Farmer Managed Natural Regeneration: Community Driven, Low Cost and Scalable Reforestation Approach for Climate Change Mitigation and Adaptation

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Contents

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Abstract

Farmer Managed Natural Regeneration (FMNR) is both a technical practice and community development approach for mobilizing and empowering local communities to restore their natural environment through the systematic regrowth and management of remnant vegetation on diverse landscapes, which has climate change mitigation and adaptation benefits. FMNR was developed as a distinct approach in 1983 in the Republic of Niger. Over the ensuing 20 years, FMNR spread to over five million hectares of farmland, lifting tree density from four trees to hectare to over forty, restoring some 200 million trees into a formerly barren landscape. Of note, this feat was achieved primarily through a bottom-up movement, passing from farmer to farmer and with minimal external input of resources or expertise. This in turn has resulted in sequestration of between 5 and 10 million tons of carbon dioxide (CO2) per year, a doubling of crop yields, increased incomes and diversification of income streams and greater resilience through buffering of extremes in heat, wind and rainfall. There is no consolidated figure on the total extent of FMNR globally. However, in 2016, the US Geological survey conducted a study across seven West African countries (Senegal, Mali, Ghana, Burkina Faso, Niger, Chad, Nigeria) and found 15 million hectares of FMNR, 6 million of which are in Niger Republic. A recent study in Malawi uncovered over 3.2 million hectares of FMNR with no apparent links to any government or NGO initiative (Reij, 2019, personal communication). Several organizations are now working on a dashboard to capture the global spread of FMNR.

The UN Sustainable Development Knowledge Platform lists 12 Sustainable Development Goals (SDGs) that FMNR supports, including Climate Action and Life on Land. FMNR is low cost and delivers early returns on investment. These factors enhance its potential for spontaneous adoption and make it a prime candidate for widespread scaling, particularly in arid to sub-humid zones.

This chapter provides an overview of what FMNR is, including its core components, its history, enabling and inhibiting factors for adoption and its impacts. The major finding of this chapter is that FMNR is effective as an approach to reversing land degradation and as a tool for climate change mitigation and adaptation.

Keywords

Climate change · Climate change adaptation · Climate change mitigation · Community development · Empowerment · Farmer managed natural regeneration · FMNR · Movement · Nature-based solution · Reforestation · Regeneration · Restoration · Natural resource management

Literature Review

Recent estimates show that about a quarter of the world's land is degraded, affecting at least 3.2 billion people (Scholes et al. 2018). Land degradation has negative impacts on biodiversity and ecosystems, human livelihoods, and well-being. Land degradation also poses a major constraint in efforts to achieve climate change mitigation, climate change adaptation, and sustainable development. The Agriculture, Forestry and Other Land Use (AFOLU) sector is responsible for almost a quarter of the global Greenhouse gases (GHG) emissions (Smith et al. 2014). The emissions associated with AFOLU activities are projected to increase in the future (Smith et al. 2014).

Land restoration not only represents a crucial opportunity for mitigation, restoring productivity to degraded land contributes to avoiding further destruction of natural ecosystems under rising demands for food and energy (Lomax 2016). Restoration of degraded land also has potential impacts on equity and benefit-sharing mechanisms (Rosemary 2011). According to the Intergovernmental Panel on Climate Change (IPCC) (2019), Special Report on Climate Change and Land eradicating poverty and ensuring food security can benefit from applying measures avoiding, reducing, and reversing land degradation, contributing to combating desertification, while mitigating and adapting to climate change. The report also noted co-benefits of reforestation and forest restoration in previously forested areas, using native species and involving local stakeholders to provide a safety net for food security; providing both short-term positive economic returns and longer-term benefits in terms of climate change adaptation and mitigation, biodiversity, and enhanced ecosystems. In this context, mutually supportive climate and land policies are important to ensure resource efficiency, amplify social resilience, support ecological restoration, and foster engagement and collaboration between multiple stakeholders.

Some land-related actions are already being taken that contribute to climate change mitigation, adaptation, and sustainable development including combating desertification, land degradation, and food security (Smith et al. 2014). The Bonn Challenge, a global effort to restore 350 million hectares of degraded and deforested land by 2030, and the UN Decades on Family Farming and Ecosystem Restoration represent an unparalleled opportunity and a testimony for a growing recognition of the need for a global response to facilitate land restoration. In Africa, 29 countries have committed to restore more than 125 million hectares of land by 2030. Through the African regional contribution to the Bonn Challenge (AFR100), development banks have allocated US$1 billion, and the private sector has pledged to invest US$481 million (AFR100 2020). However, the progress to date is slow and understanding of the aims of land restoration under a changing climate remains limited (Pramova et al. 2019).

Some land restoration options in response to climate change have immediate impacts, while others take decades to show measurable results. Some examples with immediate impacts include the conservation of high-carbon ecosystems such as peatlands, wetlands, rangelands, mangroves, and forests. Other options with longer-term impacts and multiple ecosystem services and functions include afforestation and reforestation, restoration of high-carbon ecosystems, agroforestry, and the reclamation of degraded soils (Smith et al. 2014).

Challenges facing land restoration are inherently embedded in socioecological systems, processes, and changing socioeconomic conditions. Land restoration is shaped by different values, behaviors, knowledge, influencing people's decisions and goals, and thus restoration trajectories. Under different climate scenarios, spatial and temporal landscape scales add another layer of complexity (Colloff et al. 2017).

Some of the world's largest food security programs are grounded in restoring degraded land together with direct cash or in-kind benefits. However, the climate mitigation co-benefits of such programs remain under-studied (Woolf et al. 2018). In the realm of climate change adaptation, recent scientific inquiries have produced relevant knowledge on both the vulnerability of different species to climate change, the effects of restoration on ecosystem services and ecosystem resilience, and the role of ecosystem services in reducing societal vulnerability (Pramova et al. 2012). Land restoration can protect against hazards and thus reduce future risks and current vulnerability (e.g., by diversifying livelihoods).

Local and traditional knowledge has been considered and used in environmental restoration and sustainable land management all over the world (Rathwell et al. 2015). Case studies in Burkina Faso, Ethiopia, Ghana, Niger, and Senegal show broader regreening trends, combining assisted regeneration and other locally adapted practices. In these cases, economic, social, and environmental benefits, including increases in crop yields, tree regeneration, and soil conservation are well documented (Stith et al. 2016).

It is estimated that nature-based solutions such as land restoration can provide 30% or more of the climate mitigation action needed to limit average temperature increase to 1.5 °C (2.7 Fahrenheit) above pre-industrial levels (Conservation International 2020). Nature-based solutions (IUCN 2020) are actions to protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits. Of note, nature-based solutions are inherently low risk in terms of unintended consequences and improve the quality of life while improving the environment.

Introduction to Farmer Managed Natural Regeneration (FMNR)

History

Developed as a distinct practice in 1983, Farmer Managed Natural Regeneration (FMNR) is a low cost, rapid, and scalable method of restoring degraded landscapes. It offers a powerful means to mitigate climate change while simultaneously assisting communities to adapt. It was developed in the Republic of Niger as a response to deforestation, the failure of conventional tree planting practices (Eckholm 1984), and to address the deteriorating livelihood conditions of small holder farmers.

Fig. 1 Maradi, Niger before and after FMNR. Left: Tony Rinaudo in the early 1980s with pick up and trailer load of trees destined for planting. Right: The same area that has now been regreened through FMNR, 2017. (© World Vision)

Its development followed the observation that, contrary to perceptions, tree-less landscapes often contain a vast repository of living tree stumps with the capacity to regenerate – at low cost, quickly and simply (with low technology) – and this can be done at scale. In areas with no, or few, living tree stumps, there are usually tree seeds in the soil, and all that is required is a change of behavior /land management practices to encourage natural tree establishment. This *discovery* led to the realization that the main constraints to reforestation were not technical or financial, but social and policy related. Hence, while the technique was being co-developed with farmers and honed to meet felt needs, much effort also went into awareness raising and popularizing the idea, which went against the standard farming practice of clearing fields of all woody vegetation.

The discovery of FMNR in the words of Tony Rinaudo.

"In 1983, after two and a half years of mounting frustration at both tree planting and at gaining popular community acceptance for this activity, I was ready to give up. On a particularly low day as I was driving to the villages with a trailer load of seedlings, the hopelessness of it all weighed heavily on me. Looking over the barren landscape one didn't have to be a rocket scientist to see that using these conventional reforestation approaches, I would never make a significant or lasting impact. I was considering giving up and going home. Even so, I still felt I was meant to be in Niger and I prayed a simple prayer, asking God to forgive us for destroying the gift of his beautiful creation and for him to open my eyes and to show me what to do" (Fig. 1).

Standing there, a common small 'bush' growing in the field caught my eye. I had 'seen' these bushes many times before but had not given them any

(continued)

thought – they appeared to be weeds, or at best, desert bushes. I walked over to take a closer look but recognized the shape of the leaves and immediately realised that this was not a bush at all – it was a tree that had been cut down and was sprouting from the stump. That realization changed everything. I immediately knew that this was the solution I had been looking for – and it had been at my feet the whole time! Across this seemingly barren landscape were millions of similar bushes representing a vast underground forest. Each year sprouting stems grow to about one metre in height – and are then slashed by farmers preparing their land for sowing the crops. Branches and leaves were burnt for ash to fertilise the soil and stems and were collected for firewood. This annual slashing and burning prohibited the bushes from regrowing into full sized trees. After felling a tree, much of the root mass remains alive and most species can regrow rapidly from the stump. Felled trees constitute underground forests – we do not see it and are often unaware of the enormous potential for seemingly insignificant bushes to become trees."

This 'discovery' was in fact a rediscovery of an ancient practice which for various reasons had fallen out of use, due to population pressure and modern farming ideas. This re-discovery changed everything: reforestation was no longer a question of having the right technology or enough funding, staff or time. Nor was it about fighting the Sahara Desert, or goats or drought. Because everything you need for reforestation is literally at your feet, the battle was now about challenging deeply held beliefs, attitudes and practices and convincing people that it would be in their best interests to allow at least some of these bushes to become trees again. Because it was peoples' actions which had reduced the forest to a barren landscape, it would require people to restore it. False beliefs, attitudes and practices would need to be challenged with truth, through love, by example and with perseverance. Starting with just a dozen farmers willing to try this new approach, the practice of managing the regrowth from tree stumps to grow into trees spread across 50% of the agricultural land of Niger in 20 years. Today it continues to spread globally as it becomes increasingly well-known and appreciated."

Today organizations such as World Agroforestry (ICRAF), The World Resources Institute, The Global Evergreening Alliance, and World Vision advocate for more enabling policies to increase adoption of FMNR. The practice was co-developed with farmers, and in each new context, it is adapted with land users to meet the unique needs and goals of local communities in line with their specific environments. FMNR would never have spread at the rate it has unless community members were given the freedom to adapt the practice to their situation and objectives.

FMNR in Practice

FMNR has been promoted by many entities including development organizations, research institutions, governments, community groups, and passionate individuals. The FMNR Hub at World Vision Australia was established in 2012 to synthesize the learnings from all these stakeholders and to co-develop effective ways of promoting FMNR with communities. Decades of FMNR training, awareness raising, and advocacy has led to the refinement of how to best spread this practice at a local level. This process is contextualized depending on the country, but it is always a highly participatory approach. This means people are at the center of every decision. FMNR is more than just the regeneration of trees. It is about ensuring all community members can have access to this practice, apply it for their own needs, and experience the rich benefits which come from increased tree cover in their environment.

Some people may wish to regenerate the forest they use for firewood. Alternatively, farming families may wish to restore trees on their agricultural land to improve soil fertility. Community members use these goals to develop their own plan for how they want FMNR to look in their environment. As well as encouraging community members to develop their own plan, they are also supported to become FMNR champions and train others in their region. Encouraging community-ownership of this practice, it ensures sustainability beyond the end of an FMNR training session or an FMNR project.

Wherever possible FMNR can be bolstered by teaching community members advocacy skills so they can encourage their law makers to adopt policies that protect trees and the environment. The practices of FMNR can also be supported by encouraging community members to take-up complimentary Natural Resource Management practices, such as Assisted Natural Regeneration, micro water harvesting techniques, and holistic grazing management to amplify the benefits of regeneration. Because FMNR can increase crop yields or generate new tree-based products, it can also provide communities with additional livelihood opportunities, such as developing local value chains, so they can profit from these new resources.

At the heart of all FMNR is the mindset shift that occurs when community members can see that they have the capacity and the resources to regreen their environment, sustainably manage it, and provide a better world for future generations.

The following section explains the components of FMNR in more detail (Fig. 2).

FMNR Core Components

The Technical Components

The technical components comprise the pruning and tree management part of FMNR. In the scientific community, this technical component is what most people are referring to when they talk about FMNR. In the development sector, FMNR is seen as a more holistic community development approach to support people in mindset change followed by adoption of this pruning practice (Fig. 3).

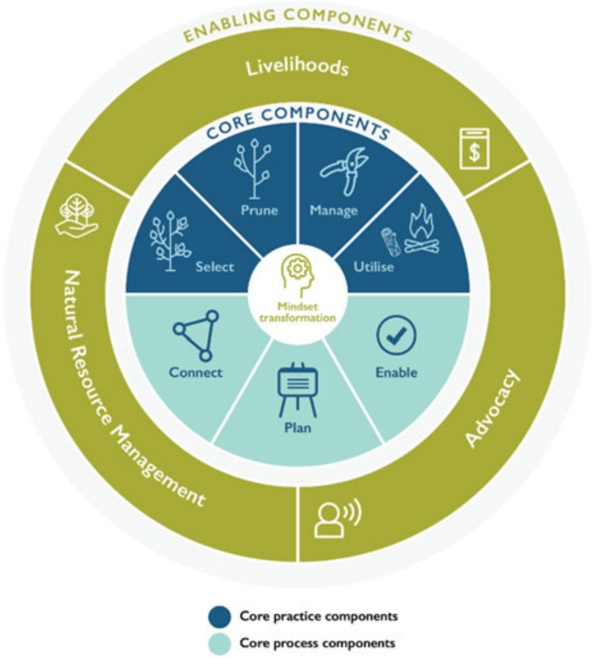

Fig. 2 The Components of the FMNR community development approach. Unpublished World Vision Australia document. (© World Vision)

Fig. 3 Three of the technical components of FMNR. (© World Vision)

Select: FMNR practitioners identify the number and species of trees and shrubs to be regenerated and/or actively managed in a landscape. FMNR is traditionally used to regenerate indigenous species, but the same principles can be applied to exotics.

Prune: FMNR practitioners selectively remove the stems and side branches of regenerating indigenous tree stumps and shrubs to maximize growth and regeneration by directing resources and nutrients to a few selected stems and side branches.

Manage: FMNR practitioners manage pruned stumps and shrubs by periodically returning to selectively remove new stems and side branches, and by protecting those that remain from potential threats including livestock, fire, humans, and competing vegetation or weeds by adopting, for example, improved grazeland and livestock management practices, social fencing, live fencing, and/or fire breaks.

Utilize: FMNR practitioners utilize stems harvested through the pruning process for planned purposes including firewood, fodder, or mulch with the understanding that shoots regenerating following harvesting of stems will be actively managed to expedite their recovery. As trees grow, practitioners may also utilize wild foods, traditional medicines, dyes, gums, and other non-timber forest products, depending on the species. In some instances, the entire tree may be felled and utilized by the FMNR practitioner. Many FMNR trees provide secondary benefits for the community such as increased soil fertility, wind breaks and erosion control.

While FMNR is commonly used to restore trees on land that has been cleared of vegetation, it can also be used to manage areas of dense bushland which have formed as a result of poor land management practices. These areas effectively become "green deserts" of limited use to either wildlife or livestock. On rangeland, this is called bush encroachment. On such sites, FMNR is applied as a tool to better manage and grow existing trees and shrubs and the pasture in between. The same approach applies: surveying and selecting and managing desired species. In some cases of bush encroachment, work involves removing invasive species to allow indigenous trees to grow.

Bush encroachment covers millions of hectares of land in Africa. Through applying the principles of FMNR, these lands can be rapidly recovered for forestry, agroforestry, pastoralism, and even conservation purposes. In Nakuru and Baringo counties, Kenya, farmers saw milk production from the same land and the same cows increase by 200–500% once scrub encroachment had been thinned and pruned (Njiru, 2014, personal communication). Land values have subsequently increased as areas once considered unproductive have become highly sought after.

The initial thinning of the vegetation in these areas ultimately leads to greater biomass and carbon sequestration as trees can grow taller with reduced competition and the thinned canopy allows grass and ground cover to grow (Fig. 4).

Fig. 4 Example of how FMNR can be used to clear and thin bush encroachment in order to allow trees to flourish. (© World Vision)

Fig. 5 Two community members and the forest area they regenerated using FMNR in Tanzania, 2016. (© World Vision)

The Community Components

As discussed, pruning is only one part of the FMNR approach (Fig. 5). For maximum impact, FMNR projects are designed to deeply involve the community and other significant stakeholders at every stage of the FMNR adoption process. A crucial part of this process is understanding the social dimensions within the community – including power dynamics and inequalities. This includes identifying leaders, as well as knowing who may face discrimination and inequality. Taking time to understand these dimensions means that the FMNR project will be as inclusive as possible. This could include simple modifications such as organizing childcare so women can attend an FMNR training, finding ways for landless community members to practice on communal land or doing an assessment for how training venues and locations can be accessible for people with a disability. The main practitioners of FMNR are land users (farmers, pastoralists, forest users) and their families, but the practice can be done by anyone who desires to regenerate trees in their area. This engagement process is always contextualized, but in general it involves the following components:

Connect: Community members come together to analyze, discuss, and connect the root causes and consequences of deforestation and landscape degradation in their community. Once the connection has been made, FMNR is introduced as a potential solution.

Plan: Community members engage in a participatory visioning process to identify common goals and agree on tangible actions to drive and enable the scale-up of FMNR on communal and privately owned/managed land. These plans can vary in formality and may be developed and refined over the years.

Objectives will vary according to the context. For example, in the Republic of Niger, major issues facing farming households addressed by FMNR include low soil fertility, drought, destructive winds at sowing time, low yields, periodic total crop failure, and fuel wood shortage. In Timor Leste, fuel wood shortage is not as big an issue as flooding, landslides, and low soil fertility. And in pastoral zones in East Africa, lack of fodder is a major issue. Typical FMNR projects working with farming families primarily seek to improve livelihoods. The main objective of an FMNR conservation project might be to restore biodiversity and ecosystem health and function. In countries where there are conflicts over scarce natural resources FMNR may be employed as a peace-building tool.

Enable: Community members are trained in the technical knowledge and skills to adopt and promote the practice of FMNR on landscapes. This component also includes the identification, training and follow up of FMNR Champions who actively work to enhance the spread and adoption of FMNR in their communities.

Beyond these recommended components, it must be recognized that all development interventions are 'journeys' involving individuals, communities, development partners, local government, and the interactions between them. In Niger, at the beginning of the FMNR journey, much energy was spent respectfully and persistently combating false beliefs (about trees growing too slowly and about trees reducing crop and pasture production) negative attitudes towards trees and destructive practices. FMNR proponents also came up against outright opposition to change, a colonial legacy, and the sheer struggle for survival in a degraded landscape scarcely able to meet the subsistence needs of a growing population. The journey involved tentative steps forward and major setbacks before eventual success when restoration was achieved.

By investing the time to ensure that this practice is owned by the community it has a far greater success rate and is therefore more likely to be continued after a project is finished. This community-ownership has ensured greater outcomes for carbon mitigation and sequestration – and livelihoods – as can be seen in the FMNR Case Studies section.

Mindset Transformation

Central to FMNR is the mindset transformation that occurs as individuals and communities meaningfully engage with the FMNR process and adopt the practice. Through this process of mindset transformation, individuals and communities experience a positive shift in their attitudes and agency toward addressing the causes and consequences of environmental degradation. The result is a transformation from hopelessness and apathy to optimism and empowerment for a more prosperous and sustainable future.

Enabling Components

These components are not a required part of an FMNR program, but they have been shown to increase the likelihood that FMNR will be adopted and owned by the community.

Livelihoods

Livelihood support could include introducing complimentary income-generating activities or supporting community members to sell the new products, such as firewood, they may have from FMNR activities. Implementing complementary economic activities, such as beekeeping within regenerated areas, can improve FMNR adoption and sustainability by increasing perceived value of trees, as well as income to households. These livelihood activities can also be used to bolster short-term fluctuations in household resource availability and income, which may otherwise undermine the success of FMNR by placing increased pressure on the use and cutting of trees. As well as introducing additional income-generating activities, some communities may benefit from support to help them decide how and when to sell the new products they have due to FMNR. This value-chain support could involve supporting famers to pool their firewood to sell as a collective or to invest in equipment to process grains to on sell at a higher price.

Natural Resource Management

Implementing FMNR with other complementary landscape management approaches can help create the enabling conditions required to accelerate the natural regeneration of trees on landscapes and provide more benefits for communities. Common complementary landscape management approaches include supplementary tree planting or reseeding on denuded or bare areas that lack sufficient regenerants such as living rootstocks and/or wild seeds (also known as enrichment planting), and the installation of small-scale physical structures for rainwater harvesting and soil and water conservation infrastructure (e.g., terraces, trenches, check-dams, sand dams or weirs). A key driver of deforestation is over-cutting of vegetation for fuelwood. The introduction of FMNR, and the protection of trees, may be perceived by some as a threat to their fuelwood supply. Reducing fuelwood demand, such as by facilitating adoption of fuel-efficient cook stoves, can facilitate FMNR adoption by reducing this demand. When integrated as a component of a broader natural resource management (NRM) approach, FMNR becomes a foundational practice upon which others may be layered to enhance NRM outcomes.

Advocacy

Building awareness and understanding of FMNR as a low-cost, scalable approach to address landscape restoration and build climate resilience enhances its adoption and helps to create an enabling environment at the community and/or sub-national level (s). This could include a law which enshrines the protection of regenerated trees or a national policy which designates that 5% of all private land must have tree cover. In communities where these laws already exist, an FMNR project simply needs to ensure that all community members are aware of these laws and policies. In a community where they don't exist, the community may need to be supported with advocacy training so they can petition their local government for greater environmental protection laws to support the adoption of FMNR and the future protection of trees.

Unique Features, Benefits, and Advantages of FMNR

Unique Features

FMNR is simple, requiring no external inputs or expertise. In the beginning, very poor farmers in Niger mostly learnt the technique from their neighbors, or by observation. They used farm utensils already at hand, such as locally fabricated axes, harvesting knives, and even sharpened short handled hoes for pruning and thinning stems and branches. They did not need to wait for a project, external resources, or expertise in order to start practicing FMNR.

FMNR is low cost and has been adopted by even the poorest farmers. Labor cost estimates to regenerate trees are in the order of US $14/hectare. However, most poor farmers do the work themselves.

FMNR is rapid in terms of tree growth. Even in semiarid Niger, trees can reach 1–2 m in the first year, and 3 m or more by the second. This is because most FMNR trees are growing from mature living tree stumps and root systems which can access soil moisture and nutrients, and which can draw on stored energy reserves. Being indigenous to the area, they are adapted to the climatic and soil conditions. And, FMNR is rapid in terms of spread of the technology. In the Niger Republic, over a 20-year period from 1984 (when FMNR was first promoted) until 2004, FMNR spread to some 5 million hectares (Reij et al. 2009: IFPRI). This is a rate of 250,000 ha per year for 20 years, and it was achieved largely by word of mouth and by the example of farmers.

FMNR is scalable. It rapidly went to scale in Niger primarily as a bottom up, farmer-led movement. Today, World Vison and other organizations are promoting the technique to governments, non-government organizations, and farmers and community organisations. Early signs of scale up can now be seen in Ethiopia, Kenya, Tanzania, Uganda, Malawi, South Sudan, Mali, Ghana, and Senegal.

FMNR provides early and increasing returns. Poor farmers begin to realize benefits from FMNR even in the first year, particularly in terms of small amounts of fuel wood and fodder (from some species). Additionally, the existence of any trees in field has many benefits to crops, including some flow on impact from improved microclimate through reduced temperatures and windspeeds and increased soil micro biota, increased soil fertility in the case of nitrogen fixing trees. During the dry season, trees in fields attract birds and livestock which fertilize the soil. As the trees grow, greater amounts of fuelwood and timber will be harvestable, and farmers will have access to wild foods, traditional medicines and new enterprise opportunities will arise such as bee keeping. A 2013 Social Return on Investment (SROI) report on World Vision Ghana’s Talensi FMNR project calculated that, after accounting for discounting factors, the investment of funds, staff, and technical input generated an SROI ratio in the target communities of 6:1 by the end of the 3 year project (Weston and Hong 2013). The study also calculated that the project will generate a ratio of 17:1 by 4 years after project closure and 43:1 by 10 years after project closure.

FMNR is farmer (or land user) managed, led, and owned. While FMNR has broad principles, the number of trees selected per unit land area, which species are selected, and how and when pruning occurs are determined by the land user. Trainers are strongly encouraged to listen to and learn from farmers, and the body of FMNR knowledge is regularly being added to by farmers who have shared their experiences.

Benefits

The benefits of FMNR are wide-ranging. While the primary benefit of FMNR is increased tree-density, there are numerous social, environmental and economic benefits which arise from this increase in trees. It is important to understand how these are linked because, while FMNR will always provide direct benefits to the environment, community members must also be able to see how they will benefit at each step too. Some of these benefits are captured within this simple theory of change (Fig. 6).

Some of the earliest benefits of FMNR are the increases in the timber and non-timber products from trees. This could include firewood, building material,

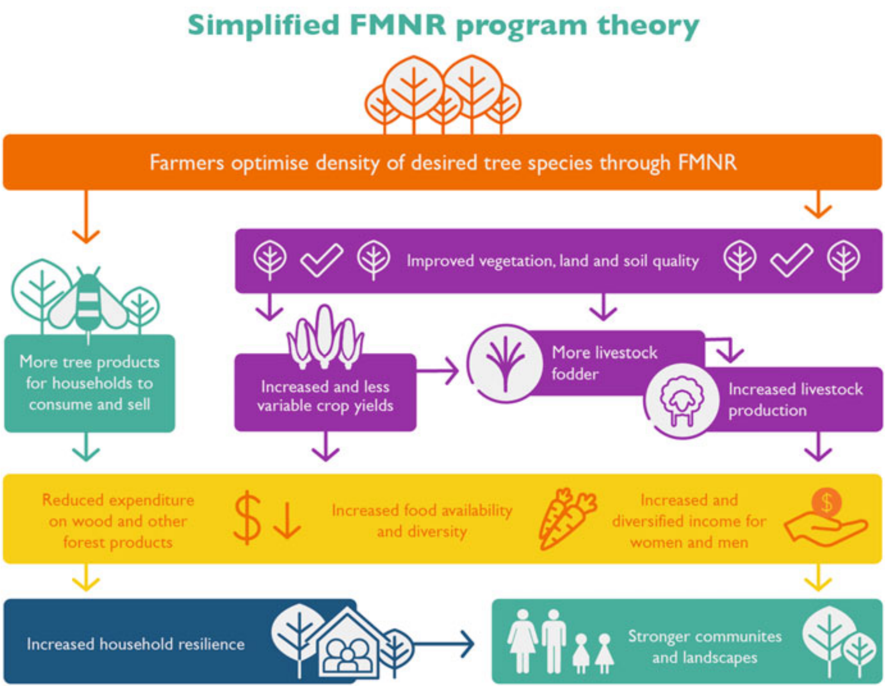

Fig. 6 Simplified FMNR Theory of Change. Unpublished World Vision Australia document, 2019. (© World Vision)

fruits, and natural medicine products. These products can be used by families or sold to increase household income. Having a new source of income provides greater resilience to families – for example, if a crop fails due to drought, they may still have firewood to sell due to FMNR.

As the trees grow, they provide a host of benefits to the land. Their root systems stabilize the soil, slow rainfall run-off and retain more water in the ground – reducing impacts of both flooding and drought. Over a large area this can even result in the rise of groundwater levels and the recovery of natural springs. Tree leaf litter acts as a natural fertilizer for the soil below. Trees provide a windbreak against harsh weather, thus protecting precious topsoil. They also provide shade which can be protective to crops, livestock and people.

Improved soil from increased tree density can have many benefits. It can increase and improve crop yields, which can have positive outcomes for families. Examples from East Africa have shown a doubling of crop yields even in harsh climates. It can mean more fodder is available for livestock, which increases both the quality of meat and milk. Increased produce from livestock and crops can be consumed by families or sold in market – thus increasing household income and resilience. Improved soil quality, in conjunction with increased tree-cover, can act as a form of disaster-risk-reduction by reducing the community's susceptibility to drought, flooding, and landslides.

By supporting communities to better manage shared natural resources and regenerating the productive potential of diverse landscapes, FMNR can strengthen social cohesion by mitigating intra and inter-communal tensions and conflicts over scarce natural resources. It can also reduce irregular migration by proactively addressing its common drivers including scarcity of natural resources and related declines in health and wellbeing.

In addition, town and city people benefit because of the regular supply of fuel wood coming from rural areas and from increased local grain and livestock production. When incomes of rural people increase from sale of wood and surplus grain and livestock production, their purchases from urban areas increase also. In the early 1980s before the technique had become widely adopted in Niger, wood merchants were plundering remnant forests, progressively travelling further and further as they razed the forests. A point would have been reached when no forests remained, and already high fuel wood prices would have escalated (Table 1).

Advantages of FMNR over Tree Planting

In comparing FMNR with tree planting, it is important to note that these are complementary practices, and not mutually exclusive. There is a place for FMNR and a place for tree planting and sometimes the two approaches are practiced together. However, for low cost, rapid and scalable restoration of indigenous vegetation, FMNR should be given high consideration. FMNR can be readily adopted by even the poorest farmers and communities with minimal to no external assistance. Thus, its spread is not dependent on often slow, expensive, and cumbersome

Table 1 Examples of the environmental, economic, and social benefits of FMNR

Benefits	Examples
Environmental	**Improved tree density** – World Vision's Food and Livelihood Enhancement Initiatives project in Senegal reported an increase in tree density from zero to 33 trees per hectare over 3 years. The mid-term review of the FMNR East Africa project found tree density on farms rose from 33 to 198 trees per hectare in Rwanda over 3 years (Cornwell 2019). **Improved land and soil quality** – A meta-analysis of eight FMNR projects indicated substantial improvements in land and soil quality as a result of FMNR: project participants were 15% more likely to report an improvement in soil quality and fertility and 10% more likely to report a reduction in erosion compared to non-participants (Cornwell 2019). **Increased water availability** – Tigray is Ethiopia's most water insecure region, but numerous communities through their natural resource management programs have become among Ethiopia's most water secure. The World Vision-supported community of Abreha Weatsbha were at the point of abandoning their ancestral land because it had become so degraded and they regularly suffered from both floods and severe drought. However, through strong leadership and great effort in adopting FMNR, soil and water conservation measures, tree planting, and digging of 350 shallow wells their situation has turned around. Despite having a very variable 600 mm average rainfall (80% falling in just one month), restoration activities resulted in recharging of the water table. An assessment for water potential revealed that Abreha Weatsbeha was the only site with exploitable water potential in the whole district. One of the deep wells developed for Wukro discharges 28 l/s. (Asfesha, 2016, personal communication)
Economic	**Increased income and decreased poverty** – Participant households in a meta-analysis of eight FMNR projects were 9% more likely to report a decrease in poverty in their communities. The decrease in poverty was reported similarly by poorer households, female-headed households, and female respondents (Cornwell 2019).
Social	**Improved gender equality** – FMNR groups served as an entry point for women to be more involved in community decision-making, with 24% of female respondents in the FMNR East Africa four-country project identifying increased involvement in village affairs among the project benefits for women (Cornwell 2019). Increased availability of natural resources, such as water and firewood, also decreases women's workload by reducing their overall travel time. **Improved social cohesion and reduced conflict** – Anecdotal evidence from Rwanda, Ghana and Kenya suggests that increased natural resources reduced conflicts within the community – particularly where pastoralists and farmers were previously competing over scare areas of land.

government or NGO interventions. A limitation of FMNR and one which can be compensated for through tree planting is that one can only regenerate what is there already. That is, restoration of tree cover through FMNR is dependent on the existence of living tree stumps and roots and dormant seeds in the soil with the capability to sprout. Even so, by restoring even a limited number of species from what is initially present, natural processes (colonization by wind, water, birds, wildlife, and livestock) will add additional species. However, if a land user wants, for example, specific high-value fruit, timber, fodder or fertilizer species, or wants a specific tree layout, planting is usually required. FMNR trees occur in nature where they germinate – thus FMNR offers little choice on where trees grow, and in mechanized agriculture settings, this can be problematic though not insurmountable. Farmers in one region of Mali, for example, only regenerate naturally occurring trees along regularly spaced rows where they will grow to form wind breaks. They fill in any gaps in the row by transplanting desired tree seedlings which germinate between the rows.

Depending on the context, costs of tree planting can exceed $400 (Brown 2007) per hectare and there can be considerable losses from drought, livestock, fire and other causes. In the Sahel for example many tree planting projects have registered mortality rates greater than 80% (Eckholm 1984). Eckholm (1984) describes an extreme case from the West African Sahel. Between 1975 and 1982 more than $160 million was spent on forestry programs. Achievements were approximately 20,000 ha of 'not doing very well' plantations at a cost of approximately $8000 per hectare. By comparison, typical FMNR project costs range between $20 and $50/hectare, depending on the activities included in the program and survival rates can reach 100%. Whereas individuals and communities rarely continue tree planting activities once externally directed tree planting projects end, FMNR has the potential to keep spreading beyond the life and financial expenditure of the project from farmer to farmer, as it did in Niger Republic. Thus, year on year after the close of an FMNR project, if FMNR continues to spread from farmer to farmer, as the area reforested increases, the cost per hectare of FMNR in the original project decreases accordingly. Once introduced, FMNR costs nothing to the farmer except his/her labor. It is estimated that implementation of FMNR on one hectare of land in Niger by farmers cost $14 in labor equivalent.

Thus, costs wise, FMNR comes out very favorably when compared to conventional tree planting and this partially explains how, over a 20 years period between 1985 and 2005, 200 million trees were regenerated across five million hectares of agricultural land with minimal government or NGO support. Average tree density on farmland increased from four trees per hectare to 40. By deduction, the practice of FMNR appears to have spread across Niger at a rate of 250,000 ha per year without the knowledge of government or NGO alike – a phenomenon described by Chris Reij (Hertsgaard 2009) as perhaps the biggest positive environmental transformation in the Sahel, if not all of Africa. By comparison, in the 20-year period prior to 1980, some 60 million trees were planted in Niger yet, according to officials, only 20% survived.

FMNR and Climate Change Adaptation and Mitigation

Climate Change Adaptation

By virtue of its multiple positive impacts, FMNR is an amazingly versatile tool for climate change adaptation. By buffering against extremes in temperature, wind and rainfall, reducing the risk of landslides and flood, reducing the impact of drought, by

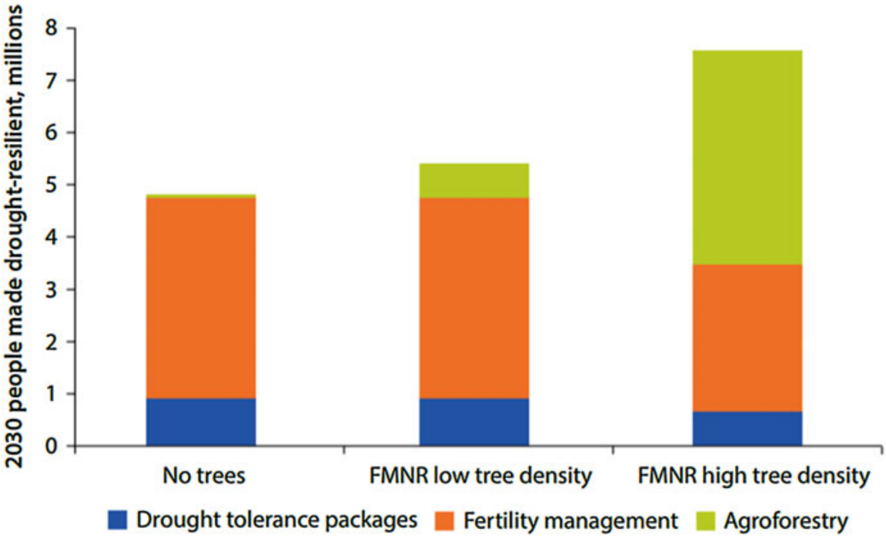

Fig. 7 Estimated Reduction in the Average Number of Drought-Affected People Through Use of FMNR and Other Technologies by 2030. (World Bank © License: Creative Commons Attribution CC BY 3.0 IGO)

providing alternate income and food sources and by boosting agricultural production, trees contribute significantly to climate change adaptation.

Crop modelling carried out for a World Bank study in 2018 (Carfagna et al. 2018) helped provide orders of magnitude of the benefits of FMNR in terms of reduction of drought impacts. When FMNR of native species is added to other productivity-enhancing technologies, the effects are impressive. In a group of 10 countries in East and West Africa, the projected number of poor, drought-affected people living in drylands in 2030 fell – compared to the business-as-usual (BAU) scenario – by 13% with low tree density systems (defined as five trees per hectare) and by more than 50% with high-density tree systems (defined as 10 trees per hectare) (Fig. 7.) Considering that in Niger, average tree density through FMNR is 40 trees per hectare with farmers in some districts leaving over 100 trees per hectare, potential adaptation benefits are far greater than even this optimistic modelling suggests. More research is warranted to determine the optimum number of trees, ideal species mixes, and management practices required to maximize adaptation benefits in different contexts.

Two aspects of how regenerated tree cover through FMNR provides adaptation to climate change are temperature and moisture availability.

Temperature

Rising temperatures will negatively impact crop and livestock production. Many crops are already growing at the upper limits of their optimum temperature thresholds. Maize productivity could decrease by 5–10% and rice productivity by 2–5% for each degree of warming (Ramirez-Villegas and Thornton et al. 2015). For livestock, most species perform best in temperatures between 10 and 30 °C. At temperatures above 30 °C, cattle, sheep, goats, pigs, and chickens all reduce their feed intake by 3–5% for each one-degree increase (Thornton et al. 2015).

Shade from trees significantly lowers air and soil surface temperatures. Measurements taken in Burkina Faso revealed that while soils started at about the same temperature in early morning, soils in shaded areas were sharply cooler (35 °C) by mid-morning and early afternoon than soils under direct sunlight (Pool and Winterbottom 2017). Air temperatures in the shade of trees can be 10 °C cooler than unshaded air. It is estimated that 15% tree cover would bring down air temperatures approximately 10 °C and because high temperatures can cause crops to stop growing in the middle of the day, a light shade can increase crop yields by up to 40% (Bunch, 2020, personal communication).

Almost universally, farmers express fear that shade from trees will depress crop and pasture yields. This data shows that properly managed trees, and by default, tree-shade, can increase plant growth. As average global temperatures continue to rise, the need to understand the nuanced relationship between plants and shade will increase. The issue is even more critical when one considers that "heat spikes" – dramatic temperature rises, can destroy or severely damage plants in a single day, no matter what the average temperature is.

Moisture

The impact of trees on water (Sheil and Bargues 2020) is equally significant. In drylands, water tables often lie deep below the surface, but deep-rooted trees have access to it. Research in Senegal (Kizito et al. 2012) reveals how certain tree species re-distribute some of that moisture through surface roots benefitting near-by crop plants. The tap roots can move water from high water potential strata in the sub-soil to low water potential strata near the surface through the process of hydraulic lift, sometimes commonly named "bio-irrigation". This water can be important to assist crops through drought periods that are very common in semiarid regions. This supply of water also maintains the diversity and functioning of microorganisms in the rhizosphere and in the roots.

Trees improve water infiltration. Landscapes with some tree cover can sometimes capture several times more water than otherwise comparable treeless landscapes. Groundwater recharge, the infiltration of water from surface level to deeper within the soil profile, is maximized with an intermediate tree cover. At this optimum, mean annual recharge is 5 to 6 times greater than in treeless conditions, thus greater tree cover can improve recharge over vast regions, especially where land degradation has impaired infiltration.

Trees recycle rain. Continental rain depends much more on moisture derived from trees and other deep-rooted vegetation than was recognized until a few years ago. Furthermore, intensified recycling means that after water arrives over land, in rain from moist winds or clouds, the presence of more trees results in the same water falling more frequently on land before it departs back to the ocean.

Trees attract rain. Water transpired to the atmosphere by trees can be returned with added interest, as the likelihood of rain depends on atmospheric moisture. Under suitable conditions, a 10% increase in local relative humidity may increase precipitation by more than 50% (Sheil and Bargues 2020). Furthermore, some regions depend on rainwater from elsewhere. Since trees bolster atmospheric moisture, greater tree cover increases overall rainfall, though not necessarily in the same location. If sufficient tree cover was established over broad dryland areas, it seems that net rainfall would increase, with the wider benefits that this implies.

Climate Change Mitigation

FMNR is a nature-based solution for climate change mitigation. In Niger Republic, over a ten-year period the adoption of FMNR across five million hectares of farmland has resulted in significant CO_2 sequestration. In this dry climate with tree densities of only 40 per hectare estimated sequestration rates of between 1 and 2 t $CO_{2e/hectare}$ were attained, resulting in the sequestration of between 50 and 100 million tons of carbon dioxide equivalent (CO_{2e}) into the landscape (Thomson, 2018, personal communication). By extrapolation for the estimated 15 million hectares of FMNR on farmland in West Africa, potentially 15–30 million tons of $CO_{2e/hectare}$ are being sequestered per year.

The World Vision Ethiopia, Humbo FMNR project, which is in a more humid climate (between dry and moist montane forest) with tree densities of between 1500 and 2000 per hectare averaged sequestration of 8.5 tCO2e per ha pa from 2006 to 2017. This 30 year project is due to end in 2036. Between 2006 and 2018, 225,000 t of CO2e had been sequestered through the Humbo reforestation project (Fig. 8). A business as usual scenario (soil erosion, overgrazing, and removal of regrowth stems and tree stumps) would have resulted in net CO2 emissions.

Agroforestry, of which FMNR is a subset, is a particularly important strategy for sustainable land management in the context of climate change. Zomer explains that

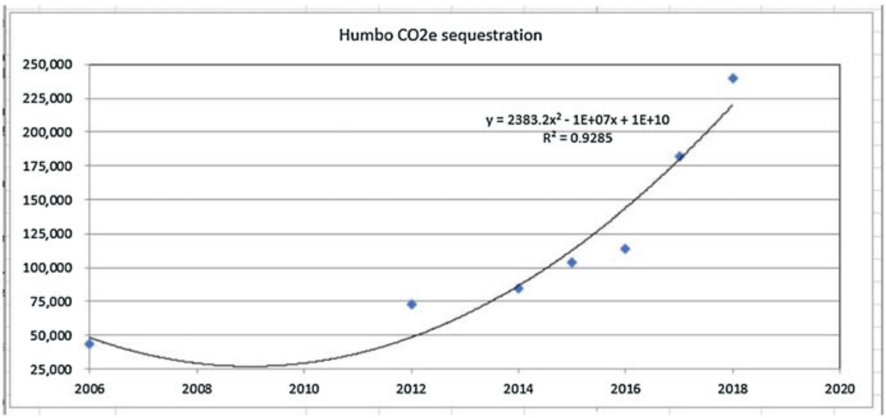

Fig. 8 Time series analysis: CO2e sequestered by Humbo reforestation project between 2006 and 2018. (Data Source, Kebede Regassa, World Vision Ethiopia. Unpublished data. © World Vision)

this is because of the large potential to sequester carbon in plants and soil and enhance resilience of agricultural systems. In fact, he found that existing trees in agroforestry landscapes increased carbon stock by 7.33 $GtCO_2$ between 2000 and 2010, or 0.7 GtCO2 year (IPCC 2019).

Agroforestry is an underappreciated mitigation option that deserves more attention by governments who have tended to focus on technical solutions to reduce emissions over nature-based solutions. The integration of trees and shrubs onto agricultural land positively impacts soil carbon sequestration, reduces soil erosion, improves soil quality, mitigates Green House Gas (GHG) emissions, improves food security, and allows for ecologic and crop diversification. Rather than being a negative cost to land users, properly designed agroforestry systems can increase incomes.

Agroforestry can curb GHG emissions of carbon dioxide (CO2), methane (CH4) and nitrous oxide (N20) in agricultural systems. Mbow et al. (2014) found that soil carbon sequestration, together with biological nitrogen fixation, improved land health, and underlying ecosystem services may be enhanced through agricultural lands management practices, including incorporation of trees within farms or as living fences. According to Griscom and others, the mitigation potential from agroforestry ranges between 0.08 and 5.7 GtCO2 year1, (medium confidence) (IPCC 2019). This high estimate is from an optimum scenario combing four agroforestry solutions silvopasture, tree intercropping, multistrata agroforestry, and tropical staple trees. Ramachandran Nair and others estimated the carbon sequestration potentials of differing agroforestry systems. These include sequestration rates ranging from 954 (semiarid) to 1431 (temperate), 2238 (sub-humid), and 3670 tCO2 km–2 year–1 (humid) (in IPCC 2019). Additionally, there is enormous scope for FMNR outside of agricultural and pastoral landscapes in forest restoration settings. Global annual GHG emissions are approximately 50 GtCO2e, thus the potential contribution of FMNR to draw down carbon is significant.

Additionally, increased tree-cover through FMNR enhances the microbial activity of the soil and boosts the productivity of the grass under cover. CO2 emissions are therefore reduced through lower rates of erosion due to better soil structure and more plant cover in diversified farming systems than in monocultures. There is great potential for increasing above-ground and soil carbon stocks, reducing soil erosion and degradation, and mitigating GHG emissions.

FMNR Case Studies

The following case studies provide examples of the impacts possible when communities take ownership of FMNR.

Humbo Forestry Project: FMNR for Climate Change Mitigation

FMNR has been instrumental in World Vision's flagship climate change mitigation project in Humbo, Ethiopia (Fig. 9). The project is focused on reforestation, natural resource management, and carbon sequestration as a mechanism for environmental and social benefits for households. It began in 2006 and will continue until 2036 and the community have already regenerated 2724 ha of degraded native forests utilizing FMNR (World Vision Ethiopia, 2019, unpublished). These regenerated trees act as a "carbon sink" to mitigate climate change, while at the same time building environmental, social, and economic resilience for future climate change impacts.

The Humbo project has contributed significantly to climate change mitigation. To date, the project has sequestered 165,000 t CO2, generating over USD 500,000 as carbon offsets for the community through the World Bank's BioCarbon Fund (World Vision Ethiopia, 2019, unpublished). The carbon revenue has improved livelihoods and enhanced economic resilience by allowing the local community to make investments in grain storage, solar energy, and new businesses. Carbon credit income has enabled the local community to build eight flour mills and nine grain stores, purchase 240 solar panel to provide off-grid energy, and give access to micro-credit services to over 1200 households for investment in different businesses.

As well as generating income through carbon credits the area regenerated using FMNR has provided environmental benefits for the community such as increased grass for livestock, increased domestic firewood, improved ground water and springs, and increased biodiversity. By improving the functioning of the natural environment, the Humbo community is less vulnerable to extreme weather events because the regenerated trees provide a wind break and reduce erosion through their root systems (Fig. 10).

FMNR has also increased the resilience of the Humbo community to climate variabilities and food insecurity. The restoration of trees and protection of the environment have increased soil fertility and improved crop yields. The community had received food aid every year to since 1984. In 2013, instead of receiving aid, they sold 106.7 t of grain to the World Food Program – a complete turnaround from their previous position (Regassa, 2017, personal communication). In 2016, Ethiopia

Fig. 9 Humbo, Ethiopia before (2002) and after (2010) the project. (© World Vision)

Fig. 10 Humbo Cooperative members purchasing grain. (© World Vision)

Fig. 11 Satellite image of Humbo in 2016. (Courtesy of Google Earth)

experienced its worst drought in 30 years, affecting over 10 million people. However, communities in Humbo remained food secure (Fig. 11).

Most importantly, landscape restoration over the past 18 years has also led to a mindset change: community members now see it as their role to sustainably manage the area, placing a high value on their natural resources. The broad benefits, both income and non-income, of a functioning landscape are increasingly recognized by the community as being of more significance than income generated through carbon offsets.

FMNR East Africa: A Household-Led Approach to Increasing Tree Density

While the Humbo Forestry Project focused on reforesting a designated mountain range area, the FMNR East Africa project took a mosaic approach. This project supported households to adopt FMNR on farmland, pastoral land, and forest land dotted throughout communities in Kenya, Rwanda, Tanzania, and Uganda. The project used training, awareness raising, and advocacy to influence FMNR adoption and national reforestation policies. Project staff worked closely with community members to deepen their understanding of how trees could improve their food security and livelihoods – as well as their climate resilience. By ensuring the community could see benefits for their households, such as crop yields and firewood, they were more willing to start managing and protecting trees. The project ran from 2012–2017 and led to over 100,000 people adopting FMNR and restoring their land (World Vision East Africa, 2017, unpublished) (Fig. 12).

One of the key successes of this project was changing community attitudes to slash-and-burn farming. Slash-and-burn farming involves clearing farmland of all trees and vegetation and using fire to clear the area. While this does give an initial increase in soil fertility, it is not sustainable as its continued use year-on-year destroys the soil microbiome and the removal of trees leads to soil erosion. Through FMNR, farmers regenerated the tree stumps they had left behind when they cleared their fields and they soon began to see improved soil fertility from these regenerated trees. In Kenya, there were only nine trees per acres on project land but by 2016 there were 30 trees per acre – more than triple (Odwori, 2016, unpublished). At this time, 44% of participants in Kenya reported an increase in crop yield as a result of growing

Fig. 12 A women’s FMNR group in Tanzania, 2016. (© World Vision)

crops with trees (Odwori, 2016, unpublished). In Uganda, tree cover increased by 50%, and 69% of respondents reported that crop yield had increased as result of growing trees and crops on farmland (Alexander, 2016, unpublished) (Fig. 13).

As well as increased crop yields, one of the primary benefits that communities appreciated was the increased availability of firewood. As trees are pruned and managed, they grow quicker, and excess branches and shoots become more abundant and can be used as firewood. In Kenya, within 3 years 91% of households reported sourcing firewood from their own land, a significant increase on 76% in 2012 (Odwori, 2016, unpublished). In Rwanda, 57% of respondents affirmed that time collecting firewood had been reduced over 3 years (Gapusi and Gishinge, 2016, unpublished). In Tanzania, 26% of respondents reported that firewood collection time had decreased; this number is lower because of the preference to source firewood from community forests in Tanzania, which are more abundant than in the other three countries (Masanyiwa and Safari, 2016, unpublished). In Uganda, 61% of participants were able to source firewood from their own land, a huge increase from 5% at the start of the project (Alexander, 2016, unpublished). Increased availability of firewood, and decreased firewood collection time, also have positive gender effects. Women are overwhelmingly the primary collectors of

Fig. 13 An FMNR Youth Group in Uganda performing teaching the value of trees. 2015. World Vision uses culturally appropriate means of communication including skits, music and use of proverbs as powerful tools for mindset and practice change. (© World Vision)

firewood in all four countries, and in some cases would spend over 4 h per day in search of fuel prior to the introduction of FMNR.

Judith Mukamunana was one of the early adopters of FMNR in Kenya. She began practicing in 2014 and was trained as an FMNR extension agent (someone who teaches other community members how to do FMNR).

> Before I was trained on the regeneration of indigenous trees, I used to clear all sprouts from indigenous trees on my farm. I considered them useless bushes, and in some of my farms I invested money to uproot the stumps because I was thinking they would compete with my main crops, said Judith.

"The results I got from pruning stumps of Ficus on my farm are unbelievable. From some branches that have never been over 1.5 m high, I'm able to harvest a big pile of firewood every season and my trees are now over six meters high after two years," she said. Apart from firewood Judith testified that she increased her agriculture production because of biomass from leaves she used to fertilize the soil.

Throughout the project community members were asked what their landscape used to look like in the past, and many identified that climate change had negatively impacted their environments. They wanted to restore their landscapes but restoration on its own is not enough of a motivation for time-poor farmers and pastoralists. By showing community members the potential for FMNR to restore their land and provide short-term benefits such as crop yield increases and firewood, they were more willing to invest in the practice. The strong focus on community engagement in FMNR meant that 85% of those trained adopted the practice (World Vision East Africa, 2017, unpublished).

FMNR in Ghana: Linking Regeneration of Trees and Fire Management

Communities in the Taensa district of Ghana have been practicing FMNR since 2009. More than 24 communities have now adopted the practice (Crawford 2018). They have practiced FMNR on hillsides (as for Humbo, Ethiopia) as well as on farmland and pastoral land as do the communities participating in World Vision's FMNR East Africa project. The key to the success of FMNR in this region has been contextualization and ensuring that both the community and the environment, benefits from the practice. A big challenge for this region is bushfire. These fires are often sparked from people doing slash-and-burn farming but are exacerbated by climate change. In the past, bushfires destroyed homes, crops, and forestland. Therefore, as well as providing information about the harms of slash-and-burn farming, these communities were also trained as fire management volunteers to ensure the sustainability of FMNR and their restoration efforts.

An evaluation of this area in 2017 found that only 13% of community members were practicing slash-and-burn farming – a significant reduction from 59% in 2013 (Crawford 2018). Since 2009, over 400 community members have been trained as fire volunteers – learning fire prevention techniques, such as how to create fire breaks, as well as firefighting skills (FMNR Hub 2016). By 2017, over 50% of this group was women (Crawford 2018). In a 2015 evaluation, 90% of FMNR adopters across the project sites believed bush fire occurrence has decreased (Trend, 2015, unpublished).

As well as decreasing fires in the area, the community have also experienced the benefits of regenerated trees. In 2013, 59% of community members saw an increase in tree cover and by 2017 that number had increased to 81% (Crawford 2018). As with all FMNR projects, these trees mean different things to different people. Here is what one community member from Yameriga village had to say: "As for tintung lebge tii (FMNR), I don't know where to start. It has helped us in many ways! Our goats go there to graze, our women get firewood, our children get fruits and we also harvest honey from the FMNR site."

Global Opportunities and Constraints for FMNR

Opportunities

Prospects for the further spread of FMNR are very bright. World Vision is a founding member of the Global Evergreening Alliance, a coalition of organizations whose stated aim is to massively scale up FMNR globally. Member organizations include World Vision, World Agroforestry Centre (ICRAF), the World Resource Institute (WRI), the African Forest Forum, the African Union, NEPAD, Oxfam, CARE International, Catholic Relief Services, Concern Worldwide, Conservation International, UN Environment, UN Food & Agriculture Organization, and many others.

Through the collaborative approach promoted by the Global Evergreening Alliance, FMNR is rapidly becoming more widely known, and the methodology is being promoted by an ever-increasing number of organizations and governments. World Vision and partners support the Bonn Challenge (to restore 350 million hectares of degraded land globally by 2030), and subsidiary initiatives (AFR100 which aims to restore 100 million hectares of degraded land in Africa) by awareness creation and by providing capacity building and support. In the same way, World Vision supports the African Union, which made the following declaration in the second African Drylands Week in Ndjamena, August 25–29, 2014: "RECOMMEND AND PROPOSE that the drylands development community, through the African Union, and all collaborating and supporting organisations, commit seriously to achieving the goal of enabling EVERY farm family and EVERY village across the drylands of Africa to be practicing FMNR and Assisted Natural Regeneration by the year 2025 (Fig. 14)."

About two-thirds of the developing world's three billion rural people live in about 475 million small farm households, working on land plots smaller than two hectares (Rapsomanikis 2015). The potential to use FMNR in these contexts is enormous. The practice is highly transferable, and the principles are applicable across a wide range of eco-zones in different regions and continents. While the principles are transferrable, greatest adoption of FMNR tends to be in the more arid to semi-arid

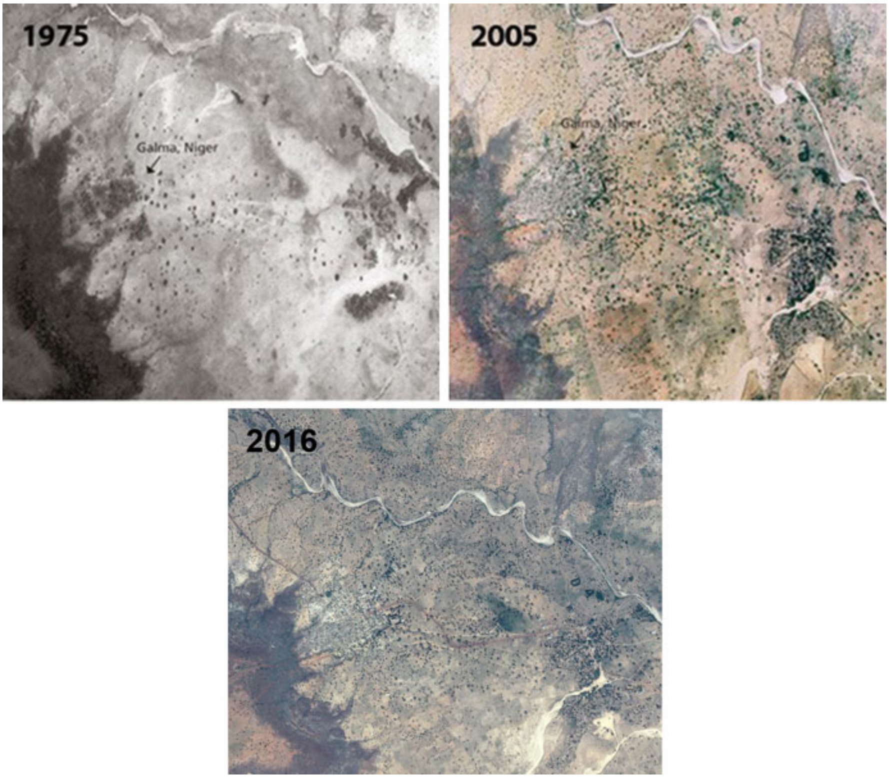

Fig. 14 The spread of FMNR in Southern Niger over 41 years, as seen by satellite. (Courtesy of Gray Tappan, US Geological Survey, EROS Centre)

zones. This is perhaps because the drier the environment, the fewer viable options available to land users. For example, in more humid zones, farmers would be more likely to opt for higher value cash crops and planted timber and fruiting trees than regenerated indigenous trees, even though there are clear environmental and economic benefits.

Through World Vision's interventions FMNR has been introduced in 26 countries – Somalia, Ethiopia, Kenya, Tanzania, Rwanda, Uganda, Malawi, Zambia, Zimbabwe, Lesotho, eSwatini, Democratic Republic of Congo, South Sudan, Chad, Niger, Mali, Burkina Faso, Ghana, Senegal, India, Myanmar, Indonesia, Timor-Leste, Haiti, Lebanon, and Afghanistan. Major research and advocacy organizations, notably The World Agroforestry Centre and the World Resources Institute, and non-government organizations including the Global Evergreening Alliance and World Vision are also actively promoting, researching and/or reporting on FMNR widely. The practice is being applied to different land use types, including agricultural land, pastoral land, forests, and highly degraded land. It is being adopted in extremely arid countries such as Somalia, arid and semiarid countries in the Sahel, humid and tropical countries such as Haiti, and it is being adopted on flat land, sloping land, and hilly land in Timor-Leste.

Additionally, FMNR is occurring spontaneously without any apparent contact with government or external agencies. Recently a USAID funded World Resources Institute study in Malawi found over 3.2 million hectares of FMNR across farmland. This occurred with no government or external intervention and appears to be an entirely farmer-driven movement. Meanwhile, in Mali, almost 0.5 million hectares have been regenerated on the Seno Plains, perhaps primarily in response to positive changes in forestry law in 1994. Around six million hectares of old and ageing agroforestry parkland (i.e., farmer managed trees) can be found in southern Mali. The emergence of some 300,000 ha of new agroforestry parklands in Yatenga and Zondoma provinces in Burkina Faso coincided with an upsurge in adoption of water harvesting techniques. The World Resources Institute has taken lessons learnt to date and developed a guide for rapid scale up of FMNR called "Scaling Up Regreening: Six Steps to Success" (Reij and Winterbottom 2015) in order to make the information available to a wider audience and speed up the adoption rate. World Vision has used workshops, online courses, and technical tools to train other NGOs, CBOs, FBOs, and government departments in FMNR. This has enabled them to go on and spread the practice further.

Constraints

There are four major categories of FMNR constraints: mindsets, policies, inequality and poverty.

Mindsets. The primary constraint early-on is mindsets. The first line of opposition to the uptake of FMNR is what people believe – about trees on farmland, about indigenous trees and perceptions on how slowly they grow and their overall usefulness. Other recurring constraints to FMNR uptake include fire, livestock damage, and removal of all woody biomass by others. The authors argue that these are symptoms rather than root causes of constraints. Each of the above constraints is a result of mindsets or unchallenged world views that see indiscriminate use of fire, unrestricted livestock grazing, and harvest of woody biomass as normal and rightful activities. As such they are deeply entrenched and potentially very difficult to influence or change. One approach that works well is to ask community members to reflect on how changes in the environment since they were children have affected their wellbeing. Usually, conditions and hence wellbeing have deteriorated. After giving time for reflection, community members are then asked to project their life into the future – if we continue, business as usual, destroying the environment, what will life be like for our children and grandchildren? Most know intuitively that things will only get worse. Because most parents want a better future for their children than the current reality they are experiencing, this exercise can lead to changed attitudes and behavior.

Introducing FMNR into a community invariably involves respectfully challenging false beliefs, negative attitudes and destructive practices against trees.

Fortunately, there is a strong body of evidence, photographic records, and actual sites that can be visited which can be drawn on to counter opposition. Challenges are addressed through awareness creation, advocacy, capacity building (especially peer to peer), development of pilot sites, facilitating exchange visits, regular follow-up, and inclusion of all stakeholders.

Policies can be another inhibitor to FMNR success. To protect trees, many governments create laws assigning tree ownership to government. This effectively disempowers and disincentivizes community members from sustainably managing trees, resulting in greater tree destruction. Fortunately, governments that realize the benefit of individual and community tree ownership and user rights are creating enabling policies which give the assurance that community members will benefit from their labor. As discussed, this can be overcome at a local level through awareness raising and advocacy training for community members.

Inequality. Existing inequalities within a community can make it difficult to ensure FMNR reaches and benefits all people. Discrimination within a community may be based on gender, sexuality, disability, ethnicity, faith, or a multitude of other reasons. As discussed, wherever possible an FMNR program needs to deeply understand these dimensions of inequality and look for ways to be as inclusive and accessible as possible. However, in some situations there may be pervasive issues which cannot be addressed through an inclusive-FMNR program alone. In India, for example, caste discrimination made it particularly difficult to secure tree user rights despite government programs to assist "scheduled" classes. In these situations, there may be a need for additional targeted activities to address underlying attitudes and behaviors that drive discrimination, for everyone to fully benefit. Without addressing systemic barriers, it can be difficult to reach all people with FMNR.

Poverty can also influence a community's ability to prioritize natural regeneration. Poverty can drive negative coping strategies such as charcoal making and over exploitation of forests as individuals seek to secure their family's survival. By creating market opportunities for timber and non-timber products and by linking FMNR promotion activities with increased agricultural production and value chain development, communities will see that there is more and longer lasting benefit in sustainably harvesting forest products than in destroying them for a one-off sale.

Join the FMNR Movement

Staying at or below a 1.5 °C global temperature requires slashing global greenhouse gas emissions to 45% below 2010 levels by 2030 and reaching net zero by 2050 (IPCC 2018). The consequences of passing 1.5 °C are terrible to contemplate, and yet, the current rate of decarbonization of economies is inadequate. Even if these urgent deadlines are met, ceasing emissions alone will not stop dangerous climate change. It is also necessary to draw down historical atmospheric CO_2.

In 2019, the Crowther lab revealed that there is enormous global tree restoration potential – nearly a billion hectares in fact, enough area for around 500 billion trees

(Bastin et al. 2019). And, importantly, the suitable sites are reported to be outside of existing forests and agricultural or urban land. The 0.9 billion hectares of new tree canopy cover, which could store 205 gigatons of carbon in areas that would naturally support woodlands and forests give grist to the argument that restoration of trees is among the most effective strategies for climate change mitigation. While the availability of that land, and the question of who foots the reforestation bill will need to be addressed, the potential area for restoration is even greater when you consider that beyond the 0.9 billion hectares of land presumed to be suitable for tree planting, at least two billion hectares of agricultural and pastoral lands are suitable for agroforestry and silvopasture. Inclusion of trees in these already utilized areas not only makes for beautiful landscapes, it simultaneously increases their productivity and resilience, while helping to mitigate climate change.

Many people in government, climate, development and agricultural circles have a false perception that agricultural land and trees are mutually exclusive, and that globally the practice of agroforestry is of little importance. But in fact, with management of appropriate species, the reverse is true – they are not only compatible, they are complementary. Additionally, few decision makers seem to be aware of the vast areas of land currently under agroforestry, nor the potential for a massive increase of trees on agricultural lands.

It is not too late to avert the worst impacts of climate change if we act decisively now. We know what to do and we have the means to do it. If Niger Republic, one of the world's poorest countries, with a harsh environment and with minimal external input or direction can achieve restoration rates of a quarter of a million hectares per year for 20 years through a bottom up movement, what might be possible if there was a global collaborative approach – government, NGOs, academia, research, civil society and rural communities, all working together towards a common goal? Technically there is no reason why multiple countries couldn't achieve restoration rates of 5 million trees per hectare/year simultaneously – everything you need is already present in the ground.

There is a saying that goes, "If you have nothing to lose and everything to gain, go for it. In other words, give 'it' all your energy and commitment since no harm and a lot of good will be done. FMNR is a no regrets technology. There is no insurmountable downside to employing this method of reforestation. It is low cost, rapid and scalable and there are no technical impediments to its widescale adoption. It is a tool of choice for both climate change mitigation and adaptation and it can be applied immediately.

Summary and Comments

The introduction and promotion of FMNR has been a game changer for reforestation efforts, particularly in arid and semi-arid zones where tree planting has largely been an expensive failure.

Though based on traditional tree coppicing systems, FMNR emerged as a distinct agroforestry practice in 1983 in Niger Republic. The development and adoption of

FMNR marked a turning point from top down, high cost, low success rate tree planting schemes to low cost, rapid and scalable reforestation driven by the people themselves. Thus, FMNR is both a technical practice involving pruning and management of tree shoots and a development approach involving mindset change, enabling and empowerment of individuals and communities. There are wide-ranging benefits of FMNR including social, economic and environmental. FMNR can be a powerful tool for both climate change mitigation and adaptation. FMNR assists communities to adapt to climate change particularly through reducing impact of extreme weather events and by providing alternate livelihoods options. FMNR also has enormous potential for contributions to climate change mitigation both through application in various agroforestry approaches and through forest restoration.

Increasing global awareness on the link between forests and climate change provide bright prospects for further spread of FMNR. Organizations such as World Vision, The Global Evergreening Alliance and the World Agroforestry Centre actively promote, implement, and research FMNR, contributing to major international land and climate initiatives such as the Bonn Challenge. Additionally, apparently driven by need, FMNR is occurring spontaneously in diverse rural communities without contact with external organizations. The major constraints to adoption of FMNR include mindsets, policies, inequality, and poverty. These constraints are not insurmountable but must be taken into account when planning introduction of FMNR.

Remarks

This chapter has provided quantitative and qualitative data demonstrating the efficacy of FMNR as an approach to reversing land degradation and as a tool for climate change mitigation and adaptation. Examples have been provided where adoption has occurred at low cost, quickly, and at scale. There is an urgent need to address issues of land degradation and climate change yet, FMNR's potential as a component of actions employed to reduce atmospheric greenhouse gas concentrations and to restore millions of hectares of degraded farm, pasture and forestlands is relatively unappreciated and untapped. Given the evidence, the authors call for greater awareness and application of FMNR on the part of international donors, governments, policy makers, NGOs, and land managers.

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