FMNR). Across all eight countries, regreening (including FMNR, tree planting and agroforestry) was implemented in 161,111 households and on 353,435 ha (Regreening Africa Program, 2023). A key principle behind the Regreening Africa program was that restoring land through FMNR interventions changes the mindsets and behaviors of individuals and communities (Jere and Aluoch 2022). The program also emphasized the importance of enabling policies and advocacy for policy change in sub-Saharan Africa (Program 2023) and developed guidelines and tools for upscaling FMNR, increasing capacity and integrating women in restoration practices (Kalinganire 2022, Muriuki et al. 2022, Obwocha et al. 2022).

# Where are the best opportunities for ANR?

As an approach to restoring ecosystem functions, ANR is most viable and cost-effective where natural regeneration of forest, woodland and savanna ecosystems has a moderate to high potential and where opportunity costs of land use are low, as in cases where farmland has been abandoned due to poor financial returns. Spatial predictive models can be used to identify suitable areas for assisted natural regeneration with high certainty, based on locations where natural regeneration has already occurred and persisted. Martins et al. (2014) assessed the potential for natural regeneration across 12 zones within the state of Espirito Santo in Brazil's Atlantic Forest region based on extensive field inventories. Natural regeneration potential was classified according to three main indictors: the total area with potential to receive seeds from surrounding forest fragments, precipitation, and soil and terrain factors. The study concluded that nearly 61% of the total area of the state have high potential for natural regeneration (Martins et al. 2014). Nunes et al. (2017) developed a spatially-explicit model of the costs and benefits of native vegetation regeneration across three biomes in Minas Gerais, Brazil state based on size and distance of local forest fragments, topographic and climate factors, and land-use history. They estimate that 30% of all pasturelands in Minas Gerais (8 Mha) holds medium to high potential for natural regeneration, including 5.7 Mha in Atlantic Forest biome (Nunes et al. 2017).

Robin Chazdon

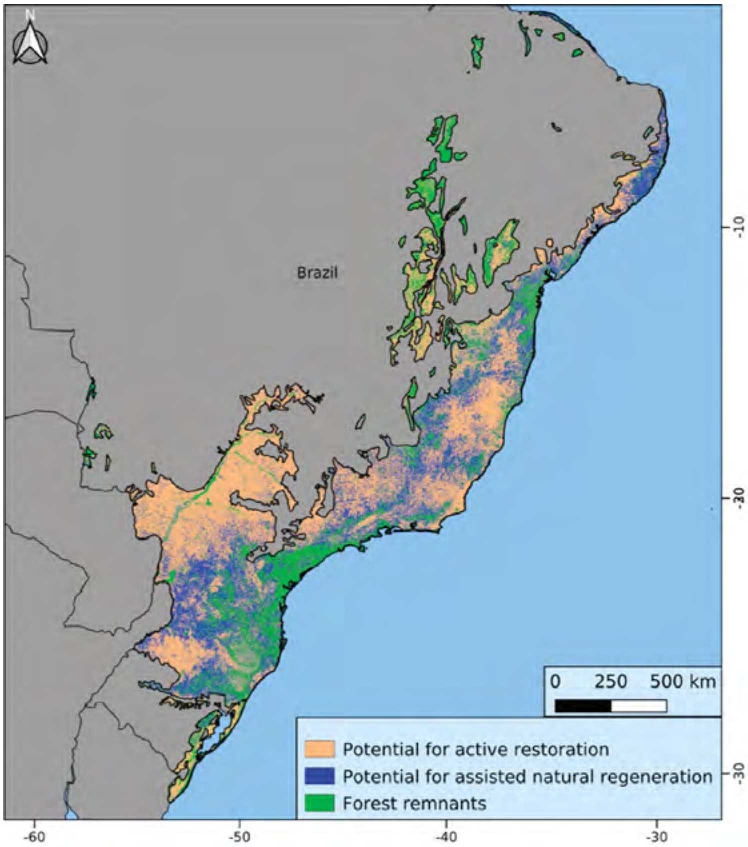
5-yr old ANR site in Anda, Bohol, Philippines

Applying spatial modelling methods across the entire region of Brazilian Atlantic Forest, Crouzeilles et al. (2020) found that 21.8 million hectares, 30% of the entire restorable area, presented good opportunities for ANR (Crouzeilles et al. 2020, Figure 3). Balancing natural regeneration and tree planting is most likely to ensure social equity and compliance with environmental policies in Brazil (Gastauer et al. 2021).

Vieira et al. (2017) assessed the potential for natural regeneration in the Brazilian Amazon based on remote sensing data on mature and secondary forest fragments, early stages of forest regrowth, and cleared pastures. Considering all the areas in the biome with less than 60% forest cover, they identified and mapped 39% microbasins classified with a high potential for natural regeneration, composing an area of over 20 M ha (Vieira et al. 2017).

Recent global analysis based on data on natural forest regeneration across the global tropics and subtropics (Fagan et al. 2022) estimated that 215 million hectares of tropical and subtropical areas have moderate to high potential for assisted natural regeneration. The top three countries with highest potential for ANR are Brazil (43.7 Mha), Indonesia (29.3 Mha), and China (15.5 Mha) (Williams et al. 2023). To be most useful, mapping priority areas for ANR should also take into account the specific ecological benefits and opportunity costs, based on the needs and socio-economic conditions of local communities (Chazdon et al. 2017). Compared with a range of other forest restoration techniques, ANR should be prioritized in areas with high proximity to forest fragments, low to moderate levels of land degradation, secure land tenure/tree tenure rights, high levels of national and international support, and low opportunity costs (Wilson et al. 2022). In the Philippines, ANR implementation has worked best in areas of intermediate population density, where farmland pressure is not too high and sufficient numbers of local people are available to carry out sometimes labor-intensive ANR practices, such as grass pressing and fire break construction (Durst, pers. comm.).

**Figure 3. Priority areas for assisted natural regeneration across Brazil's Atlantic Forest Region. Source: Crouzeilles et al. (2019)**

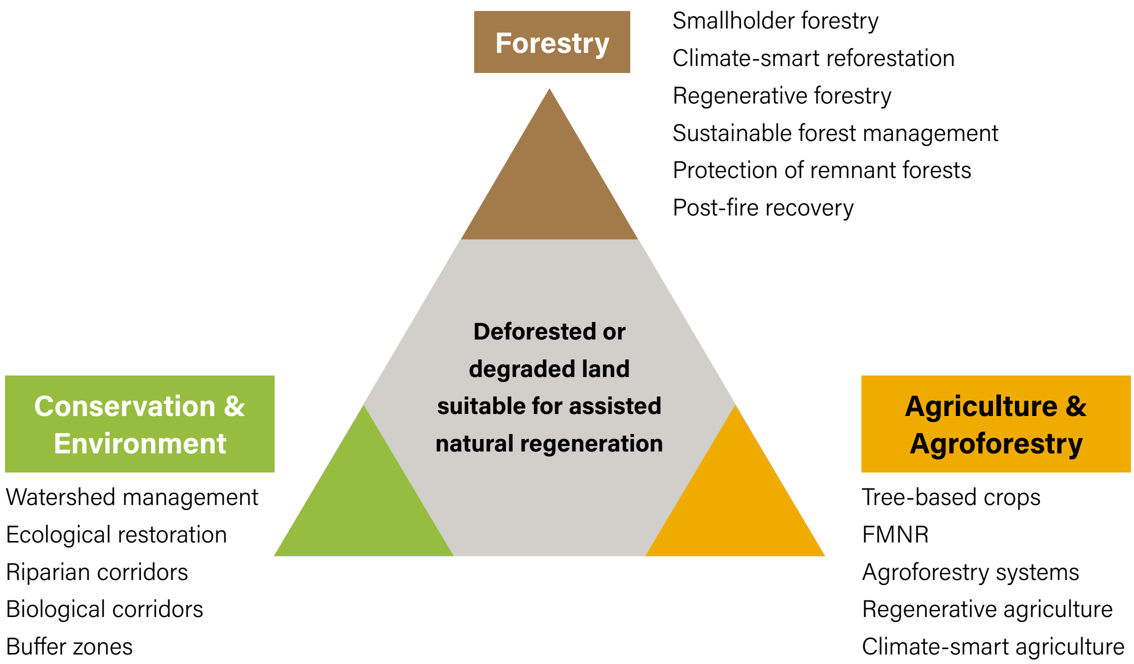


# What policies and governance arrangements can support ANR?

The policy context of ANR is complex, due to the varied nature of ANR interventions, their spatial scale, and livelihood contexts. Nurturing a forest transition through ANR approaches presents immense policy and institutional challenges (Sloan 2015). Although ANR interventions can be implemented within an agricultural, forest management or conservation/ecological restoration context, ANR (and active restoration practices in general) lacks a unified policy foundation and governance framework (Figure 4). Specific policies supporting agroforestry are also lacking in many countries, discouraging ANR practices based on regenerating trees on farms (van Noordwijk et al. 2020). In many cases, reforestation or restoration policies fail to officially recognize ANR as an approved and encouraged method of forest regeneration. Thus, policies often fail to provide the same incentives, cost-sharing, etc. that are available for tree planting. Meeting these challenges requires further policy analysis, reform and innovations in policy and governance (Chazdon et al. 2020b, Chazdon et al. 2021c), an activity that could be supported by guidelines and recommendations from the ANR Alliance.

Supporting and promoting assisted natural regeneration requires a major shift in perception and priorities from conventional resource management approaches. In contrast to policies that effectively criminalize shifting cultivation and long-fallow management to favor mechanized production of cash crop monocultures and globalized agribusiness, ANR-enabling policies embrace the role of shifting cultivators and smallholder producers that understand and rely on natural

**Figure 4. The intersection of ANR implementation with existing practices in forestry, agriculture, agroforestry and conservation/environment sectors**



regeneration processes to produce a wide variety of timber and non-timber products.

In a reversal of policies, programs and institutions that marginalize indigenous peoples and peasant societies, ANR-enabling policies and programs can empower these groups to become champions and beneficiaries of ecosystem and landscape restoration (Hecht 2014, Pain et al. 2021). For example, Junglescapes, an Indian non-profit organization, has been restoring degraded forest habitats in Bandipur Tiger Reserve in South India since 2008. Working together with local tribal peoples who were displaced by the formation of the Tiger Reserve, areas of the reserve are being restored using ANR techniques including removal of dense stands of the invasive shrub *Lantana camara* and fire protection (McDonald et al. 2023). Recently, Junglescapes has initiated a "barefoot restorer" program where experienced community members will train around 100 new community members in different aspects of restoration, including *Lantana* removal (Wilson and McCallum 2023).

A major policy barrier to adoption of ANR is lack of land or tree tenure (Kibru et al. 2021). Uncertainty over land tenure security was a major reason behind a failure of farmers to adopt ANR practices in the Democratic Republic of the Congo (Peltier et al. 2014). In Niger, transfer of tree tenure from state ownership to local ownership led to widespread adoption of FMNR by smallholders (Tougiani et al. 2009). Moreover, farmers practicing FMNR in the Sahel generally own at least one farm plot under a tenure arrangement; farmers under lease and loan tenure arrangements have less motivation to adopt FMNR practices (Binam et al. 2015). In many African and Asian countries, land owners and customary land users often have no legal rights to tree ownership on their properties, discouraging management of regenerating vegetation for economic and environmental benefits. In the Brazilian Amazon, indigenous territories with secure tenure were associated with both reduced deforestation inside their lands and higher secondary forest growth on previously deforested areas (Baragwanath and Bayi 2020).

Policies that favor ecosystem restoration on poorly producing agricultural land can be supportive of ANR. Using annual land-cover time series, Crawford et al. (2022) found high levels of cropland abandonment across 11 sites in four continents and diverse biomes. But more than 50% of these abandoned croplands were recultivated within 30 years of initial abandonment (Crawford et al. 2022). Studies of land-use change in tropical forest biomes confirm that regenerating forests are ephemeral (Schwartz et al. 2020, da Cruz et al. 2021, Piffer et al. 2021). Since 2009, loss of secondary forest has exceeded loss of primary forests in the Brazilian Amazon (Wang et al. 2020). The average life of secondary forests in the Brazilian Amazon is only 5.2 years (Aguiar et al. 2016). In southern Costa Rica, 50% of secondary forest cover is re-cleared within 20 years of land abandonment (Reid et al. 2019), and in Brazil's Atlantic Forest they persist for no more than 8 years, on average (Piffer et al. 2022). Legal instruments to protect naturally regenerating forests in private properties were created in Brazil, specifically in the Atlantic Forest and in the Amazon. Pará was the first (only) Amazonian state to launch a law protecting these ecosystems; forests regenerating for more than 20 years or forests between 5 and 20 years of age with basal area greater than $10m^2$/ha of basal area are not allowed to be cleared (Vieira et al. 2014).

In July 2020, a decree by the President of Niger strengthened the rights of farmers practicing FMNR and provided other incentives, such as an annual national prize for FMNR practice. The decree awards exclusive rights to trees regenerated or planted on farms to producers and regulates FMNR by defining management modalities of agroforestry parklands. The decree was promoted by civil society actors since a national workshop on agroforestry in 2013, with stronger efforts since 2018-2019. Landowners are now encouraged to legally establish "village committees to monitor the trees" and are fully supported by technical extension services of the Ministry of Environment who now monitor national progress of FMNR (Abasse et al. 2023). A favorable political environment could support a similar policy pathway process in Mali and Senegal (Karambiri et al. 2023b), although advances in policies promoting FMNR are urgently needed across Africa.

In the Philippines, Technical Bulletin #27 was issued in 2019 by the Department of Environment and Natural Resources to promote ANR as a forest restoration approach within the nationally-funded Philippines National Greening Program (NGP). Under the Bulletin, specific costings are outlined for payments to community organizations implementing ANR as part of contracted reforestation under the NGP, now known as the ENGP ("Expanding the Coverage of the National Greening Program"). This Bulletin provides one of the few policy instruments on ANR in Asia-Pacific, including very specific and clear guidance for implementing ANR on public lands (Republic of the Philippines 2019).

In the absence of policies and instruments (or the implementation and enforcement of existing laws) that provide incentives for assisting natural regeneration, abandonment of marginal agricultural lands will remain a missed opportunity to reduce biodiversity loss and climate change (Crawford et al. 2022). Such incentives could include payments for environmental services for private landholders who protect regenerating forests on their property (Porras and Chacón-Cascante 2018, Chazdon et al. 2020b). But where lands are suitable for agricultural intensification (often based on mechanization), allowing forests to regenerate greatly reduced financial benefits to landowners. Following large-scale abandonment of cattle pastures in northeastern Costa Rica, landowners favor clearing young secondary forest to establish tree plantations or for growing export crops such as pineapple (Fagan et al. 2013, Shaver et al. 2015). Across much of Brazil's Atlantic Forest, natural regeneration of forests on abandoned cattle pasture occurs is restricted to hilly terrain that is not suitable for mechanized sugarcane production (Molin et al. 2017).

An important financial incentive for assisting natural regeneration is the sustainable harvest of timber and non-timber products, which could enhance the value and persistence of regenerating forest ecosystems (Souza et al. 2016; Box 3). On-farm timber production is an important subsistence and economic activity of smallholder farmers around the world (Sears et al. 2021a, Toledo-Aceves et al. 2022). But production and sale of timber and fuelwood products from regenerating forests face serious obstacles in many countries due to legal restrictions, lack of appropriate government incentives for timber production through ANR, and limited dissemination of information regarding the contributions of regenerating forests to sustaining rural livelihoods, among other barriers (Román-Dañobeytia et al. 2014, Chazdon et al. 2020b, Bieng et al. 2021, Sears et al. 2021b).

If ANR is to fulfill its potential for providing a diversity of environmental goods and services, policies will need to foster multiple-use management of regenerating forests and support legal instruments for supply chains for timber and non-timber products (Sears et al. 2021a, Toledo-Aceves et al. 2022), such as those clarified in the Presidential Decree in Niger. In Peru, forest authorities do not recognize "fallow forestry"—based on processing of small-diameter lumber from regenerating forest fallows—as a legitimate silvicultural system, forcing smallholders to participate in informal and often illegal transactions to sell products from managed regenerating forests (Sears et al. 2021). These restrictions, intended to boost reforestation through tree planting, create major disincentives for ANR in many countries.

A second barrier for selective harvest by smallholders using ANR on farms emerges from the association between forest regeneration and conservation policies designed to protect forests from unregulated harvesting and degradation. Environmental legislation tends to emphasize protection of existing forest rather than to encourage establishment or management of new forests (Chazdon et al. 2020b). When legal prohibitions against deforestation apply to young stages of forest regrowth, smallholders commonly clear early stages of forest regeneration to maintain agricultural land use. In West Africa, farmers prefer to uproot young trees of "protected" species rather than facing legal restrictions on use rights when these trees mature (Yatich et al. 2014).

Strict conservation policies, intended to protect vulnerable species or prevent forest loss and degradation, can have perverse outcomes with respect to ANR, particularly for smallholders who find it difficult to comply with legal requirements for permits for tree harvesting or management. Ambiguities in forest definitions and criteria for forest conservation further complicate efforts to protect young regrowth forests (Vieira et al. 2014).

Policies and regulations that appear to be effective and feasible from the perspective of government officials and forestry agencies can present major obstacles to FMNR implementation by farmers. In Senegal, where development policy frameworks acknowledge and support FMNR and related agroforestry practices, farmers still do not have full ownership and use rights over the trees they nurture on their property, and must apply for permits granted by the Water and Forestry Services (Karambiri et al. 2023a). The aim of forestry institutions to protect trees disregards the need to balance ecological, socio-economic and cultural objectives and impedes farmer-led practices that promote regeneration of these same trees. The root of this policy and regulatory gap in Senegal and many other countries is that the agroforestry sector lacks its own policy and regulatory framework. Thus, forestry-related laws are enforced for the management of agroforestry systems that were not originally intended to be applied to the management of trees on farms (Karambiri et al. 2023a).

Another perverse incentive, from the perspective of protecting natural regeneration, is a new land tax policy in Thailand that charges high tax rates for vacant or uncultivated land. Because land that is regenerating naturally with young secondary forest trees or scrub vegetation is generally considered "unused" by land assessors, several plots covered with dense natural tree regeneration have been cleared and planted with seedlings of fruit trees to bring the land into legal compliance with productive use, which significantly reduces landowners' tax rates (Durst and Durst 2022).

# How can ANR be integrated within forestry and agricultural production systems?

When ANR is incorporated into forestry and agricultural production systems, existing sectoral policies can provide an enabling environment for implementation of a variety of approaches. Forest management using ANR approaches can be applied to promote regeneration of tree species in logged or degraded forest parcels or to promote timber species in naturally regrowing forests on formerly cleared land (Kassaye et al. 2023). Scientists working in the Philippines were among the first to label and describe ANR, which they recommend as a technique to reforest *Imperata* grasslands (Friday 1999, Haglund et al. 2011). Based on early work in the Philippines, FAO began promoting ANR more widely in Southeast Asia as a means of forest rehabilitation and restoration (Dugan et al. 2003, Durst et al. 2011).

From a commercial production perspective, management plans are more feasible and efficient for owners of forest plantations or agroforestry systems, as laws and regulations are simpler than for naturally regenerating forests (Bieng et al. 2021). Commercial tree species recover rapidly during tropical forest regeneration on former pastures or farmland, supporting the potential for management of regenerating forests for timber production (Vilchez-Alvarado et al. 2008, Oliveira et al. 2018, Fantini et al. 2019, Bieng et al. 2021, Souza Oliveira et al. 2021, Zambiazi et al. 2021). In fact, there is evidence that timber production from fast-growing species in secondary forests can reduce logging pressure on dwindling areas of old-growth forests within the Brazilian Amazon (Wang et al. 2020). Although timber from regenerating forests is often rejected from commercial sawmills, it has a high value in local markets, particularly in informal economies (Sears et al. 2018, Bieng et al. 2021, Sears et al. 2021a). Managed regenerating forests can also provide fuelwood and other non-timber products (Toledo-Aceves et al. 2022). Experiments in several countries suggest promising potential for enrichment planting of timber species in combination with silvicultural treatments in naturally regenerating forests (Paquette et al. 2009, Mangueira et al. 2019, dos Santos and Ferreira 2020).

In tropical regions of Nepal, many naturally regenerated forests have been protected from harvesting for several decades. In these cases, silvicultural interventions, such as creating sequential canopy gaps using the irregular shelter wood system, promote regeneration of light-demanding commercial species such as sal (*Shorea robusta*) (Khatri et al. 2021). Yet in many countries, such as the Philippines, local communities who are granted limited tenure over formerly logged natural forests are not allowed to harvest timber from the regenerating forests that they are expected to protect. A 2011 moratorium on cutting and harvesting of timber in natural and residual forests restricts timber harvest to planted trees (Pulhin and Ramirez 2016).

On the forest management side, enrichment planting of naturally regenerating forests with native and non-native (but non-invasive) tree species can increase their commercial value, biodiversity, and carbon stocks (Paquette et al. 2009, Fantini et al. 2019, Minh Quang et al. 2020, (Bernard et al. 2021). Native species with commercial value can also be managed in naturally regenerating forests and agroforests (Souza et al. 2016; Box 3). Alternatively, mixed plantations can combine short-term harvest of commercial species for wood production with long-term natural regeneration (Amazonas et al. 2018a, Amazonas et al. 2018b). Harvested *Eucalyptus* plantations provide favorable conditions for natural regeneration in Brazil's Atlantic Forest region (César et al. 2017, Brancalion et al. 2020b). Diverse native tree regeneration has also been documented in exotic tree plantations in Southern Philippines (Tulod et al. 2017), Thailand (Kitamura et al. 2018), Uganda (Chapman and Chapman 1996), Madagascar (Randriambanona et al. 2019) and Hong Kong (Lee et al. 2005).

A growing regenerative forestry movement aims to convert monoculture tree plantations into more diverse native forests, in a reversal of the predominant trend of replacing native forests with monoculture tree plantations. In China, tree plantations cover 69 M ha and account for 36% of the total forest area (Huang et al. 2018). One approach is to use natural regeneration based on diverse native species in the soil seed bank and seed rain in tree plantations. In Fujian Province (China), the soil seed bank in monoculture Chinese fir plantations and mixed conifer-broadleaf plantations had higher species richness and higher seed density than in an adjacent natural forest (Liu et al. 2022). Seed rain density and diversity were similar across all three forests. The encouraging findings suggest that seed rain and seed bank in plantations can assist the efforts of local forests to promote natural regeneration of diverse forest communities. Rubber plantations can also be managed as integrated systems with a higher diversity of native trees and non-trees in the understory (Chima et al. 2022).

Following selective logging operations, ANR interventions are widely used to promote forest recovery and regeneration of commercial tree species (Soegiri and Pramono 2003, Pena-Claros et al. 2008, Philipson et al. 2020, Bieng et al. 2021). In the context of natural forest management and commercial forestry operations, silvicultural interventions include removal of lianas or competing vegetation around favored trees (Marshall et al. 2016, Swinfield et al. 2016), thinning (Ouedraogo et al. 2011, Hu et al. 2020), enrichment planting (Paquette et al. 2009, Minh Quang et al. 2020), and site protection against premature re-entry of loggers. In Jari Valley of eastern Amazonia, (Schwartz et al. 2013) found that tending naturally established seedlings and saplings in logging gaps was generally more efficient for regeneration than planting and tending together, particularly in areas where there is sufficient natural regeneration of species having high commercial or conservation value.

### Box 3. Market-driven regeneration model

In 1996 Guayaki began producing and marketing shade-grown, organic and fair-trade yerba mate (*Ilex paraguariensis*), sustainably harvested by indigenous communities in Paraguay, Argentina and Brazil. In these regions, the native mate tree grows as an understory tree in natural forests, as a planted tree in agroforestry systems (Montagnini et al. 2011), and in open-grown plantations. Shade-grown mate is a higher-quality but slower-growing product and contributes to sustaining and regenerating forests. Guayakí started buying mate from an indigenous community in Paraguay. To satisfy rising demand for mate demand, Guayakí now works with 1190 indigenous and smallholder farmers in the three countries, paying a living wage depending on the weight of the harvest. Through their production practices, farmers are protecting wild mate trees, reintroducing cultivated mate trees into native secondary forests, and transforming sun-grown plantation into shade-grown plantations through introduction of native fast-growing trees, including Paraná pine (*Araucaria angustifolia*) (Foster 2020, Roblick 2021). The company (a certified B Corp since 2011) pays a licensing free to the Aché Guayakí tribe for the use of the name (Carr 2009).

Photo credit: Robin Chazdon


Guayaki Yerba Mate display in a Boulder, CO supermarket (2015).

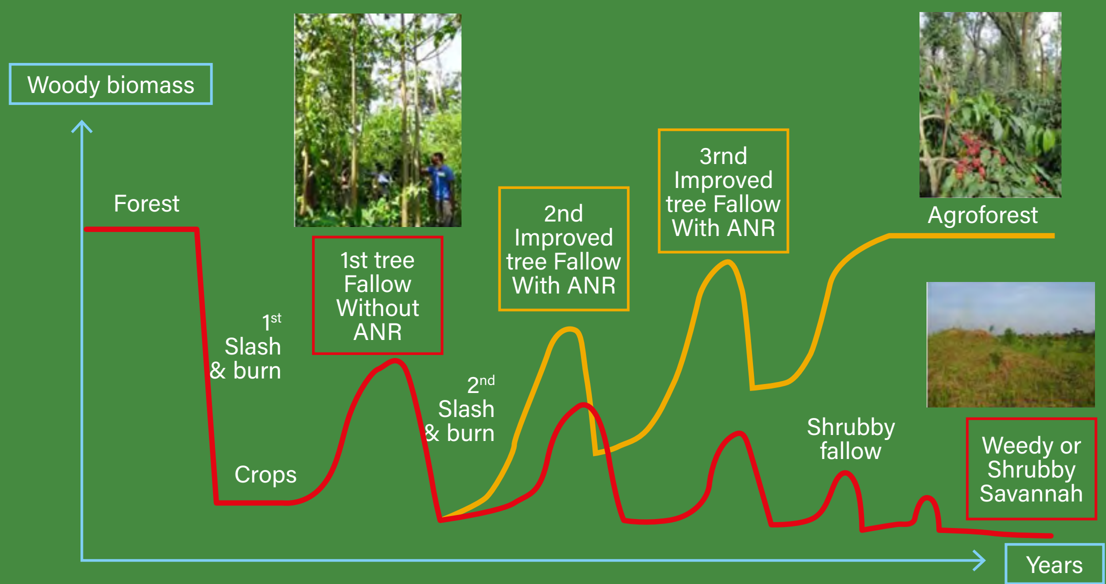
ANR approaches have been closely aligned with agriculture and agroforestry systems for decades (Smale et al. 2018, Kandel et al. 2022). In Niger, farmers traditionally leave stumps and roots when clearing their fields of vegetation, creating an agroforestry parkland. The FMNR practice is based on the selection of tree stumps focuses on the use of particular species for food, fuel, or fodder (Smale et al. 2018). FMNR practices have been introduced in 27 countries and extend over an estimated 18.2 million hectares, according to Tony Rinaudo, an Australian agronomist, who first popularized the technique while working in Niger with World Vision.

ANR approaches can also be applied in shifting cultivation and slash and burn agricultural systems to create a land-use transition to more permanent, sustainable and climate-smart agriculture and agroforestry systems (Box 4). For example, the Quesungal System in Honduras integrates basic grain crop production with multi-purpose trees selected from shifting cultivation fallows (Schnetzer, 2018). An initial test in the Democratic

### Box 4. Transforming fields into agroforests in Central African Republic

Kpolita et al. (2022) describe a program based on ANR in two villages in Central African Republic that gradually transforms degraded slash-and-burn fields into multi-functional agroforests. The program involves training of farmers and their careful selection of useful tree saplings that are protected during crop weeding in fallows. Communities in the supported villages showed interest in applying selective weeding techniques to enhance tree density and diversity in fallow vegetation, creating opportunities for sustainable management of forests and sustainable livelihoods.
Wider adoption of this ANR technique faces challenges of insecure land tenure, lack of government support, short-term project cycles, fires, and political unrest from civil war (Kpolita et al. 2022).

**Hypothetical changes in aboveground woody biomass of a plot cultivated in slash-and-burn agriculture, with ANR (green curve) or without ANR (red curve).**




*Source*: adapted from Kpolita et al. (2022)

Republic of Congo showed that ANR techniques could be adopted in a shifting cultivation system without upsetting habitual routines, payments, or requiring supplementary material (Peltier et al. 2014). Prior to clearing and burning patches of gallery forest to plant crops, farmers selected trees that were marked and protected. Trees were also selected for protection from weeding crops. After the final harvest, conserved and newly established trees grew over a fallow period of 6–12 years, during which time farmers used the land to gather non-timber products. Survey results showed that the conservation of trees prior to clearing and burning motivated collective and family efforts to move from an unmanaged fallow to a managed fallow system (Peltier et al. 2014). The main barriers to adoption are lack of land tenure security, the low survival rate of trees in shifting cultivation fallows, extra labor required to clear around selected trees, and loss of some charcoal production (Peltier et al. 2014).

Robin Chazdon

Toucan eating fruits of *Miconia* sp. in Costa Rican second-growth forest.

In forest biomes, silvopastoral systems, which combine livestock raising with use of trees and shrubs, can also integrate ANR practices. Pastures can be managed to promote the natural regeneration of trees and shrubs, including through protection of isolated remnant trees and use of living fences where seed dispersing animals forage and perch (Esquivel et al. 2008, Pignataro et al. 2017, Insfrán Ortiz et al. 2022). In central Nicaragua, 46% of the 85 tree species found in cattle pastures showed high likelihood of perpetuating their populations through natural regeneration (Esquivel et al. 2008). Chol Mayan farmers in the Tulijá River Valley in Chiapas, Mexico, promoted the regeneration of trees in cattle pastures (Pignataro et al. 2017). Of the 61 tree species found in 35 cattle pastures studied, 17 species showed natural regeneration potential; these species were dominant in the pastures and are common in successional vegetation of the area. Management practices included protecting adult trees in pastures and surrounding areas and manually weeding around young trees (Pignataro et al. 2017).

Several studies suggest that cattle promote seed dispersal of some woody species in pastures and may favor development of particular tree species by removing competition from grasses (Janzen 2002, Miceli-Méndez et al. 2008).

# What are the costs, benefits and financial mechanisms of ANR?

Implementation and maintenance costs are directly associated with the levels of human interventions required to initiate the long-term process of forest restoration, with natural regeneration being the lowest-cost alternative for large-scale restoration (Holl and Aide 2011, Chazdon and Guariguata 2016). ANR approaches are particularly well suited where opportunity costs are low, such as areas that offer low financial returns for agricultural commodities (Crouzeilles et al. 2020, Edwards et al. 2021).

Yet much of the information available regarding implementation, maintenance and opportunity costs of ANR and financial benefits is anecdotal and incomplete. For example, analysis by Reij and Garrity (2016) concluded that FMNR can be achieved at a cost of US$20 per ha was based on expert estimates rather than on explicit economic analysis (Chomba et al. 2020). A robust analysis of the implementation costs of different forest restoration approaches was conducted in 2016 in Brazil by the Instituto Escolhas. Implementation costs for ANR (with fencing and enrichment planting) were 33% and 32% of costs of full-scale planting of native tree species in Atlantic Forest and Amazonia, respectively (Instituto Escolhas 2016). Based on a variety of sources, Shono et al. (2017) compiled data on implementation costs, which include costs of interventions (weeding, fencing, site protection) and annual maintenance and monitoring costs (Table 3).

**Table 3. Costs of establishing and maintaining ANR in the tropics based on data from the Americas, Africa and Asia (from Shono et al. 2017)**

| Cost category | Direct cost |
|---|---|
| Establishment cost per ha, year 1 | Average = USD 257; range = USD 20-579 |
| Annual maintenance and monitoring cost per ha per year; years 1-5 | Average unavailable; range = USD 31-213 |
| Annual maintenance and monitoring cost per ha per year; years 5-15 | Average unavailable; range = USD 14-17 |

The economic benefits of FMNR have been evaluated more than other types of ANR practices. Trees on farms increase water infiltration into soils, reduce soil temperature, and protect crops from wind damage. In addition, non-timber forest products such as fruits, nuts, fuel wood, forage and thatch bolster the economies of rural households in sub-Saharan Africa (Westerberg et al. 2019). A study in Ghana found that FMNR combined with crop rotation provides an additional income of EUR 102/hectare for the typical farmer. Farmers who adopt FMNR practices such as intercropping with legumes, crop rotations, higher tree densities, tree pruning and exclusion of fire have higher crop yields (Westerberg et al. 2019). A survey of 99 agricultural households in Niger showed that practicing FMNR yielded a wide diversity of products (wood, leaves, flowers, fruits, bark, roots). Self-consumption and the sale of these products provide relatively high incomes and other benefits that contribute to community adaptability and resilience (Lawali et al. 2018).

Using spatially explicit estimates of the rate of carbon sequestration and the opportunity cost of agricultural production, Evans et al. (2015) examined the economic viability of ANR relative to environmental plantings used a discounted cash flow analysis. In the state of Queensland (Australia), their analysis showed that the average minimum carbon price required to make assisted natural regeneration economically viable was 60% lower than what was required to make viable tree plantings. ANR could sequester 1.6 to 2.2 times the amount of carbon possible compared to tree plantings. As a reforestation approach, ANR can cost-effectively deliver both carbon and biodiversity benefits (Evans et al. 2015, (Lennox et al. 2018). Naime et al. (2020) conducted economic valuation for different stages of natural regeneration on former pastures in a tropical dry forest ecosystem in Mexico based on the trade-offs of different types of ecosystem services that develop over time. They found that the economic value of regulating ecosystem services (carbon sinks and carbon stocks) provided by secondary tropical forests comes at the expense of provisioning ecosystem services (fodder and timber) (Naime et al. 2020). Naturally regenerating forests can also provide benefits for pollination services to surrounding agricultural lands, but, financial and political instruments are lacking in most countries to support these benefits (Farfan et al. 2022).

Studies conducted in other regions evaluate the cost effectiveness of ANR compared with other restoration approaches. Natural regeneration was the most cost-effective approach for carbon sequestration; timber and non-timber products, tourism, and livestock production in four dry forest areas of Latin America (Birch et al. 2010). Molin et al. (2017) used a landscape approach to model the estimated costs and benefits of restoration based on ANR and full-scale tree planting in the Piracicaba River basin in São Paulo State, Brazil. The results showed that even in landscapes with low levels of forest cover, prioritizing low-cost restoration through natural regeneration could increase cost-effectiveness. The cost effectiveness of carbon storage averaged US$74 per additional ton of carbon stored in restored forests in a mechanized agriculture landscape compared to US$58 in a pasture-dominated landscape and US$41 in a forested landscape where natural regeneration was the predominant approach. Cost effectiveness of landscape connectivity for biodiversity showed a similar trend (Molin et al. 2018).

Wills et al. (2022) used a landscape approach to estimate the cost effectiveness of biomass gain through different restoration practices in the Udzungwa-Kilombero Landscape in Tanzania. In the first five years, planted areas were 20% more expensive to implement than those restored through ANR. But because planted sites accumulated aboveground biomass at a faster rate initially and gained more biomass overall, they became 19% more cost-effective in the long run than those restored through ANR (Wills et al. 2022). Similar to the findings of Molin et al. (2018), the most cost-effective restoration sites were protected moderately degraded areas of forests and savanna.

For rural household farmers in the West Africa Sahel, implementing FMNR brings significant financial and livelihood benefits. Binam et al. (2015) conducted a study in Burkina Faso, Mali, Niger, and Senegal to assess the economic and socio-cultural benefits of FMNR practices to guide decisions on whether, where and how to scale up the practice to other dryland and sub-humid areas. They categorized farmers based on the intensity of FMNR practices used (Binam et al. 2015). Tree products are the second most important income-generating activity after crop production, supplementing the farm households' income and food needs, and are particularly important during the late dry season and early rainy season when crops have not been harvested. The study estimated that if a community with 1,000 average households newly involved in natural regeneration decided to practice ANR continuously, it would increase gross income in the community by $72 per household per year. These results clearly show that upscaling and intensifying the practice of FMNR could be a viable pathway for the development of the rural economy in these West African countries (Binam et al. 2015). But, a study in southwestern Niger found that economic benefits of fuelwood resources in agroforestry parklands were not sufficient motivation for farmers to engage in FMNR (Boubacar et al. 2022).

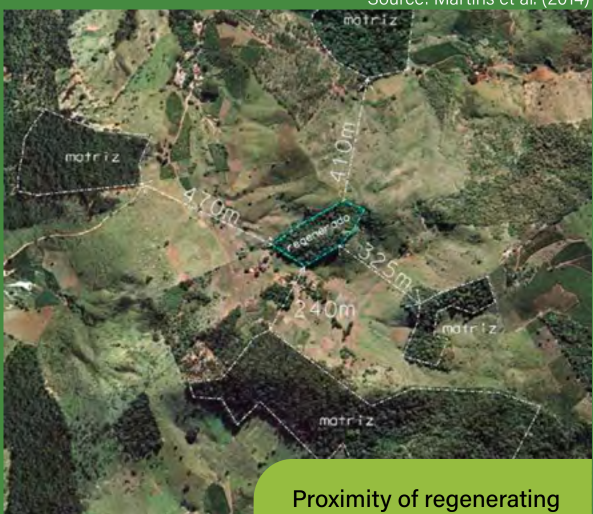
Among the options for financing ANR initiatives (outside of FMNR), the most commonly utilized approach is based on payments for environmental services (PES) to farmers and landowners. These payments have generally been used in programs managed by state or national governments. Examples are the Reflorestar program in Espirito Santo State, Brazil (Box 5; Seixas and Jabor 2020) and the Costa Rican PES program (Porras and Chacón-Cascante 2018). These programs also provide institutional support and some technical training, which increases enrollment and successful implementation. Some PES programs that support ANR, such as Brazil's Water Producer project, have involved partnerships between government agencies and NGOs such as The Nature Conservancy (Viani et al. 2018, Viani et al. 2019). Under Vietnam's 5 Million Hectare Reforestation Program, 2 of the 5 million hectares were targeted to be natural regeneration (de Jong et al. 2006). China's Natural Forest Protection Program (which was eventually renamed the National Forest Protection Program) included protecting some 90 million hectares of natural forests across 17 provinces and including 68% of the country's forest cover. The NFPP severely restricted logging in the 17 provinces and emphasized efforts to regenerate the forests and return them to healthy status.

If policy restrictions are removed, income from sustainably managed timber and non-timber products and agroforestry products can lead to self-sustaining ANR projects. Commercial trees are abundant in naturally regenerating forests in Brazil's Atlantic Forest after 30 years of growth, even without enrichment planting and silvicultural interventions (Fantini et al. 2019, Zambiazi et al. 2021). Timber

### Box 5. Incentivizing rural producers to assist natural regeneration

The Reflorestar progam was initiated in 2015 by the Secretariat for the Environment and Water Resrouces of the government of the Brazilian state of Espírito Santo to restore hydrological cycles through the conservation and restoration of forest cover. The program works with the Espírito Santo Development Bank to provide income for participating rural producers through payments for environmental services. Smallholders enroll in the program through six modalities; one of the modalities is "conducting natural regeneration" through isolating the site from grazing or other sources of degradation. To be eligible for receiving payments through this modality, the land must be located within a zone with a high and medium/high transition potential for natural regeneration, based on a state-level study of naturally regenerating forests and their landscape matrix conditions (Martins et al. 2014). This survey and expert assessment was key to including natural regeneration as a reforestation modality within the Reflorestar program. From 2015–2023, the Reflorestar Program executed a total of 3,892 contracts with smallholders, covering a total of 19,634 ha. Of these, 1,677 contracts include conducting natural regeneration either as the sole modality or in combination with full tree planting or agroforestry. The area of natural regeneration within Reflorestar represents 16.7% of the total area of all interventions applied.

Source: Martins et al. (2014)




Proximity of regenerating forest fragments to other forest fragments is a strong determinant of the potential for natural regeneration in Brazil.

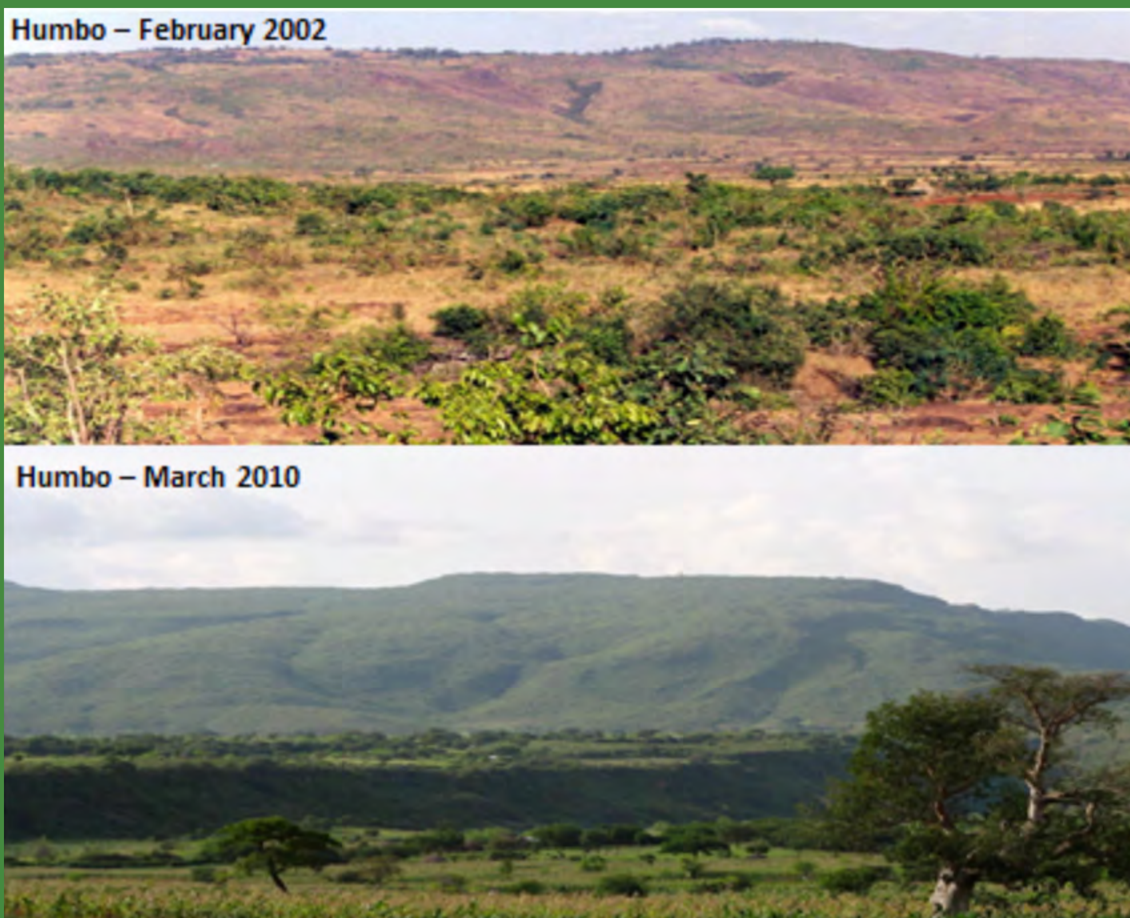
production showed negative financial returns in a naturally regenerating cloud forest in Mexico, however (Toledo-Aceves et al. 2022). It may be possible to achieve positive financial returns if support is provided for forest owners to reduce production costs and if timber prices increase. Income generated from selective timber harvesting would require supplemental income from marketing of non-timber products or other sources. Some experimental models are testing mixed reforestation systems that blend ANR with commercial forestry production during early stages (Amazonas et al. 2018a).

A third avenue for financing ANR comes from direct payments to landowners or communities that generate sales of verified carbon credits. Today, several initiatives are underway to market carbon credits through ANR, often in combination with plantation establishment. One of the best examples is the *Scolel' te* project in Chiapas, Mexico, which began in 1997, where smallholder farmers are paid to store carbon through agroforestry practices on their farms and promoting natural forest regeneration after fires (Tipper 2002, Soto-Pinto et al. 2010). The program has shown remarkable success for over 30 years (Chazdon 2022). In 2004, World Vision Australia and World Vision Ethiopia identified the potential for forestry-based carbon sequestration to stimulate community development while restoring native tree cover through ANR practices (Box 6). Some challenges face the use of ANR sites for verified carbon credits, however, including issues of additionality, leakage and permanence (Pan et al. 2022, Brancalion et al. 2023).

## Box 6. The Humbo community-based natural regeneration project

In 2006, the Humbo community-based natural regeneration project began implementation of their first carbon sequestration initiative in Ethiopia, led by a partnership between World Vision, World Bank BioCarbon Fund and the Federal Democratic Republic of Ethiopia. The project involves regeneration of 2,728 ha of degraded native forests, bringing social, economic and ecological benefits to seven agricultural communities while generating Temporary certified emissions reductions (tCERs) under the Clean Development Mechanism (Brown et al. 2011). The project is expected to sequester over 880,000 metric tonnes of CO2e over 30 years. This project will generate 338,000 tonnes worth of carbon credits (by 2017), of which the World Bank's Bio Carbon Fund will purchase about half (Dwumfour 2012). Initial financing with a small grant of $200,000 generated enormous impacts on local communities and enabled different kinds of livelihood activities such as beekeeping, fattening of cattle and milling flour, which were undertaken in remote sites (Dwumfour 2012).

**Before (2002) and after (2010) implementation of ANR in Humbo, Ethiopia.**




Source: Dwumfour (2012)

In Australia, ANR is a favored approach for carbon farming (Evans et al. 2015, Evans 2018). Full lifecycle accounting is important for estimating real carbon capture potential of reforestation projects, however (Lefebvre et al. 2021). Restoration concessions in Indonesia provide another potential option for financing ANR in the context of post-logging forest thinning and sustainable forest management (Harrison and Swinfield 2015, Swinfield et al. 2016, Harrison et al. 2020). But viable business models remain to be developed and implemented, as costs are high and revenue streams from carbon markets, non-timber forest products and ecosystem services are at insufficient scale (Harrison et al. 2020). The Brazilian Forest Service is also beginning to implement restoration concessions (MMAMC, 2023). Corporate environmental and social responsibility programs can provide additional sources of funding for ANR implementation (Brancalion et al. 2017).

## What are key enabling factors and challenges for ANR implementation?

Case studies provide information regarding how ANR is implemented in different contexts, and generate insights into enabling factors and challenges. Alves et al. (2022) examined 24 case studies of ANR projects, 15 from Brazil and 9 from other countries. In most of these cases, ANR was implemented in pastures dominated by exotic grass species that prevented establishment and growth of native seedlings. The most common ANR techniques used were: 1) enrichment with native species (13 out of 24 cases); 2) invasive and/or exotic species control (11 out of 24 cases); and 3) fencing (9 out of 24 cases). Additional techniques used were fire protection, ant control, grazing management, and maintenance of regenerating plants (Alves et al. 2022).

Enabling conditions and key success factors were categorized according to their importance in motivating, enabling, and implementing ANR. Among the most important factors for motivating implementers were the environmental benefits, which included improving forest quality, soil quality, and biodiversity; increasing and regulating water supplies; reducing erosion; and storing carbon in naturally regenerating vegetation. Effective coordination and governance within ANR projects were also important motivating factors. Clear assignment of roles and responsibilities and consideration of distinct needs of stakeholders lead to more successful projects.

In several cases where Brazil nut (*Bertholletia excelsa*) and yerba mate (*Ilex paraguariensis*) were grown on ANR sites, strong market conditions helped to establish sustainable value chains, enabled income generation for local communities (Alves et al. 2022). Successful implementation of ANR benefitted from training programs that empowered rural communities and households and that generated knowledge among rural extension agents, project staff, and community members. In two cases, payment for environmental services programs compensated landowners for their participation in ANR projects, as they otherwise would lose income from crops or cattle production on their land. In Brazil, landowners are also eligible to access additional financial resources for restoration on their land through compliance with legal instruments and rural licensing programs (Alves et al. 2022).

Another key success factor in ANR projects was developing a robust monitoring and evaluation system that provided data to track how implementation improved social and ecological conditions compared to baseline conditions. Transparent reporting of project outcomes also helped to attract financial resources to expand the project.

Reij et al. (2020) summarized key success factors for dryland restoration based on experiences in Africa, using FMNR and other restoration approaches. In Table 4, we included additional success factors from other ANR contexts and published ANR case studies (Alves et al. 2022) Birch et al. 2016, Mansourian 2020).

**Table 4. Key success factors and enabling conditions for implementing assisted natural regeneration (modified from Reij et al. (2020)**

| |
|---|
| **1.** Document and communicate outcomes of restoration through evidence and data; restored farmland increases agricultural yields and diversifies income |
| **2.** ANR practices have clear and positive impacts on soil fertility, water resources, and biodiversity, leading to more environmentally and economically resilient landscapes |
| **3.** Broad community support and low costs have led to widespread uptake of farmer-led, community-led, and government-led restoration initiatives |
| **4.** Enhance the capacity of local organizations, institutions, and governments to discuss, develop, and enforce their own local plans, policies, and bylaws governing access to and use of natural resources |
| **5.** Enforce policies that allow ANR implementers (individuals, communities, producer organizations) to clearly benefit from implementation practices through promotion of ecologically and economically viable local enterprises |
| **6.** Participation of women, youth, and other marginalized groups must be encouraged and supported to ensure equitable distribution of benefits from restoration activities |
| **7.** Enact clear and consistent policies and regulatory reforms at national and regional level to establish more favorable enabling conditions to support locally-led restoration initiatives |
| **8.** Empower charismatic national and local ANR champions and effective community organizers |
| **9.** Provide secure land and tree tenure |
| **10.** Provide accessible technical training on ANR practices and implementation attuned to local realities and opportunities |
| **11.** Ensure adequate sources of funding for ANR implementation, including financial incentives to compensate for implementation and opportunity costs |

It is important to overcome perceptions of policy makers and the general public that the only way to restore forests or degraded lands is through tree planting. A global review of financial incentive mechanisms used for forest restoration found that natural forest regrowth and afforestation were the least incentivized restoration approaches compared to native tree planting or direct sowing (Tedesco et al. 2023).

Another misconception is that natural regeneration should not require assistance (as it will happen anyway), and therefore should not be incentivized or supported by payments. Farmers also have persistent beliefs that trees and shrubs compete with crops for water and soil nutrients and should be removed from their farms. Monitoring the progress of natural regenerating vegetation apart from planted vegetation is also a challenge, as most monitoring programs focus only on tracking survival and growth of plantings.

## Regional perspectives on ANR

In this section, we summarize inputs received from three regional virtual workshops involving a total of 130 participants from 43 countries and 90 institutions/organizations. The following sections are based on regional reports composed by the co-leaders for each region. Many of these issues are relevant across multiple regions.

### Africa

Land use in Africa is dominated by smallholder farmers with a strong priority on food security (Mbow et al. 2014), creating enormous potential for ANR interventions that increase tree cover on farms. Tree cover on farms (areas with less than 25% forest cover) is increasing in many parts of Africa, as farmers use trees for products formerly sourced from local forests (Reiner et al. 2023). This increase in tree cover on farms has been most dramatic in countries where FMNR has become widespread. An estimated 1.4 billion trees are now growing on cultivated areas across sub-Saharan Africa (Pearce 2023). Other ANR approaches are also being used in Africa, including exclosures or living fences to delimit boundaries, exclude grazers and allow natural regeneration; fire management (protection using fire breaks, implementation of early fires to avoid late fires); and direct seedling and enrichment tree planting to diversify tree species on farms to support ANR where seed stock or tree stumps are scarce. The main implementers of ANR are government agencies, farmers, communities, NGOs, research centers, and private international companies that specialize in carbon offsetting.

The main challenges to ANR implementation in Africa are 1) lack of an efficient approach for scaling up ANR practices; 2) insufficient regeneration of preferred tree species on farms; 3) unavailability of seedlings or seeds for enrichment planting; 4) lack of clear land and tree tenure, particularly for women; and 5) lack of financial incentive mechanisms. ANR practices have been successful when individual implementers have a sense of ownership and responsibility, peer-to-peer (farmer-to-farmer) learning exchanges are encouraged, policies recognize ANR practice and land and tree ownership by implementers and when incentives and rewards are provided to implementers.

Land tenure and tree ownership present the greatest policy challenge for ANR in Africa. Other challenges stem from the lack of specific policy to promote ANR practice. Restricted tree harvesting policies were developed within the framework of forest management and conservation, not for trees growing on farms or in agroforestry contexts. Communities and farmers have not been engaged in policy development and lack decision-making authority. Local development plans do not incorporate ANR implementation, despite the strong contribution that ANR can make to improving food security and enhancing farmer income. These factors impede programs to increase availability and access of planting material for farmers when they need it and restrict resources for quality control of timber and non-timber products from ANR. Additional policy challenges stem from conflicting sectoral policies and lack of emphasis on developing alternative sources of energy to reduce pressure on naturally growing trees and forests.

But there are examples of policies in Africa that have supported ANR implementation. Recognition of communities' rights to land and trees is fundamental to scaling up ANR. For example, the Niger's Presidential Decree of 2020 recognized farmers' right and also organize annual contest to reward FMNR farmers. In Burkina Faso, the environmental law mandates that when farmlands are established at least 50 trees per ha must be spared. Burkina Faso has a decree on integral protection of selected species, mandating their protection on farms. In Kenya, policies for the targeted removal of invasive *Prosopis juliflora* trees and reclamation of these sites can enhance ANR in areas where tree planting is not needed.

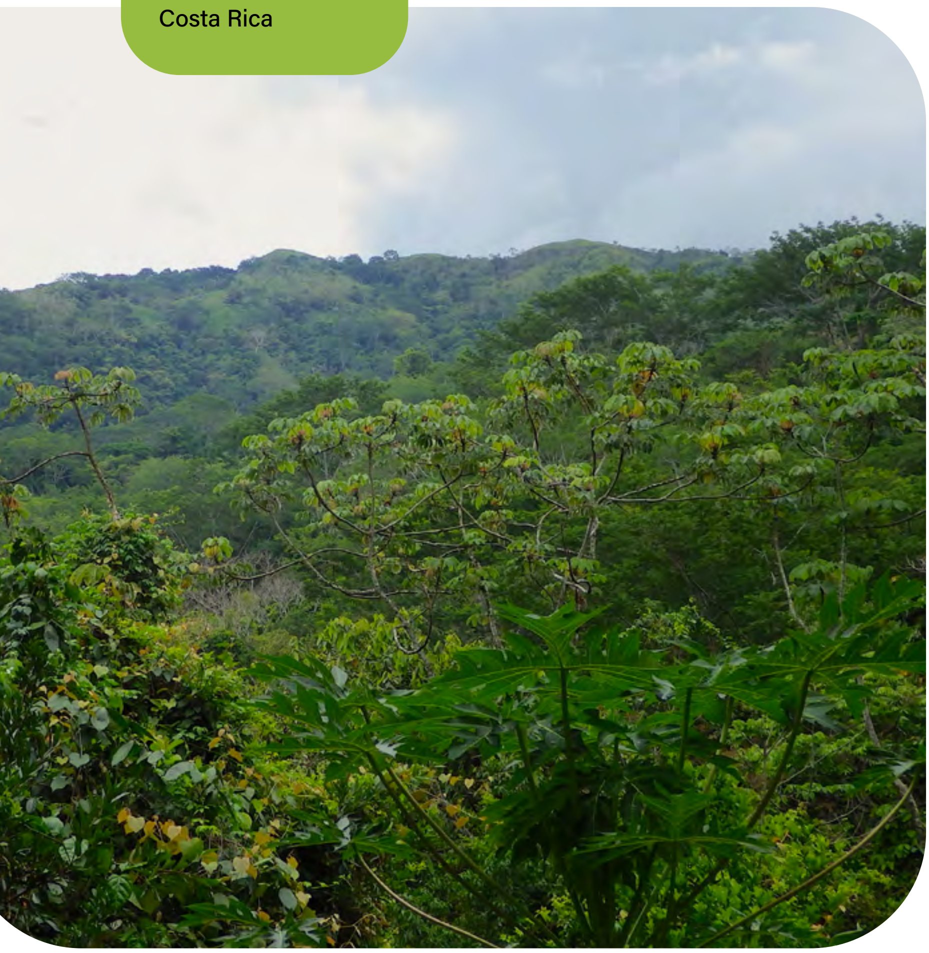
P. Savadogo

Farmer removing side stems from naturally regenerated Guiera senegalensis to enhance its growth, a key FMNR practice

Evidence for the effectiveness of ANR practice has spread from Niger—where it was already well known—to other sub-Saharan countries. The general sense of ownership of the trees on farms, growing confidence that farmers could grow and manage these trees for their own benefit and peer-to-peer learning were critical factors for boosting adoption of ANR.

More robust evidence is needed with regard to the socio-economic and environmental benefits and outcomes of ANR interventions, particularly with regard to specific types of assisted regeneration methods. Most of the evidence for ANR practice comes from dryland Sahelian countries with scarce information from humid tropical ecosystems. Further research is needed to define optimal tree densities for maximizing production on farmlands and to learn how to enhance tree growth rates and regeneration success in different ecosystems. Research is needed to determine what indicators can guide farmers' selection of seedlings to protect and manage on their farms and to evaluate the long-term costs and benefits of ANR in comparison to other approaches. Social research (including participatory action research) is needed regarding how to motivate producers to practice ANR in a context of land colonization by marginal species and to identify approaches for resolving conflicts over management of ANR lands.

Community-led ANR in Monte Alto Reserve, Hojancha, Costa Rica



Robin Chazdon

## Latin America-Caribbean

The most common types of ANR implementation in Latin America-Caribbean are protecting natural regeneration from fire and grazing, extended fallows in shifting cultivation systems, management of naturally regenerating forests, agroforestry, recovery of logged forests, and enrichment plantings and direct seeding to facilitate recovery and enhance economic potential. In some cases, applied nucleation techniques are used to stimulate natural regeneration (Wilson et al. 2021b). The main implementers of ANR include government agencies, farmers and communities, Universities and Research Centers, local, regional and global NGOs and companies.

Implementation of ANR in Latin America-Caribbean faces many challenges, largely due to unfavorable political, socio-economic and governance conditions. Indeed, significant policy and governance gaps impede the scaling up of ANR in the region. Few countries have laws and policies that specifically include ANR as an option for restoration and for enforcing legal compliance. Significant policy and governance gaps impede the scaling up of ANR in the Latin America-Caribbean region. Few countries have laws and policies that specifically include ANR as an option for restoration and for enforcing legal compliance. Political will is often lacking and there are conflicting policies regarding management and harvest of naturally regenerating trees. At the same time, regenerating forests are poorly protected and have high rates of clearance, particularly during the first 5 years. Political will is often lacking and there are conflicting policies regarding management and harvest of naturally regenerating trees. At the same time, regenerating forests are poorly protected and have high rates of clearance, particularly during the first 5 years.

Many restoration implementers have little knowledge and negative social and political perceptions about ANR outcomes. Even though scientific literature is abundant, technical information is not available or is not easily accessible. There has been little communication, expert advice or advocacy to promote ANR. Practitioners therefore assume that ANR interventions will take longer or will not provide tangible environmental and socio-economic benefits within project time constraints. Moreover, restoration project funders consistently prefer to support tree planting programs and see ANR as a risky endeavor.

Law enforcement and governance frameworks regarding naturally regenerating forests are elusive. Regenerating forests, particularly during the first few years, are often viewed as "dirty" or useless areas that should be cleared and converted to other, more economically beneficial, uses. Opportunity costs of ANR can be high, even though the costs of implementation are far lower than full tree planting. But costs can be substantial, particularly if invasive species need to be removed. Secure land tenure is also a major challenge, as there is otherwise no incentive for farmers to assist regeneration. Although some PES programs exist in specific countries or subnational units, there is a general lack of financial incentive mechanisms that support ANR practice (Tedesco et al. 2023). On the biophysical side, many areas are heavily degraded and are poorly suited for natural regeneration, such as post-mining sites or intensively used croplands and grazing lands.

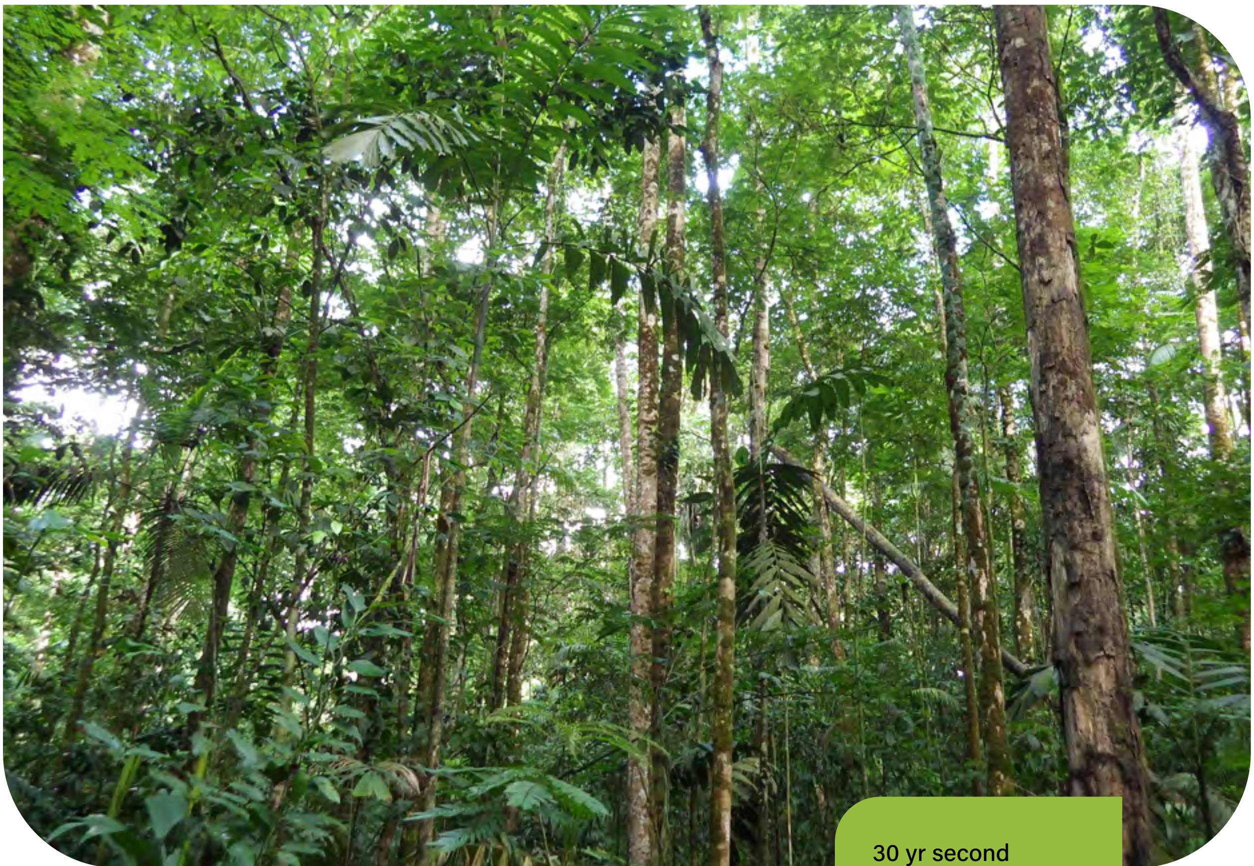
In cases where ANR has been implemented successfully, the key enabling factors include: political will, thoughtfully adapting ANR to local social and cultural contexts, land tenure rights and governance mechanisms, sustainable management practices for products from regenerating forests, economic support and tangible benefits, and prioritizing areas where ANR is well-suited and most beneficial for local communities. Important enabling policies and instruments include developing subnational programs and strategies, economic incentives such as PES and tax incentives, capacity development and education of public agents, and tailoring of ANR strategies to different groups of landowners.

Research described in this White Paper provides strong evidence for the effectiveness of ANR for carbon sequestration, biodiversity recovery, and for restoring ecosystem structure and ecosystem services. ANR has clearly been shown to be a cost-effective restoration strategy in many contexts. Many examples illustrate a wide range of effective management practices involving natural regeneration by Indigenous Peoples and smallholder farmers in the Latin America-Caribbean region.

Further research is needed to make a stronger case for scaling up ANR implementation. We need to better understand the functional ecology of regenerating systems and how drought and extreme events are impacting their function and specific outcomes. We need studies to help identify indicators and metrics for monitoring ANR outcomes that are reliable, simple, and low cost. Research is also needed on the sociocultural pathways that can change public perceptions about ANR implementation and its local, national, and regional benefits. Economic analyses are needed to assess the tangibility of socio-economic benefits and how to predict the value of goods and services produced over time as an outcome of ANR implementation. Finally, finance schemes need to be developed that support ANR and involve a wide range of aligned actors and stakeholders.

Recently, the Brazilian government announced the first concession for forest recovery and planting of native species in the Atlantic Forest, which will include removal of exotic species and protection of threatened native species (Government of Brazil 2023). These restoration concessions can be an important mechanism to scale-up ANR in the region.

Robin Chazdon



30 yr second growth Costa Rica

## Asia-Pacific

In the Asia-Pacific region, tree cover gain from 2000–2012 was dominated by tree plantations, with only 26.76% of the total gain attributed to natural forest regrowth (Fagan et al. 2022). National-level reforestation policies in the region are highly invested in planted forests, primarily in monocultures. The playing field is far from even when it comes to ANR approaches to reforestation. Yet there are cases of ANR implementation that focus on recovery of logged forests, community-based reforestation, and diversification of monoculture plantations. On a smaller scale, some ANR interventions are based on FMNR approaches, framework species reforestation approaches, and restoration and forest protection within forest reserves. The main implementers of ANR are farmers and land managers, communities and forest-user groups, and government agencies.

ANR faces multiple challenges in the Asia-Pacific region. These include technical challenges such as identification of suitable sites, tracking implementation, monitoring outcomes, and quantifying the value of ecosystem services provided or other direct benefits for local people. Assessing the direct benefits that ANR provides for local people is also a major challenge. Local forestry officials lack awareness and training in ANR approaches. There is inadequate information regarding whether species growing in ANR sites can provide economic benefits for local people. Many people have lost connections to the land and do not understand the relevance of natural regeneration. Finally, there is much uncertainty regarding long-term criteria that can be used to initiate payments to local communities (People's Organizations) for their role in ANR implementation.

Mindset change is the basis for successful ANR. This requires awareness raising among local communities, as interventions must have the support of local people. Consultation is required among all stakeholders (including government, community, NGOs, individual farmers) and the people that implement ANR need to feel ownership and accomplishment of their own work and know that it is benefitting them, their children and their grandchildren. Implementers develop a sense of pride that they improved land by themselves. Local benefits need to be emphasized and embedded in project design from the very beginning, combined with different finance streams like carbon and biodiversity offsetting which provide benefits to the community. ANR initiatives that support livelihoods and integrate with larger landscape management perspectives have greater prospects for success. Trust and credibility of the implementing organization are also important to project success. Successful ANR requires more than just local support, however. Support of the local or state government is needed, especially in situations where the community has unclear or no land tenure. Having local government officials join visits to successful ANR restoration sites enables subnational awareness that can lead to policy reform and evolution. Communication is also an important factor that enables scaling of ANR interventions. Farm radio provides a vehicle for people to share their experience and generate wider interest in ANR. Demonstration sites allow people to showcase and take pride in their work. Farmer-to-farmer communication is highly effective in motivating implementation and building capacity. Bringing ecotourists to ANR sites can generate income, build awareness of the potential of ANR, and give local people a sense of pride in their restoration achievements. The spiritual connection of some people's groups with trees can be a motivator to do restoration work.

ANR implementation is most successful when the benefits accrue to all stakeholders involved, including the community and government agencies. This requires strengthening village policies and agroforestry practices to promote income generation in regenerating forests, particularly in community controlled protected areas. ANR areas that produce high value non-timber products provide economic incentives for local people to practice ANR.

Governance mechanisms that support long-rotation shifting cultivation rather than demonizing and criminalizing these practices will bring ANR into alignment with broader reforestation agendas and nature-based solutions within Asia-Pacific countries. Policies and support need to be focused on long-term objectives and reward sustainability and longevity of programs that are based on natural regeneration approaches. Clear land and tree tenure is a major enabling condition and a key element of most successful ANR efforts, along with decentralization of restoration goals and targets and creating synergies with national and regional commitments to global environmental goals.

Many policy challenges stand in the way of scaling up ANR interventions in the Asia-Pacific region. Government programs tend to focus on commercial production rather than restoration, creating conflicts between ecosystem restoration and commercial forestry interests. Government policies discourage fallow land-management processes, including swidden cultivation. In many countries, young natural regrowth areas are viewed as "idle" or vacant lands, and are therefore not valued or protected appropriately. Some countries (e.g., Thailand, Philippines) levy significant taxes on such "idle" lands to encourage landowners to return the land to "productive use."

High-level decision makers in the region hold the view that natural-regeneration practices, while more cost-effective, are not glamorous or profitable to implement. Policies to protect existing forests restrict the harvesting and marketing of naturally regenerated trees, removing financial incentives for sustainable management of regenerating forests or regenerating trees on farms. There is a lack of clarity on the rights of local people to harvest and sell timber and non-timber products from forests restored through ANR. These issues stem from the perception that local people are forest destroyers and the government needs to protect trees from people who seek to destroy them.

## Conclusion: developing the evidence base for effective ANR practice

"Seeing is believing" remains the most compelling evidence for the effectiveness of ANR. Successful ANR sites have effectively served as demonstration areas in several countries of the region. Additional evidence is the higher cost-effectiveness of ANR compared to tree planting and the enhancement of ecological functions under ANR, including levels of carbon sequestration.

The evidence base for effectiveness of ANR needs to grow, based on case studies across the globe. We need better documentation of potential benefits for local people and stronger evidence of global benefits that ANR can deliver that are of greatest interest to project investors, donor organizations, corporations, and policy makers. Establishing long-term research plots in ANR sites allows deeper understanding of how socio-economic and ecological processes unfold and enhances local understanding and appreciation of ANR.

A concerted communications campaign is needed to build awareness of the potential of ANR. This will require dedicated resources for study tours to successful ANR project sites, farmer-to-farmer and forester-to-forester exchanges, and production of awareness-raising products such as videos, brochures, posters, and feature articles. It is time to communicate outside of the sphere of ANR followers and get the message out to other people influencing the restoration agenda.

At the policy level, effective rewards and incentive mechanisms of various types need to be implemented, similar in scale to the array of motivating levers used to stimulate planting of trees or maintaining roads. Perverse incentives that discourage ANR need to be removed. And it is important to accept the reality that in many cases ANR will not happen without external financial support and—just as with tree planting—governments and donors may have to pay people to carry out desired activities.

Pedro Brancalion

Harvesting jucara fruits in Ubatumirim, Brazil

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## Key resources and videos on Assisted Natural Regeneration

Assisted Natural Regeneration Alliance website
**https://www.anralliance.org/**

FMNR Hub, Farmer Managed Natural Regeneration
**https://fmnrhub.com.au/**

Farmer Managed Natural Regeneration Manual (English, French, Spanish);
**https://fmnrhub.com.au/fmnr-manual/**

Assisted natural regeneration: A guide for restoring tropical forests;
**https://www.conservation.org/research/guide-assisted-natural-regeneration**

The Role of Assisted Natural Regeneration in Accelerating Forest and Landscape Restoration: Practical Experiences from the Field
**https://www.wri.org/research/assisted-natural-regeneration-case-studies**

Video: Assisted Natural Regeneration: How People Help Forests Regrow (English)
**https://www.youtube.com/watch?v=PsBVOt4Kwb0&t=1454s**

Video: Reforestation Solution: Farmer Managed Natural Regeneration
**https://www.youtube.com/watch?v=2FE-4faVy68**

Video: Assisted natural regeneration as a forest restoration method
**https://www.youtube.com/watch?v=rpjhSLN65Q4**

Video: Why do we use Assisted Natural Regeneration (ANR) to restore forests?
**https://www.youtube.com/watch?v=jNwVohB9ZGg&t=2s**

Video: Junglescapes' Presentation on Assisted Natural Regeneration at the SER World Conference 2021
**https://www.youtube.com/watch?v=HoL5S17QPIw&t=210s**

Video: Assisted Natural Regeneration, a restoration solution for Zambia's charcoal-makers
**https://www.youtube.com/watch?v=erW_ZEUa7Ro**

Video: Forest regeneration in the Philippines
**https://www.youtube.com/watch?v=9RPDsi7mkSE**

Video: Assisted Natural Regeneration (ANR) in Niger as a nature-based solution
**https://www.youtube.com/watch?v=YPaYBrmEkaA**

Video: Assisted Natural Regeneration: Saving Forests with Community
**https://www.youtube.com/watch?v=d6caMwl7P6Y**

Video: How the Sahara Desert is Turning into a Farmland oasis
**https://www.youtube.com/watch?v=KuISSupXpdw**

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