



The social, environmental and economic benefits of Farmer Managed Natural Regeneration (FMNR)



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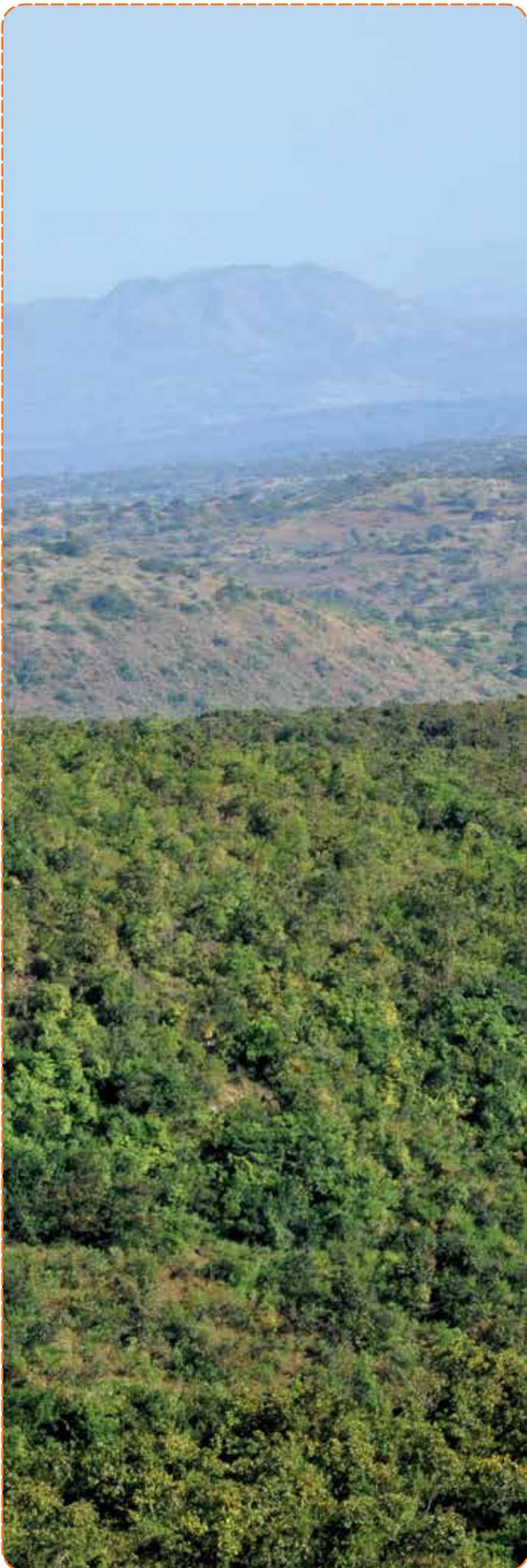
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Executive summary

This study reviews the key literature related to Farmer Managed Natural Regeneration (FMNR) in order to establish its benefits and limitations as well as identify any gaps in evidence. The study then outlines potential challenges in meeting the identified gaps and recommends next steps to guide further evaluation and measurement.

This study aims to inform World Vision's FMNR Project Model and be a valuable resource for those involved in the promotion and scale-up of FMNR globally.

Literature on FMNR, produced up to the end of 2014, was collated and reviewed for this study, including nine project evaluations, 39 published research papers, 52 published expert reviews and opinions, 28 field reports, plus personal correspondence with FMNR experts and farmers, and recorded anecdotes from the field.

Throughout the developing world, huge tracts of farmland, grazing lands and forests have become degraded to the point they are barely productive. This has an extremely detrimental effect on subsistence farming households and their communities who make up a large proportion of rural populations and who suffer regularly from hunger and malnutrition.

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. It also restores biodiversity and increases resilience to severe weather events.

Since its inception in Niger in 1983, FMNR has spread across five million hectares or 50 percent of that country's farmlands, which is the largest positive environmental transformation in Africa in the last 100 years. Since then, FMNR has been introduced in 18 countriesⁱ across Sub-Saharan Africa, Southeast Asia, Timor-Leste, and most recently India and Haiti.

Evidence across the Sahel region of Africa, where FMNR is most prevalent, shows that communities can transform their lives through the social and environmental benefits of FMNR, leading to economic sustainability. As such, FMNR is an integrated development approach, leading to sustainable development outcomes.

Front cover: Nancy Kemboi, local leader and FMNR advocate, Kenya.
Source: World Vision

ⁱ Countries where FMNR is practised: Senegal, Mauritania, Mali, Burkina Faso, Ghana, Niger, Chad, Uganda, Rwanda, Tanzania, Malawi, Ethiopia, Kenya, India, Myanmar, Indonesia, Timor-Leste, Haiti.

The 24 broad social, environmental and economic benefits of FMNR identified by this study are as follows:

Social benefits

1. Fosters realisation, acceptance and the resolve to change
2. Creates an enabling environment
3. Builds collaboration, networks and partnerships
4. Fosters tree ownership and land tenure security for farmers
5. Increases education and training
6. Increases empowerment for women
7. Creates community advocates
8. Increases food security, health and resilience
9. Improves the environmental comfort of rural communities
10. Gives rise to hope and optimism which improves adaptive capacity
11. Reduces conflict

Environmental benefits

12. Widespread adoption of FMNR restores tree cover
13. Increases biodiversity
14. Reduces erosion
15. Enriches soils
16. Increases water availability
17. Reduces wind speed and temperatures
18. Increases climate change adaptation and mitigation

Economic benefits

19. Increases incomes through improved crop yields
20. Increases incomes through sale of tree products, including building timber, firewood, food, medicines, tool handles, furniture, etc
21. Increases incomes through improved livestock production
22. Reduces expenditures and increases consumables
23. Increases household assets
24. Offers new income opportunities via carbon credit revenues

Limitations

One short-term limitation was identified – the difficulty in collecting firewood during the lag time required for tree regeneration (1-2 years).

Gaps in evidence

While the benefits and limitations of FMNR have been clearly identified from the literature, they are not currently proven by impact evaluation studies. As such, FMNR currently lacks an evidence base informed by counterfactual research trials in the field. This level of evidence is required for acceptance of the benefits of FMNR by development research communities.

FMNR also currently lacks data on standard measurements over time relevant to its principal beneficial outcomes that can be measured in any location, for example, annual crop yields per hectare, ground temperature, water table depth and soil fertility. This type of clear and concise evidence is particularly important to provide to potential funding bodies for further scale-up of FMNR.

Potential challenges

Potential challenges exist to building an evidence base and collecting data on standard measurements in response to the identified gaps in evidence.

FMNR is outside the mainstream of agroforestry, agriculture and development practices in that it restores the environment mostly with naturally occurring vegetation, is holistic as it relies on integrated social, environmental and economic factors, and is also simple and inexpensive. This means that it may be more challenging for FMNR to be generally assessed and accepted by the appropriate research communities.

In addition, there is no guiding body or coordinated research strategy for building an evidence base for FMNR. Hundreds of methodologies for impact evaluation are available. Some development practitioners prefer method selection according to individual project needs and others advocate selection of a common methodology to be applied across all FMNR projects.

Recommendation

The key recommendation from this study is the development of a coordinated research strategy that determines the next steps in building an evidence base for FMNR, including an approach for impact evaluation and identifying standard measurements to record over time.

Conclusion

This study reviews the current literature for the benefits and limitations of FMNR from social, economic and environmental perspectives and identifies 24 key benefits that can change the livelihoods of the rural poor. An evidence-based agenda is now required to prove these benefits for the further development of FMNR globally.



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Introduction

Farmer Managed Natural Regeneration (FMNR) is a method of restoring degraded environments to health and productivity. The method is simple to execute, yet maintains an optimal balance between farmers' objectives and capabilities, and the land's capacity and resources, which enables local ecosystems to flourish over time. Farmers began practising FMNR in Niger some 30 years ago and the method has since spread around the world by word of mouth and through development projects. FMNR is now growing into a global movement.

This study reviews the key literature related to FMNR in order to establish its benefits and limitations as well as identify any gaps in evidence. The study then outlines potential challenges in meeting the identified gaps and recommends the next step to guide further evidence building.

This study aims to inform the FMNR Project Model and to be a valuable resource for those involved in the promotion and scale-up of FMNR globally.

Literature on or related to FMNR, produced up to the end of 2014, was collated and reviewed for this study, including nine project evaluations, 39 published research papers, 52 published expert reviews and opinions, 28 field reports, plus personal correspondence with FMNR experts and farmers, as well as recorded anecdotes from the field.

Background

Throughout the developing world, immense tracts of farmland, grazing lands and forests have become degraded to the point they are barely productive. Deforestation continues at an alarming rate. In Africa's drier regions, 74 percent of rangelands and 61 percent of rain-fed croplands are damaged by moderate to very severe desertification. In some African countries deforestation rates exceed planting rates by 300:1.¹

Degraded land has an extremely detrimental effect on the lives of subsistence farmers who depend on it for their food and livelihoods. Subsistence farmers often make up to 70-80 percent of the population in African countries and they regularly suffer from hunger, malnutrition and even famine as a consequence.^{2 3 4}

In the Sahel region of Africa, a band of savannah which runs across the continent immediately south of the Sahara Desert, removal of forest cover from large tracts of once productive farmland has resulted in the land turning to desert.⁵

Severe famines across the Sahel in the 1970s and 80s led to a global response, and stopping desertification became a top priority. Conventional forestry methods of raising exotic and indigenous tree seedlings in nurseries were used – transporting, planting out, watering, protecting and weeding. However, despite investing millions of dollars and thousands of hours of labour, there was little overall impact.⁶ Conventional approaches to reforestation in such harsh environments faced insurmountable problems. Once planted out, annual dry season heat, sand storms, pests, competition from weeds and

destruction by people and animals negated efforts. Low levels of community ownership were another inhibiting factor.⁷

Existing indigenous vegetation was generally dismissed as “useless bush”, and was often cleared to make way for exotic species. Exotics were planted in fields containing living and sprouting stumps of indigenous vegetation, the presence of which was barely acknowledged, let alone seen as important.⁸

This was an enormous oversight. In fact, these living tree stumps are so numerous they constitute a vast “underground forest” ready to grow and provide multiple benefits at little or no cost. Each stump can produce between 10 and 30 stems each. During the process of traditional land preparation, farmers saw the stems as weeds and slashed and burnt them before sowing their food crops. The net result was a barren landscape for much of the year with few mature trees remaining. To the casual observer, the land was turning to desert. Most concluded that there were no trees present and that the only way to reverse the problem was through tree planting.⁹

Meanwhile, established indigenous trees continued to disappear at an alarming rate. In Niger, from the 1930s until 1993, forestry laws took tree ownership and responsibility for the care of trees out of the hands of the people; and even though ineffective and uneconomic, reforestation through conventional tree planting seemed to be the only way to address desertification at the time.^{10 11 12}

What is FMNR?

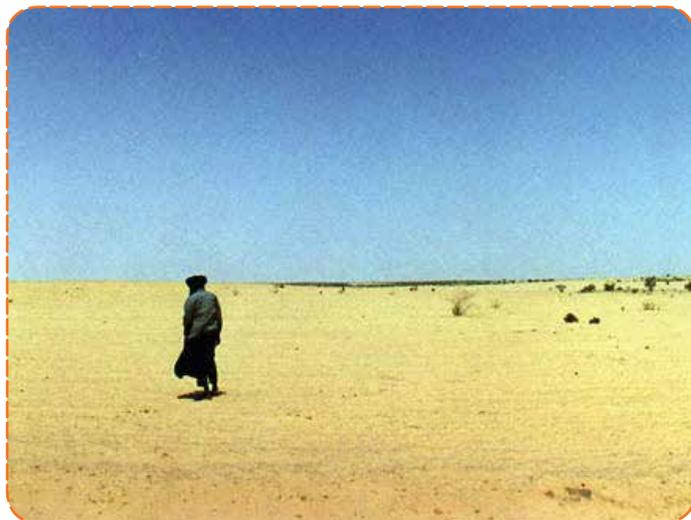
FMNR is a low-cost, sustainable land restoration technique used amongst poor subsistence farmers to combat poverty and hunger in developing countries by increasing food and timber production, and resilience to climate extremes (see Figures 1 and 2). It involves the systematic regeneration and management of trees and shrubs from tree stumps, roots and seeds.¹³

FMNR is especially applicable, but not restricted to, the dryland tropics. As well as returning degraded croplands and grazing lands to productivity, it can be used to restore degraded forests, thereby reversing biodiversity loss, and restoring environmental services and natural resources which in turn reduce vulnerability to climate change. FMNR can also play an important role in maintaining still healthy landscapes in a productive state, especially when combined with other sustainable land management practices such as conservation agricultureⁱⁱ on cropland and holistic management on rangelands.¹⁴

FMNR adapts centuries-old methods of woodland management techniques, called coppicing and pollarding, to produce continuous tree growth for fuel, building materials, food and fodder without the need for frequent and costly replanting. On farmland, selected trees are trimmed and pruned to maximise growth while promoting optimal growing conditions for annual crops (such as access to water and sunlight).¹⁵ When FMNR trees are integrated into crops and grazing pastures, crop yields, soil fertility and organic matter, soil moisture and leaf fodder tend to increase, while there is a corresponding decrease in wind and heat damage, and soil erosion.¹⁶

In the Sahel region of Africa, FMNR has become a potent tool in increasing food security, resilience and climate change adaptation in subsistence farming communities where much of Sub-Saharan Africa's poverty exists. FMNR is also being promoted in southern African countries, Timor-Leste, Indonesia and Myanmar.

FMNR complements the evergreen agricultureⁱⁱⁱ, conservation agriculture and agroforestry movements. It is considered a good entry point for resource-poor and risk-averse farmers to adopt a low-cost and low-risk technique. This in turn has acted as a stepping stone to greater agricultural intensification as farmers become more receptive to new ideas.^{17 18}



Figures 1 and 2: The Maradi region of southern Niger before (above) and about two years after (below) the implementation of FMNR. Source: Tony Rinaudo, Principal Advisor Natural Resources, World Vision Australia

ii Conservation Agriculture (CA) is an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment. CA is characterised by three linked principles, namely: continuous minimum mechanical soil disturbance, permanent organic soil cover, and diversification of crop species grown in sequences and/or associations. See <http://www.fao.org/ag/ca/1a.html>

iii Evergreen Agriculture is the incorporation of trees into crop land and pastures. The three types of evergreen agriculture are: FMNR, the planting of trees in conventional crop fields, and conservation agriculture with trees. Evergreen agriculture is one of several types of agroforestry.

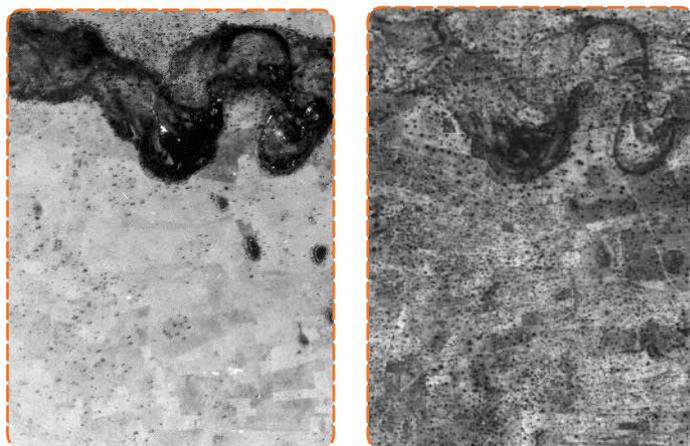
FMNR's origins and spread

In the early 1980s, in the Maradi region of the Republic of Niger, the missionary organisation, Serving in Mission (SIM), was unsuccessfully attempting to reforest the surrounding districts using conventional means. In 1983, SIM agricultural missionary, Tony Rinaudo, partnered with 10 farmers to experiment with what we now know as FMNR. During the severe famine of 1984, SIM made use of a food-for-work program to “pay” 70,000 people to introduce FMNR into their farms. Consequently, the practice was applied to 12,500 hectares of farmland. From 1985-99, FMNR continued to be promoted locally and nationally. Exchange visits and training days were organised for non-government organisations (NGOs), government foresters, Peace Corps Volunteers and farmer and civil society groups. Additionally, SIM project staff and farmers visited numerous locations across Niger to provide training.¹⁹

By 2004 it was ascertained that FMNR was being practised on over five million hectares or 50 percent of Niger's farmlands – an average reforestation rate of 250,000 hectares per year over a 20 year period (see Figures 3 and 4). This transformation prompted Senior Fellow of the World Resources Institute, Chris Reij, to comment that “*this is probably the largest positive environmental transformation in the Sahel and perhaps all of Africa*”.^{20 21}

It should be noted that FMNR in one form or another is not new. In fact examples that are centuries old can be found in various parts of the world including Europe, Japan and Africa. There is anecdotal evidence from Niger and neighbouring countries that spontaneous “rediscovery” and organic spread of FMNR occurred within the same period as the SIM experience.²²

Also in 2004, World Vision Australia and World Vision Ethiopia initiated a forestry-based carbon sequestration project as a potential means of stimulating community development while engaging in environmental restoration. An innovative partnership with the World Bank, the Humbo Community-based Natural Regeneration Project involved the regeneration of 2,728 hectares of degraded native forests. This brought social, economic and ecological benefits to the participating communities. Within two years, communities were collecting wild fruits, firewood and fodder. They reported that wildlife had begun to return and erosion and flooding had been reduced. In addition, the communities are now receiving payments for the sale of carbon credits through the Clean Development Mechanism (CDM) of the Kyoto Protocol.^{23 24}



Figures 3 and 4: Satellite photos taken in 1975 (left) and 2005 (right) show greatly increased tree cover in southern Niger. Trees show as black dots. Source: US Geological Survey

Following the success of the Humbo project, FMNR spread to the Tigray region of northern Ethiopia where 20,000 hectares have been set aside for regeneration, including 10-hectare FMNR model sites for research and demonstration in each of 34 sub-districts.²⁵ In addition, the Government of Ethiopia has committed to reforest 15 million hectares of degraded land using FMNR as part of a climate change and renewable energy plan to become carbon neutral by 2025.²⁶

In Talensi, northern Ghana, FMNR has commenced on over 500 hectares and new projects, initiated by World Vision, are introducing FMNR into three new districts.²⁷ In the Kaffrine and Diourbel regions of Senegal, FMNR has spread across 62,000 hectares in five years.^{28 29} World Vision is also promoting FMNR in southern African countries.³⁰ Other examples exist of both independently promoted and spontaneous FMNR movements occurring. In Burkina Faso, for example, an increasing part of the country is being transformed into agroforestry parkland. And in Mali, ageing agroforestry parkland of about six million hectares is showing signs of regeneration.^{31 32}

Key principles

Live stumps

FMNR depends on the existence of living tree stumps or roots in crop fields, grazing pastures, woodlands or forests. Throughout the year, bushy growth will sprout from the stumps/roots often appearing like small shrubs. Continuous grazing by livestock, regular burning and/or regular harvesting for fuelwood results in these “shrubs” never attaining tree stature. On farmland, standard practice has been for farmers to slash this regrowth in preparation for planting crops. But with a little attention, this growth can be turned into a valuable resource without jeopardising, but in fact, enhancing crop yields.^{33 34}

Selecting regrowth stems

For each stump, a decision is made as to how many stems will be chosen to grow. The tallest and straightest stems are selected and the remaining stems culled. Best results are obtained when the farmer returns regularly to prune any unwanted new stems and side branches as they appear. Farmers can then grow other crops between and around the trees. When farmers want wood they can cut the stem(s) they want and leave the rest to continue growing. The remaining stems will increase in size and value each year, and will continue to protect the environment. Each time a stem is harvested, a younger stem is selected to replace it.³⁵

Selecting tree species to nurture

Land users may select species because they provide food, soil fertility, timber or any number of other services. Various indigenous tree species provide berries, fruits and nuts or have medicinal qualities. In Niger, for example, commonly-used species include *Strychnos spinosa*, *Balanites aegyptiaca*, *Boscia senegalensis*, *Ziziphus spp*, *Annona senegalensis*, *Poupartia birrea* and *Faidherbia albida*. However, the most important determinants are whatever species are locally available, their ability to re-sprout after cutting, and the value local people place on those species.³⁶

Faidherbia albida, also known as the “fertiliser tree”, is popular for intercropping across the Sahel and in East and Southern Africa. Like all leguminous trees, it fixes nitrogen into the soil. It also provides fodder for livestock, and shade for soil and livestock in the hottest seasons. As an added advantage, it sheds its leaves in the wet season providing plenty of sunlight to crops under the tree. Leaf fall contributes useful nutrients and organic matter to the soil.³⁷

Adapting FMNR to site and purpose

The practice of FMNR is not confined to croplands. It is being practised on grazing land and in communal forests as well. When there are no living stumps, growth from spontaneously sprouting trees seeds may be protected. In reality, there is no fixed way of practising FMNR and farmers are free to choose which species they retain, the density of trees they prefer, and the timing and method of pruning.³⁸

FMNR relies upon a cross-section of sustainable development outcomes to make it successful. To place this in context, it is important to understand that subsistence farmers in developing countries do not normally have affordable access to fertiliser, pest control, irrigation and technical resources that are the norm in developed countries. Periods of drought, other severe weather events and pestilence cause heavy crop and livestock losses, decreasing the food supply and farm income for subsistence farmers. Therefore, low-input sustainable agriculture solutions like FMNR help farmers increase and diversify production and increase their resilience to these forces outside their control.^{39 40 41}

FMNR in practice⁴²

FMNR depends on the existence of living tree stumps, tree roots and seeds to be re-vegetated. These can be in crop fields, grazing lands or degraded forests. New stems, which sprout from these stumps and tree roots, can be selected and pruned for improved growth.

Sprouting tree stumps and roots may look like shrubs and are often ignored or even slashed by farmers or foresters. However, with culling of excess stems and by selecting and pruning the best stems, the re-growth has enormous potential to rapidly grow into trees.



Figure 5: A sprouting tree stump in Niger. Source: Tony Rinaudo, Principal Advisor Natural Resources, World Vision Australia

Seemingly treeless fields may contain seeds and living tree stumps and roots that have the ability to sprout new stems and regenerate trees. Even this “bare” millet field (Figure 6) in West Africa contains hundreds of living stumps per hectare which are buried beneath the surface like an underground forest.



Figure 6: The Maradi region of southern Niger. Source: Tony Rinaudo, Principal Advisor Natural Resources, World Vision Australia

Step 1

Do not automatically slash all tree growth, but survey your farm noting how many and what species of trees are present.



Figure 7: Farmers in Maradi region survey their field. Source: Tony Rinaudo, Principal Advisor Natural Resources, World Vision Australia

Step 2

Select the stumps that will be used for regeneration.



Figure 8: Unpruned stems growing from tree trunk. Source: Tony Rinaudo, Principal Advisor Natural Resources, World Vision Australia

Step 3

Select the best five or so stems and cull unwanted ones. This way, when you want wood you can cut the stem(s) that are needed and leave the rest to continue growing. These remaining stems will increase in size and value each year, and will continue to protect the environment and provide other useful materials and services such as fodder, humus, habitat for useful pest predators, and protection from the wind and sun. Each time one stem is harvested, a younger stem is selected to replace it.



Figure 9: Pruning and thinning stems. This is quick, low cost, simple and uses locally available tools. Humbo, Ethiopia. Source: Tony Rinaudo, Principal Advisor Natural Resources, World Vision Australia

Step 4

Tag selected stems with a coloured rag or paint. Work with the whole community to draw up and agree on laws that will protect the trees being pruned and respect each person's rights. Where possible, include government forestry staff and local authorities in planning and decision making.



Figure 10: Using ribbons to signal protection of FMNR trees. Humbo, Ethiopia. Source: Tony Rinaudo, Principal Advisor Natural Resources, World Vision Australia

Effective FMNR project management

In terms of introducing the method into a region through funded development projects, experience has shown that FMNR is more readily incorporated into land-user practices when a project:

- has a full-time project manager in each individual location who is experienced and credible in the eyes of land users, and an expert in sustainable agriculture;
- ensures the project manager has enough time and motivation to provide routine follow-up training and encouragement to each of the partners and community groups (not simply relying on isolated training events);
- involves the most influential and authoritative figures in the community as key planning partners and advocates (notably, community chiefs, district governments and regulators);
- promotes landscape management techniques that are easily shared from one household to the next because they are relatively free of external inputs, conceptually easy to understand and copy, and that yield visible results in the short term;
- focuses beyond individual farmer behaviour to encourage and mediate whole-of-community agreements and regulation (in relation to tree cutting, field burning and fighting bushfires);

- creates mechanisms by which volunteer lead farmers/trainers benefit from their role, to create ongoing incentive to stay with the role. It may include income generation support during the project lifetime, or having priority access to the surplus natural resources that come from communal forest sites they manage, or formal recruitment as paid community extension workers; and
- integrates the project goals and approaches with the wider strategy and field operations of the district representatives of government ministries (agriculture, environment, forestry, etc).^{43 44 45}

While appropriate and replicable technical solutions are critical to attaining successful land and tree cover rehabilitation, they will not bring lasting results by themselves. Assistance schemes for farm forestry must understand and adapt to the complexities of smallholder decision making, or explicitly recognise interconnections between production, markets and policies.⁴⁶

It is also advantageous to regenerate trees in combination with other soil restoration and nutrient trapping/concentrating techniques such as planting pits and fertiliser micro-dosing. This can increase biomass production and diversity by creating conducive micro-environments for trapping and spontaneous growth of tree seeds.⁴⁷



Figure 11: FMNR demonstration and training, Tigray, Ethiopia. Source: Tony Rinaudo, Principal Advisor Natural Resources, World Vision Australia

Study of benefits and limitations

Literature on FMNR, produced up to the end of 2014, was collated and reviewed for this study, including nine project evaluations, 39 published research papers, 52 published expert reviews and opinions, 28 field reports, plus personal correspondence with FMNR experts and farmers, as well as recorded anecdotes from the field.

As a key proponent and financier of FMNR globally, World Vision undertakes regular project monitoring and rigorous end-of-project evaluations, carried out by project managers and evaluation specialists. These reports utilise household surveys, focus groups and key informant interviews, as well as other research where available, to establish the progress, outcomes and sustainability of projects.^{48 49}

World Vision evaluations analyse a wide spectrum of impacts that affect the current and future livelihoods of farming households and communities. These include environmental restoration, increased agricultural production and economic impacts. Emphasis is placed on social and communication impacts such as participation, community ownership, partnerships, networks (community connectivity), capacity building, gender, nutrition, school attendance and children's involvement in sustainable farming. Evaluations also seek to uncover unexpected outcomes, issues, threats and constraints.^{50 51}

The study answers the following questions:

1. What does the literature identify as the key benefits and limitations of FMNR with regard to social, economic and environmental outcomes in target communities/regions?
2. How should/can FMNR stakeholders position themselves to lead knowledge generation in these areas?

The following section on benefits uses a sustainable development structure (social, environmental and economic outcomes) to document the findings.

Social benefits of FMNR

World Vision evaluations and monitoring reports point to FMNR as being the catalyst for transformed communities that are better educated, networked and empowered to change their environments and hence their livelihoods for the better. These findings are supported by a broad body of evidence that such networks, partnerships and community interaction enhance the "efficiency and sustainability of development programs"⁵² through reducing destructive opportunism, facilitating knowledge-sharing on technology and markets, and promoting collective action.⁵³ Indeed, what FMNR projects tend to do is what McKnight and Kretzmann (2005) refer to as transferring focus from community needs and deficiencies to community assets through fostering its capacity to change.⁵⁴ FMNR does not offer handouts, although it does offer valuable external assistance for communities to actively develop their social assets. Collier (1998) considers that this kind of social interaction has an economic worth and is productive "capital" – "social capital".⁵⁵

Weston and Hong's (2013) case study in northern Ghana valued this social worth using the social accounting method called Social Return on Investment (SROI), which expresses important project outcomes as equivalent monetary values so that they can be compared with the cost of inputs (both cash and in-kind).⁵⁶ SROI is "specifically tailored to the analysis of social purpose activities"⁵⁷ and interprets value according to the primary stakeholders' experience and valuation of

the outcome.⁵⁸ An SROI ratio of 1:1 means that for every dollar invested in a project, one dollar of benefit has been created for the project's stakeholders. A ratio of 2:1 means that two dollars of value was created in the life of the partner community for every dollar invested. Beyond the ratio, SROI analysis constructs a story of qualitative and quantitative change expressed by a project's primary stakeholders, regardless of the project's original objectives and targets.^{59 60} In the Talensi FMNR Project in Ghana, the overall SROI ratio of the project was forecast to be 13:1, once direct project costs and volunteer time in the community were factored as inputs. The SROI study found that the most important project outcomes to the community were:

1. Increased household and communal assets in the form of trees and healthier livestock;
2. Increased household consumables sourced from natural resources;
3. Increased soil fertility and incomes from agriculture;
4. Improved health;
5. Psycho-social benefits; and
6. Atmospheric benefits (carbon sequestration).⁶¹

Across the broader literature, this study identified the following 11 social benefits of FMNR:

I. Fosters realisation, acceptance and the resolve to change

“The real battle for attaining food security is not primarily in the physical realm (technically, food security is possible with existing knowledge), but at the level of beliefs and attitudes to change.” – Tony Rinaudo and Salifou Yaou⁶²

A key benefit of FMNR occurs at the initial stage of the intervention during introductory sessions on FMNR between programming staff and community members. These foster a realisation and sense of acceptance by the community that their current situation of poverty and its by-products – lack of education, poor health, and lack of capacity and empowerment – are caused in large part by a badly degraded environment, and recognition that the current situation can change for the better.

This echoes McKnight's and Kretzmann's (2005) observation of an attitude change by all stakeholders from one of dependency to one of having the ability to change, or from problem to asset. It is a considerable first step, but Rinaudo (2012) argues that it can be achieved by firstly inviting all stakeholders to an awareness workshop where they:

- consider the environmental issues and agree they have problems;
- want to lead a change; and
- get a hands-on understanding of the basics of FMNR.

Stakeholders include the men, women and youth of the community, majority and minority ethnic groups, sedentary and nomadic land users, community leaders and influencers, local government representatives, agriculture and forestry department representatives, local partners, and other non-governmental organisations, etc. Women and children are particularly crucial because in most societies, women are responsible for fuelwood collection and children are often required to clear and burn the trees in agricultural fields before planting time. Children are also receptive to new ideas and they are the next generation of farmers.⁶³

Tony Rinaudo, a pioneer and champion of FMNR, argues that, first and foremost, a community needs to come to the realisation that:

- the environment has become degraded;
- it cannot support the community as it used to;
- business as usual will mean that the situation will continue to worsen; and
- the community has the power to change its circumstances.⁶⁴

Although this recognition and acceptance varies by community, cultural and environmental needs, evidence from several FMNR projects across West Africa supports Rinaudo's position.

- In the Niger Republic, where FMNR has spread across five million hectares in harsh and impoverished conditions.⁶⁵
- In Niger and Senegal, where FMNR is currently spreading rapidly, the timely realisation of the link between poverty and the environment, building on community assets that already exist, and changing traditional perceptions so that trees are recognised as important to farm productivity and income, are consistently key determinants to the success of FMNR.^{66 67}

2. Creates an enabling environment

Right from the initial intervention, a successful FMNR project generates interest, informed discussion and debate across and between different strata of a society in regard to confronting land management aspirations, barriers and potential solutions. This enables discoveries to be shared and innovation to occur.

FMNR adoption flourishes when an “enabling environment” exists or is introduced and nurtured by a project. Success in this regard typically requires many stimuli for achieving community-wide interest and engagement. Enablers for FMNR can be similar to those of other community-led initiatives. In World Vision's “Beysatol” (Work your Land) FMNR project in Senegal, these activities included:

- strategic partnerships with authorities and community leaders;
- the negotiation of ownership rights over the trees on their farms;
- FMNR education in schools;
- radio programs;
- engagement with religious leaders to become advocates; and
- FMNR coaches or champions in each community to encourage and train farmers.⁶⁸

The emergence of an enabling environment for landscape re-greening that occurs from the implementation or spread of FMNR practice is supported by several studies. Examining the spread of FMNR in Niger, Tougiani et al (2009) came to the conclusion that:

“the unique flora of the region and the capacity of the people to change, given an enabling environment, were the keys to reversing desertification and attaining sustainable rural livelihoods through diversified production systems.”⁶⁹

Brown et al (2010) conclude that two main reasons enabled FMNR to spread so widely in Niger: attitudinal change by the community about what constitutes good land management practices, and granting farmers' ownership of trees.⁷⁰

Also in Niger, adapting Scoones' (1998) five capitals for sustainable rural livelihoods – human, physical, social, financial and natural – Haglund et al (2009) observed that FMNR households transformed human, physical and social capital through *“available structures and processes into livelihood strategies in order to achieve positive livelihood outcomes”*, thus creating an enabling environment to achieve beneficial outcomes. Human capital includes attributes such as skills, knowledge, good health and an ability to work. Physical capital includes infrastructure such as shelter, transportation and communications; and social capital includes networks, associations and access to social institutions.⁷¹ This is similar to McKnight's and Kretzmann's identification of community “assets” rather than “problems” outlined above.

Examples that support the capacity of introducing FMNR into communities to create an enabling environment are as follows:

- In northern Ghana, Weston and Hong (2012) found that facilitating stakeholders through learning, planning and deciding on the beneficial outcomes they wanted to measure created an enabling environment for positive change and accelerated FMNR adoption.⁷²
- From the outset, FMNR projects incorporate the selection of charismatic leadership (or champions) at project, community, country and regional levels. In Niger and Burkina Faso, Reij et al (2009) found that these project champions help create an enabling environment for change and are a key success factor in the development of FMNR.⁷³
- In Senegal, Kabore et al (2011) found that FMNR promotion fostered positive change in land management awareness, capacity, practice and resilience.⁷⁴
- World Resources Institute (2008) observes that in Niger, solidarity arises around FMNR that helps create a social movement: bringing together government, donor agencies and other external support with communities that in turn fosters experimentation and learnings in land regeneration.⁷⁵

3. Builds collaboration, networks and partnerships

“Individual farmers adopting innovations on single fields or farms can achieve impacts. But when communities work together collectively, they will produce more sustainable benefits.” – Chris Reij, Gray Tappan and Melinda Smale⁷⁶

FMNR programs build high levels of social capital in the forms of durable intra and inter-community cooperation and collective decision making to achieve an organised community-led approach to environmental regeneration, improved agricultural production and a more functional community. Examples of this include the development of networks such as farmer-to-farmer knowledge sharing, training workshops, school curricula, local radio and talkback programs, pilot farms and farmer champions, and local educators such as government extension workers, teachers and cultural and religious leaders.

A growing body of evidence suggests that the proliferation and density of social networks, and the interactions of individuals within them, *“significantly affect the efficiency and sustainability of development programs”*.⁷⁷ Successful innovation and development in sustainable agriculture programs rely on whole-of-community mobilisation, especially through farmers' groups, women's groups and in children's education. In Mali, Niger and Burkina Faso, impacts have been greater when programs have incorporated social components and/or were combined with complementary interventions.^{78 79}

- In Burkina Faso and Niger, the spread of innovation in sustainable agriculture systems, including FMNR, was attributable to long-term collaboration between individual farmers, farmers' groups, community groups, NGOs, bilateral and multilateral donors, and national governments.⁸⁰
- In Senegal, community networks and partnerships are an important facilitator and impact of FMNR underpinning the outcomes of the project. FMNR adoption accelerated rapidly once a partnership between the community, the Water and Forests Department and World Vision enabled the

community to take a formal role in the protection and benefits of FMNR trees and work with the department to establish new regulations.⁸¹ The project in Senegal also encouraged partnerships between children, parents, teachers and local forestry agents. While such networks and partnerships have been supported by the project, they are now becoming community-led and acting as change agents both within the community and more broadly.⁸²

- In Ghana, farmer focus groups described how the need to work together to develop FMNR sites, develop community covenants on land and tree management and to suppress fires in the landscape has resulted in an unprecedented level of collaboration between neighbours in the project area.⁸³

- Similarly, a mid-term evaluation of the Humbo Community-based Natural Regeneration FMNR project in Ethiopia concluded that, *“Formation of the forest management groups as cooperatives, with broad membership, legal recognition and written by-laws, has contributed to the capacity of the community to organise around a common vision - to bring the forest into a collective form of management.”*⁸⁴
- FMNR has demonstrated a reduction in regional conflict through collaboration built by different groups coming together to make and implement rules regarding their natural resources.⁸⁵

4. Fosters tree ownership and land tenure security for farmers

“Without this consensus and support for the protection of private property, it is unlikely that FMNR could have spread as fast as it did.”
– Tony Rinaudo, Principal Advisor Natural Resources, World Vision Australia⁸⁶

FMNR programs impart a sense of ownership and empowerment for farmers to gain control over land tenure and what they grow on their land.

In many African countries, the management of trees is controlled by government departments. As Gates (2012) found in Senegal, *“often well-intentioned conservation laws and a lack of property norms that allow anyone to cut wood and herd animals nearly everywhere”* have acted as a disincentive for farmers wanting to grow trees for economic return.⁸⁷ In other countries, for example Niger, FMNR farmers would manage the development of trees on their land for timber or firewood, only to be fined when they harvested them.⁸⁸ Additionally, government agents who enforced forestry regulations were *“rarely skilled or interested in capacity building or education, and they did not encourage farmer participation”*. Such regulatory systems discourage farmers’ sustainable use of trees.⁸⁹ In fact, a study of farmers across the Sahel found 44 percent of farmers considered unreasonable forest regulations as a limiting factor; and another 38 percent mentioned *“heavy-handedness on the part of forestry officers”*.⁹⁰

Successful implementation of FMNR requires farmers to have control over their land and what they grow on it. As such, FMNR projects incorporate assistance to broker agreements between the relevant stakeholders – for example, government agents, farming communities and other forms of local leadership – to ensure four key rights:

- legal and cultural recognition of trees as possessions of the land user;
- the land user’s right to exploit the trees;
- consequences for cutting down someone else’s trees; and

- land tenure arrangements where the land is owned by the government or customary owners (eg, the village chief).⁹¹

Evidence of the introduction of FMNR benefiting tree ownership and land tenure includes the following:

- In Senegal, successful FMNR projects incorporated the *“development of by-laws to govern FMNR within communities”*.⁹²
- Also in Senegal, Weston (2011) observed that, although it took two years, agreements were reached as part of the FMNR program there between farmers, village chiefs and the Water and Forestry Service on tree ownership, as well as working together to document farmers’ fields to secure tenure. The Water and Forestry Service became a partner in the FMNR project, which transformed farmers’ perception of its agents from “tree police” to “agricultural extensionists”.⁹³
- A study of the deforestation of Niger through the 20th century, followed by the unprecedented rate of reforestation since the 1980s, correlate reforestation expansion to NGOs promoting FMNR, more local land management autonomy, and a decline in centralised government interference.⁹⁴
- According to Brown et al (2010), referencing Tougiani et al (2008), *“institutional change in tree tenure, from state ownership to local ownership by those with individual land holdings”*, was an integral part of the spread of FMNR in Niger.⁹⁵

5. Increases education and training

The adoption of FMNR by a community incorporates increased education and training with farmers, families and children in schools. Evidence shows that school attendance increases in FMNR communities.

Many cultural norms exist in rural communities that create barriers to FMNR adoption. Innovation and individuality may be ridiculed. Differing land users' interests may inform divergent perceptions of the value of trees – for example, between farmers and herders. Many FMNR projects have initially encountered a collective mindset that sees trees on farmland as “nuisance weeds” and/or “crop competitors”. Farmers who haven't experienced FMNR often fear that productivity will be affected, believing that trees will compete with crops for soil moisture and nutrients, or shade out too much sunlight. In fact, FMNR evidence shows they tend to be moisture neutral, reduce evaporation and provide additional nutrients to crops and pastures. Good projects engage local knowledge and innovation (“barefoot science”) as much as cutting-edge research. Cunningham and Abasse (2005) suggest that the single most important factor contributing to FMNR's success is the change in farmers' perceptions from trees as “weeds” to “beneficial agents” of sustainable farming.^{96 97}

The promotion that is an integral part of FMNR projects contributes to these changed perceptions by various educational activities paired with ongoing follow-up such as training of farmers, training of trainers, the use of FMNR “coaches” or “animateurs” who work with farmers to encourage and deal with issues, training visits to other FMNR projects (local, regional and international), and the introduction of environmental and FMNR education into schools' curricula. Children tend to be receptive to new ideas and are the next generation of farmers.^{98 99 100} Education about the environment and the benefits of FMNR instills children with increased hope and security about their future.

- In northern Ghana, at least 60 percent of FMNR members had developed the attitude of pruning important tree shrubs irrespective of whether they are found in their homes, farms or other locations,¹⁰¹ which is a significant change in previous behaviour such as slashing or burning.
- In Senegal, FMNR adopting communities experienced:
 - a radical shift in attitude amongst communities from exploitation of their natural resources to one of collective management;
 - that FMNR farmers could articulate the approach to protecting tree resources and how the community participated in the design of local bylaws;
 - that teaching children the benefits of FMNR influences parents and educates the next generation to continue the program. This demonstrates the two-way, win-win approach of FMNR projects where mobilising one part of the community benefits the current impact and future of the program and establishes a platform for other community development;
 - an improvement in stakeholder knowledge about land restoration issues and opportunities;
 - an improvement in the capacity of communities, partners and stakeholders to respond to land restoration issues and opportunities; and
 - an improvement in social, environmental, physical and economic conditions, reduced vulnerability or increased resilience.¹⁰²

6. Increases empowerment for women

“The main beneficiaries of this [FMNR] approach are those who use or depend on tree resources such as farmers, herders, community members, and particularly women and children who harvest wood and non-timber forest products.” – FMNR Project Model, World Vision International¹⁰³

FMNR improves women's lives through more efficient production and collection of firewood, which in turn gives women more time to spend on nutrition and caring for children. Through promoting gender inclusiveness, FMNR provides a platform for women to take increasingly important roles in agriculture production and community decision making.

In many countries across Africa, women are marginalised from decision-making processes affecting the whole community. They are often responsible for the daily task of firewood collection and the harvesting of other tree products, and in some instances conflict has arisen between the men who manage trees and the women who harvest them. Where landscapes are deforesting, women walk increasingly long

distances to find firewood for cooking and heating, often taking many hours out of their day.¹⁰⁴ Although it has been found that in the initial years of an FMNR project, access to firewood can be limited by the management of tree regrowth, FMNR increases wood supply and reduces the time required by women to collect firewood.^{105 106}

Because of the centrality of women in matters of field management and timber harvest, World Vision FMNR projects insist on involving women in training, committee formation and decision making. This has accelerated success of projects and community development in general. World Vision FMNR initiatives in Senegal benefited from women's natural capacity for networking, recruiting and training and they were particularly enthusiastic in promoting FMNR.¹⁰⁷ In Senegal and Ghana, women were more likely to embrace complementary programs, such as savings groups and the use of wild fruits and berries for nutritional and medicinal purposes, which become prevalent with FMNR reforestation.^{108 109} When women's control over resources is increased, as occurs in FMNR programs, it can create dramatically increased benefits for child nutrition and health.¹¹⁰

- In Senegal, the introduction of FMNR, which incorporates gender sensitive program implementation, has resulted in a shift in the balance of power towards women.¹¹¹
- In an FMNR project in East Sumba, Indonesia, women were benefiting through full participation in decision making and activities and they manage their own income generating farms.¹¹²
- In Ghana, FMNR programs promoted equal participation in training and decision making for women and men.¹¹³
- In Niger, the inclusion of women in decision making assisted in addressing conflict and managing access to regenerating trees.¹¹⁴

"On the first night of the workshop I did not sleep because I was thinking about our lost forest. I am just an illiterate woman, but I know the value of the forest. I drew this picture for you. It expresses my love for the forest." – Anandi Verma, Radapura, Baran, Rajasthan, India



Figure 12: Anandi Verma, Radapura, Baran, Rajasthan, India. Source: Tony Rinaudo, Natural Resources Advisor, World Vision Australia

7. Creates community advocates

“Thousands of projects have come through here but this FMNR, there is no comparison, if we are the judges ... The type of benefits we see pushes me sometimes to leave my home and just walk through my field to appreciate the trees and environment. When things get to where they need to be, we will see more yields and the path will be clear.” – Female lead farmer, Thiapy, Senegal

Through the way it is structured – inclusiveness, networks, champions (coaches), farmer-to-farmer learning, school curricula, and local radio – FMNR creates advocates for its programs and community development.

There is a growing body of evidence to suggest that social networks and institutions, and the interactions of individuals that are part of them, “*significantly affect the efficiency and sustainability of development programs*”.¹¹⁵ Once underway, a successful FMNR program appears to be self-sustaining and expanding as early and subsequent adopters see and experience the benefits of FMNR and become advocates themselves.¹¹⁶ In Niger, for example, after the original projects had finished in the early 1980s, over the ensuing 20 years, FMNR has spread, farmer-to-farmer, over five million hectares.¹¹⁷

The networks at various levels of the community appear to foster local innovations for promoting FMNR. In his role of monitoring FMNR projects in Senegal, Weston (2011) observed how extension staff from the Water and Forest Service moved from being feared by farmers to becoming “champions” for FMNR among the communities. To accelerate farmer-to-farmer learning, projects contracted early adopting

farmers to become animateurs (or coaches) to encourage and support other farming households to apply FMNR to their own land.¹¹⁸ Project staff and community stakeholders jointly promoted their work to foreign embassies, the national media and created entertaining shows on local radio which included plays, songs and educational segments.¹¹⁹

- In Niger, FMNR has sparked a “*regional, farmer-led re-greening movement*”.¹²⁰
- Also in Niger, FMNR was promoted through farmer-to-farmer engagement, making it “*one of the few truly sustainable and expanding agro-forestry practices in the Sahel*”.¹²¹
- In Ghana, the Talensi FMNR Project has engaged the broader community – farmers, villagers, local chiefs, the District Chief Executive and regional government ministers.¹²²

8. Increases food security, health and resilience

“This year is very exceptional for me because I have been able to get enough sorghum. I cultivated 1 hectare and harvested 15 bags of sorghum. Generally, I could get 3 to 5 bags when working in this land in the past. This would have been impossible if I was not taught the new FMNR technique of land management.” – Khadidja Gangan, 35-year-old mother of six, Chad¹²³

FMNR helps put more food on the table, reducing communities’ vulnerability to food shortages and famine. With more food and better nutrition, people are healthier and more resilient.

The absence of sustainable agriculture production in degraded rural environments has resulted in hunger and poor nutrition and abject poverty for smallholder farmers. Across Africa, four-fifths of chronically undernourished people are smallholder farmers.¹²⁴ In many cases, such as in Burkina Faso, this led to mass labour migration to the cities leading to dysfunctional rural communities.¹²⁵ The situation in one region became so dire that the government was considering relocation of the communities there. But the people decided to make changes, and the virtual moonscape of the mid-90s is now an FMNR showcase producing 2-3 irrigated crops per year in flourishing communities.¹²⁶

Low-cost sustainable agriculture, agroforestry and agro-ecological techniques such as FMNR have improved rural households’ food security and resilience. A study of households involved in an FMNR project in Humbo, Ethiopia, suggests that the number of main meals that include animal protein has increased following involvement in the project.¹²⁷

The multi-faceted and indirect benefits of FMNR help farmers find ways to improve their living standards even in adverse seasons when crops fail. These include:

- harvesting wood, seed pods and leaves for sale;
- production of surpluses in good years for use or to sell in poor years;¹²⁸
- food and income from fruits and nuts from regenerated trees (also contributes to a diversified diet and improved nutrition);
- better health and income from medicinal products (such as bark, leaves, roots, etc) provided by certain regenerated trees;¹²⁹
- In Niger, FMNR has produced dramatic results by increasing crop harvests and, in some communities, significantly reducing the annual “hungry period” when food supplies are exhausted from six or more months to 2-3 months, and to zero in some locations;^{130 131}

- In Ghana, FMNR-adopting households experienced increased availability of meat and fruit in their diets.¹³² And in Niger, FMNR helped reduce seasonal

migration because it requires year-round inputs and outputs.¹³³

9. Improves the environmental comfort of rural communities

"In the past the environment use to be dry. You could sit here and see the next village. That is no longer the case. The shade alone gives good health to us." – Chief of Tongo-Beo, Talensi, Ghana¹³⁴

Rapid restoration of tree cover around rural dwellings, farms and surrounding landscapes makes a significant contribution to the psychological and physical wellbeing of residents.

A strong correlation has been identified between environmental degradation, deforestation and deterioration of people's mental and physical wellbeing.^{135 136} FMNR project evaluations have revealed FMNR's contribution to reducing people's levels of physical stress, which in turn, improves people's mental wellbeing as well. In FMNR project evaluations, respondents highlighted that increasing the vegetation not only made the landscape more beautiful, it created shade and reduced wind and dust, making conditions around their home more comfortable.

In Ghana, following a three-year project to introduce and promote FMNR in fields and community forests, "better shade and beauty" was reported by householders as the fourth most significant outcome of the project, after soil fertility, fire control and increased reforestation. The report notes, *"The cooler micro-climate under tree canopy and aesthetic pleasure of a greener landscape, availability of food in the landscape and coolness of grassy ground instead of hot exposed soils have reduced people's exposure to heat stress and made a positive contribution to adult's and children's mental state of well-being."*¹³⁷

10. Gives rise to hope and optimism which improves adaptive capacity

"Look at the surroundings. These trees were felled but we have preserved them and there are other forested area[s] where we no longer do bad things. So in the future, those shrubs on the FMNR land will also help." – Men's focus group, Yindure, Talensi, Ghana¹³⁸

Seeing is believing: seeing the results of an improved environment shows communities what can be achieved and helps them believe that they can achieve real change. Rapid restoration of tree cover around rural dwellings, farm and surrounding landscape makes a significant contribution to psychological and physical wellbeing of residents.

As local environmental degradation progresses, so does deterioration of the land's productive capacity. For farmers and rural communities this generates perennially heightened levels of stress. On top of the social and relational strain this places on families and communities, long-term stress also reduces people's capacity to process change and adapt to changing climatic and environmental circumstances. They retreat into known routines, attitudes and practices instead of learning to adapt to new conditions.¹³⁹

The inverse to this situation, acquainting land users with simple and affordable adaptation options, supported by evidence, provides people with a reason for hope and optimism. In psychological terms, hope and optimism counteract the negative effects of prolonged stress, re-balancing mental health and mental energy to pursue adaptation.¹⁴⁰

This reinvigoration of farmer hope and optimism, and its connection to longer term vision and planning, is evident through numerous FMNR evaluations.

- A World Vision, multi-country FMNR evaluation across dryland West Africa found that, *"Where the project had succeeded in mobilising communities to reintroduce trees into the agricultural landscape, children were positive about their community and the future of farming. Where tree cover continues to decline, children expressed a pessimistic future for farming."*¹⁴¹
- The Talensi FMNR Project in Ghana resulted in *"the increase in optimism that children and adults have for the future of their farming and their communities' survival"*. In the project area, 88 percent of all respondents (n=258) anticipate that FMNR will bring about greater benefits in the future.¹⁴²

II. Reduces conflict

The practice of FMNR creates an increased availability of natural resources, improved interaction between herders and farmers, and support for greater community organisation and working towards common goals, which results in a reduction of conflict levels in rural communities.

A reduction in conflict levels has been demonstrated in communities that take up the practice of FMNR. A study in Niger has shown that the village of Dan Saga, with an above average population for the region of around 3,000,¹⁴³ as well as surrounding villages, experienced between 70 and 100 conflicts per year prior to the introduction of FMNR, particularly between herders and farmers. This number dropped to around a dozen per year following an FMNR project intervention.¹⁴⁴

The factors introduced by FMNR that work to reduce conflict include:

- An increase in the amount of available natural resources, such as more available fodder and in some cases more water. This means that there is more to share and while it does not eradicate conflicts, it helps to significantly reduce them.¹⁴⁵
- FMNR projects, particularly in the initial stages, typically involve advisors, agents and trainers to assist communities with implementation. These people provide assistance to communities to resolve complex legal, social and technical resource management issues, such as conflicts between herders and farmers, and misunderstandings stemming from land ownership and forestry exploitation laws. As such, communities have more support to reduce conflict and to establish

formal bodies, by-laws and agreements that act to reduce existing conflicts.¹⁴⁶

- The initial support, as well as the needs of communities that practise FMNR to cooperatively address issues and manage natural resources, builds over the longer term a more effective dialogue within and between rural communities¹⁴⁷ that reduces conflict.
- Conflict prior to the introduction of FMNR can arise from nomadic herders allowing their stock to enter farmers' crops before they are harvested. The old transhumance routes that had traditionally been used by nomadic herders have often been abandoned due to a lack of water and large pastures.¹⁴⁸ Mutual distrust and competition for scarce resources under these circumstances make it difficult for agreements to be made between farmers and herders.¹⁴⁹ Following the introduction of FMNR, existing networks of marked laneways can be formally re-established through a consultation process.¹⁵⁰ Nomadic herders can remain away from growing areas until the end of harvest, substantially reducing conflict with farmers.¹⁵¹
- In general, FMNR has a unifying effect. FMNR involves community forestry projects where communities and the government work together for the benefit of the community.¹⁵²

Figure 13: World Vision Myanmar district manager demonstrates rapid growth through FMNR. Source: Tony Rinaudo, Principal Advisor Natural Resources, World Vision



Environmental benefits of FMNR

The natural environment and biodiversity have their own intrinsic value. However, for an organisation like World Vision, action on environmental health is prioritised according to how it affects the livelihoods of vulnerable people, especially children. Thus, this section emphasises the environmental impacts of adopting FMNR through the lens of sustained wellbeing.

The environment is the foundation for food security. Rural populations in developing countries are heavily reliant on ecological resources from forests and savannah lands for food (in the form of tree products, wild animals and honey), medicinal resources and inputs (firewood, fodder and construction materials).¹⁵³

In Africa, the environmental challenges that confront rural people are driven by two core trends: loss of tree cover and biodiversity; and disappearance of traditional fallow periods.

Africa's tree cover is disappearing under firewood and charcoal production, logging and agricultural clearance. Approximately 34 percent of land in Africa is now threatened by desertification. Each year 2.3 million hectares of woodland are cleared or harvested for new farmlands.¹⁵⁴ West Africa lost 28 percent of its tree cover between 1961 and 2002¹⁵⁵ and continues to lose an additional four percent annually.¹⁵⁶

Otherwise fertile soils are exposed to heat, wind and erosion, which degrades and removes arable top soils. Removal of trees and associated biodiversity breaks the fertility cycle that

replenishes soils with nutrients and organic matter. Without soil cover to slow runoff, rainfall does not percolate through the soils, further damaging soil structure and depleting or eliminating springs, streams and subterranean aquifers. For example, in the early 1980s, groundwater levels in Niger's Central Plateau dropped an estimated 0.5-1.0 metre per year; so wells and boreholes went dry just after the end of the rainy season.¹⁵⁷

Following land involves setting aside agricultural land so natural vegetation regrowth can replenish the soil's organic matter and micro biota over 10 to 15 years. African agrarian societies have maintained soil condition for centuries under such a regime.¹⁵⁸ Over the 20th century, land use has largely converted from rotating fallows to continuous cropping on the same parcel of land as populations have grown, farm sizes shrunk and agricultural agencies promoted intensive farming. This has led to soil depletion and productivity losses in as little as four or six years. Population growth and shrinking farm sizes have now forced most farmers to crop all their land every year just to survive.¹⁵⁹

Evidence to date indicates that tree numbers increase under FMNR, and that biodiversity recovery depends on the species selection choices of land users. A farmer may preference a mix of regrowth trees or focus on trees with specific uses such as nitrogen fixation, firewood, timber, fodder, fruits, nuts and edible leaves.¹⁶⁰

12. Widespread adoption of FMNR restores tree cover

When FMNR is adopted into rural land management, large areas of land can have indigenous tree cover restored for relatively little cost.

Land clearing for agriculture and charcoal production are the primary contributors to Africa's disappearing biodiversity and increasing areas of bare land.^{161 162 163}

Currently, the earth possesses four billion hectares of forest, yet this stock is decreasing rapidly with 5.2 million hectares per year cleared in the first 10 years of the 21st century.¹⁶⁴ Africa has some of the heaviest rates of loss with 75 million hectares cleared between 1990 and 2010.¹⁶⁵ Despite vast expenditure from international development agencies on forestry in Africa, there continues to be a massive scale of deforestation and desertification in the Sahelian zone of Sub-Saharan Africa. It is clear that traditional approaches to reforestation cannot change or reverse the current trends. It has been estimated that deforestation is proceeding at a rate at least 30 times greater than reforestation in many Sub-Saharan countries.¹⁶⁶

- A study by Larwanou and Saadou across three regions of Niger found that in most cases, over 30

years, lands shifted from having almost no mature trees to around 100 per hectare, with huge increases in tree species diversification.¹⁶⁷

- In Zinder, Niger, though natural forest had completely disappeared during the 20th century, FMNR tree cover is now the dominant form of land cover, on over one million hectares. Tree densities per hectares varied from 20 to 120 trees.¹⁶⁸
- Across the whole of Niger, Reij et al (2009) studied satellite imagery and secondary data to establish that, since its inception in 1983, FMNR restored tree cover to approximately five million hectares of land over 20 years, representing around half of all Niger's farmland, despite a doubling of population over the same period. Consequently, Niger is the only African country to record net increase in tree cover in recent history.¹⁶⁹
- Sendzimir et al (2011) used mathematical formulae to correlate ecological, economic and socio-political

factors of massive tree clearings for commercial agriculture in the 1970s; and to model how, in the 1980s, a decline in centralised government interference and more local land management autonomy combined with NGOs promoting FMNR led to expansion of reforestation.¹⁷⁰

- An end-of-project evaluation of World Vision's Talensi FMNR Project in the dryland north of Ghana recorded that, over the course of three years,

FMNR-adopting communities added 396,000 trees to their landscape on over 500 hectares. FMNR was applied both on farmlands and community-managed reforestation sites.¹⁷¹

- As a result of World Vision's promotion of FMNR in Senegal in the late 2000s, farmers have implemented FMNR on over 50,000 hectares of cultivated land, raising tree densities from four trees per hectare to around 36.¹⁷²

13. Increases biodiversity

Studies of FMNR sites across Africa have found that the widespread adoption of FMNR into landscapes is accompanied by a restoration of vegetative, animal, insect and soil organism biodiversity as conducive habitats are recreated.

Historically, rural communities in developing countries have depended on certain local tree, shrub and wild animal species as supplementary foods, especially during agriculturally lean times.^{173 174} Research demonstrates that, in drylands, populations that fare best, with better nutrition in times of drought, are those that have access to and know how to make use of “a diversified food base with an emphasis on wild food plants”.^{175 176}

Yet, “The conventional model to achieve food security has been to convert wild lands to intensive commercial agricultural use leading to the increased homogenisation of natural landscapes. An immediate result of this model of land use has been a drastic loss of wildlands, the biodiversity they contain and the ecosystem services they provide.”¹⁷⁷

Apart from the benefit of stabilising the indigenous ecosystem, restored biodiversity also restores the diversity of natural resources to communities for medicine, construction, fuel, and plant and meat consumption. According to the Centre for International Research on Forests, “Malnutrition could be greatly reduced and food security improved by ensuring improved access to nutrient-rich forest-derived foods like berries, wild animals, roots, insects and nuts for the world's poorest populations.”¹⁷⁸

- After World Vision's Senegal Food and Livelihoods Initiative in central Senegal, data obtained by the Senegalese Department of Waters and Forests indicate a significantly higher diversity of species composition of young FMNR saplings compared to more mature trees left standing in fields under traditional land management practices.¹⁷⁹ Thirty-five percent of survey respondents in FMNR-adopting communities cited observing an increase in the number of wild animals, compared to the time before trees were returned to the landscape.¹⁸⁰

- After World Vision's Talensi FMNR Project in Ghana, 46 percent of survey respondents observed that the FMNR practices have generated more wild foods (fruits, nuts, rabbits and partridges), while only 4.5 percent believed the wild food would have increased without FMNR.¹⁸¹ This led to a profound increase in consumption of fruit by children, in particular.
- Studies in Maradi, Niger, where FMNR adoption had become mainstream, 79 percent of farmers surveyed had observed increased wildlife diversity. Animals and birds have re-entered the region.¹⁸² A similar result was found in Tahoua region where, “For decades, wild fauna has experienced a drastic reduction, even a quasi-total disappearance ... However, according to the farmers, a renewal seems to start with the appearance of hares, wild guinea fowls, squirrels, rats, jackals, and varans.”¹⁸³
- Furthermore, in Niger, the increase in trees has led to a return of animals, birds and insects with “predatory” characteristics towards crop pests, which reduces the need for pesticides and hence restores a balance in the ecosystem.¹⁸⁴
- A multi-country evaluation of World Vision FMNR projects across West Africa also documented the return of indigenous fruits to the landscape and increased consumption.¹⁸⁵
- Reintroducing trees into farming systems has also been shown to reinvigorate a “greater abundance and activity of beneficial soil organisms” necessary for optimal soil moisture retention and soil nutrient availability to plant roots.¹⁸⁶

However, it is important to note that the precise composition of returning tree species is dependent on farmer decisions. While the number of trees may increase, farmers may choose to limit the species diversity of those trees.¹⁸⁷ Selection depends on what species occur naturally, coppicing ability,

local beliefs and knowledge, usage, and tree characteristics (such as thorniness). Farmers will make rational choices about tree species to protect and regenerate according to their prioritisation of different uses such as nitrogen fixation, firewood, timber, fodder, fruits, nuts and edible leaves.¹⁸⁸

14. Reduces erosion

Greater tree densities reduce loss of topsoil in fields by slowing wind speeds, trapping airborne top soil particles and reducing rainfall runoff.

The role of FMNR in reducing erosion was empirically demonstrated in research by Brecheers et al (2009), as illustrated in Figure 14.¹⁸⁹

- In a study of 400 farmers in the Zinder region of Niger, farmers observed that the tree cover achieved by FMNR on over one million hectares has led to reduced wind speed and soil moisture evaporation. Whereas, in the 1980s, when crops had to be replanted three or four times due to wind-blown sand, today farmers typically need only plant once.¹⁹⁰
- An end-of-project evaluation of the Senegal Food and Livelihoods Initiative found that FMNR-adopting communities reported an increase in soil fertility (85 percent of respondents), a decrease in erosion (62 percent) and an increase in crop yields (59 percent).¹⁹¹
- This is consistent with evaluation findings in northern Ghana where, after just two years, 66 percent of FMNR adopters reported an improvement in soil erosion (against 17 percent in the comparison group). Forty-seven percent of adopters reported “a lot” of improvement (against eight percent of the comparison group).¹⁹²

In each of the above examples, the role of trees in stabilising the soil, and limiting the effects of wind on soil, manure and leaf-drop losses reportedly led to improved crop performance.

- In Humbo, southern Ethiopia, during a project evaluation of a community-managed FMNR reforestation project, community members reported that, on hillsides where erosion was once a major problem, FMNR tree-greening had reduced water and wind erosion and increased soil moisture as water percolated through the soils onto agricultural fields during heavy rainfall, instead of flooding down the hillsides.¹⁹³

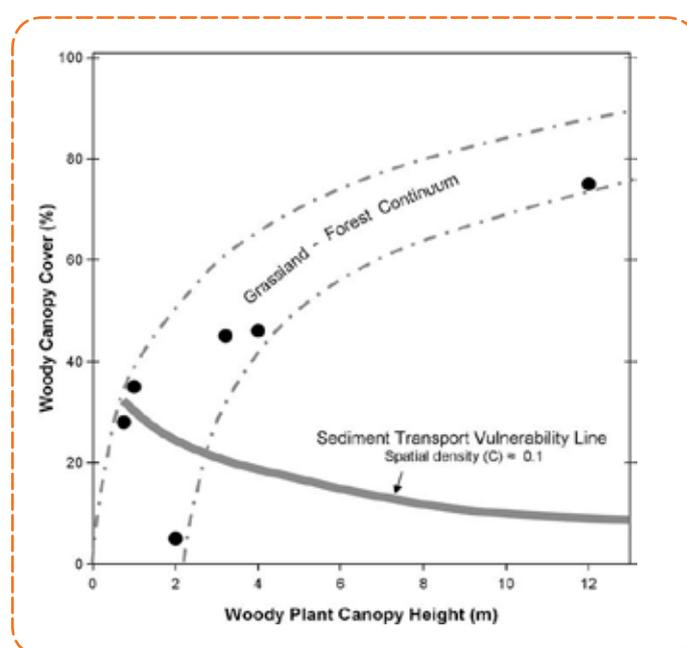


Figure 14: The greater the woody canopy, the lesser the erosion (sediment transport vulnerability). Source: A Conceptual Framework for Dryland Aeolian Sediment Transport along the Grassland-Forest Continuum: Effects of woody plant canopy cover and disturbance, *Geomorphology*, 105:39

15. Enriches soils

Higher densities of tree cover on farmland rebuild soil quality and fertility by depositing organic matter, attracting animals that deposit manure and urine, and trapping airborne topsoil. Leguminous tree species directly deposit soil nitrogen via their root systems.

In the past, across Africa, swidden agriculture^{iv} allowed farmlands to remain productive and ensured maintenance of biodiversity, soil health and water infiltration into the landscape.¹⁹⁴ Since “new world” cash crops were introduced into Africa in the early 1800s, the consequent loss of long fallows to restore soils¹⁹⁵ requires farmers to purchase seeds and chemical inputs. These drive household debt, extinguish locally adapted soil microbes, exhaust soil nutrients and force farmers to clear more forest.¹⁹⁶ Yet, depleted agricultural soils are not only lower yielding, but also respond poorly to the application of mineral fertiliser.¹⁹⁷ Reintroducing indigenous and selected exotic trees into farmland has been shown to significantly improve soil nutrients and soil organic matter and attract grazing animals that deposit manure.

- A World Vision project evaluation in the dryland north of Ghana found that 94 percent of FMNR adopters reported an increase in soil fertility (against 26 percent among the comparison group). Seventy-five percent of FMNR adopters reported high increases (against only six percent among the comparison group).¹⁹⁸
- In Senegal, the FMNR benefits most highly reported by participating communities were that it improves soil fertility (84 percent), increases crop yield (69 percent), attracts rainfall (55 percent) and controls soil erosion (41 percent).¹⁹⁹
- A study of FMNR adoption in Maradi, Niger recorded that within only one season totally unproductive hardpans were restored to arability.²⁰⁰ The pace and scale of degraded land reclamation increased significantly with FMNR because leaves, twigs and small branches from trees that scattered onto hardpan earth were rapidly incorporated into the soil profile by termites. This broke up the hardpan and improved the soil structure, allowing water infiltration while reducing soil erosion. In addition, the tree canopy and debris on the ground trapped significant amounts of wind-borne silt and fine organic matter lost from other fields.

- This is consistent with an Oxfam study of agroforestry in Mali which found that crop fields containing trees approximately 10 metres apart throughout the field would generate around 25 tonnes of soil organic matter per hectare per year. Over five years, this input is enough to increase crop production from 700kg of grain per year to over two tonnes per year.²⁰¹
- In Zambia, a comparative study found agroforestry fields were yielding 83 percent more maize than unfertilised fields.²⁰²
- A synthesis by Garrity et al (2010) records several soil benefits associated with maintaining tree cover year-round. These are:
 - bolstering nutrient supply through nitrogen fixation and nutrient cycling;
 - enhanced suppression of insect pests and weeds;
 - improved soil structure and water infiltration; and
 - greater quantities of organic matter in soil surface residues.²⁰³
- Barrios et al (2011) add that tree cover supports greater abundance and activity of beneficial soil organisms.²⁰⁴
- To accelerate the increase in soil nitrogen and other nutrients or reduce losses, other complementary farming techniques can be promoted alongside FMNR. Some include:
 - the deliberate planting of trees or shrubs (especially nitrogen-fixing leguminous trees) in crop fields;^{205 206}
 - Zai pits to trap moisture and organic matter and shelter tree and crop growth;²⁰⁷
 - contour stone bunds that reduce surface run-off from the fields (alleviating erosion),^{208 209} and
 - combining post-harvest field waste with manure and kitchen scraps to generate bulk compost in pits.²¹⁰

^{iv} Swidden agriculture (or “shifting agriculture”) is a system in which a plot of land is cleared and cultivated until soil fertility diminishes, then allowed to lay fallow and regenerate its natural vegetation while the farmer establishes another field. Cultivated fields are normally cropped for fewer years than they are allowed to remain fallow, thus preserving soil fertility.

16. Increases water availability

Agricultural research has demonstrated that vegetative cover of agricultural land and greater soil organic matter improves soil moisture retention by reducing run-off, reducing evapotranspiration^v and improving water infiltration.

A study in Burkina Faso that compared rainwater infiltration around agroforestry trees with infiltration in open fields found that, while infiltration was similar, soil moisture remained much higher under tree canopies due to higher organic matter and reduced evaporation.²¹¹

Due to the complex nature of measuring hydrology trends, no FMNR studies have yet included empirical measurement of these phenomena. Nevertheless, two World Vision projects in Ethiopia provide collaborative evidence.

- In the 2,700 hectare Humbo Community-based Natural Regeneration Project in southern Ethiopia, the rapid restoration of trees to hillsides reportedly contributed organic matter and mulch to the soils and the trees slowed rainwater runoff, helping water to percolate into the soil. Consequently, soil moisture retention increased and evapotranspiration decreased – increasing crop resistance to drought.²¹²
- In the neighbouring Soddo Community Managed Reforestation Project, like Humbo, the mountain slopes had been denuded of vegetation in the decades before the project. After four years of FMNR

reforestation, long since dried up springs downhill from the project sites began flowing again, providing direct perennial benefits for 3,000 households and their livestock.²¹³

Secondly, climatologists suggest that greater tree cover in a landscape increases cloud formation and subsequent rain events, increasing frequency and volume of rain. Inversely, where landscapes have been denuded of tree cover this is believed to contribute to an overall reduction of rainfall.²¹⁴

A study of causes of rainfall reduction over West Africa concluded that rainfall decreased by 20 percent over the last three decades of the 20th century, and that land clearing contributed 8.7 percent of that reduction due to increased albedo effect of bare land and increased evapotranspiration.²¹⁵

A separate study of clearance of West African rainforest found that this reduced rainfall in adjacent agricultural lands by as much as 50 percent.²¹⁶

It is unlikely that reforesting one district, such as with FMNR, will influence rainfall behaviour. However, if tree cover is restored at a bioregion level, this should have a beneficial effect.

17. Reduces wind and high temperatures

The rapid restoration of tree cover reduces wind speeds at ground level and also reduces soil temperatures (see Figure 13).

These phenomena have several beneficial effects for human habitation and agriculture: wind storms cause less damage to crops, homes and infrastructure; the micro-climate beneath tree canopies is more comfortable for field work and leisure; and soil temperature can remain conducive to soil biota and shallow crop roots.

Research by Brechears et al (2009) demonstrated that bare soils with little or no tree cover (commonly associated with conventional agriculture) have the highest vulnerability to topsoil loss from wind at 300 grams per square metre per day. Vulnerability decreases directly in proportion to the density of woody plant canopy cover (ie, trees) and soil loss on farmed woodland is only 0.4 grams per square metre per day.²¹⁷ Similarly, Brennan (2006) found that the presence of trees in fields contributes to “reducing windspeed, raising humidity and reducing leaf temperature of crops”.²¹⁸

- A study of the FMNR practices of 400 farmers in Niger’s Zinder region found that farmers observed that trees had reduced wind speed and evaporation. Whereas previously, crops had to be replanted three or four times because they were covered by wind-blown sand, today farmers typically plant only once.²¹⁹
- A multi-country evaluation of World Vision FMNR projects across West Africa also concluded that the restoration of tree cover protected homes against the Sahel’s violent winds and improved soil protection.²²⁰
- Likewise, Cunningham and Abasse’s 2005 study of FMNR farmers in Maradi, Niger also found that the quality of life improves markedly as wind speeds and dust load are reduced. Shade is available and the landscape is returning to a natural savannah with multi-purpose trees and shrubs.²²¹

^v Evapotranspiration is the process by which water is transferred from the land to the atmosphere by evaporation from the soil and other surfaces and by transpiration from plants.

18. Climate change adaptation and mitigation

More trees on otherwise degrading land are shown to have two positive climate change effects: agroforestry systems help farming communities adapt by protecting and diversifying farm production; and tree growth sequesters atmospheric carbon.

Various studies indicate that temperatures in northern Africa and other continents could rise by six degrees by the 2060s. With a four-degree rise, 35 percent of Sub-Saharan Africa could become unsuitable for cultivation, and with a five-degree increase it is expected to experience major reductions in growing season length. As 75 percent of Sub-Saharan agriculture is rain fed, it is particularly sensitive to climate variables and this outlines the importance of agroforestry systems that can adapt and mitigate the effects of climate change.²²²

Reij (2012) argues that on-farm trees, parklands and forests in the semi-arid and sub-humid regions of Africa and other continents offer significant potential for reducing temperatures (adaptation) and for the sequestration of carbon (mitigation). *“On-farm trees reduce wind speed and reduce temperatures. Diversifying agricultural production systems through increased production of perennial tree crops (wood, fodder, edible leaves and fruits) also buffers these systems against rainfall fluctuations and adds to their resiliency.”* Reij received a communication in November 1989 from Oursi village in northern Burkina Faso recording a marked difference for shaded and non-shaded ground temperatures (see Table 1).²²³

Table 1: Soil surface temperatures at Oursi village, Burkina Faso

Time	Soil under tree shade	Bare soil
06.45 hours	25°C	23°C
10.30 hours	33°C	54°C
13.25 hours	36°C	71°C

Important micro-organisms in the top soil will die if exposed to temperatures of 55°C and over for more than one hour at a time. Source: Mann, R 1989, published in African Regreening Initiatives Update 2013, No 2, Centre for International Cooperation, VUUniversity, Amsterdam



Figure 15: Even a small cover of vegetation reduces soil surface temperatures, Maradi district, Niger, 1989. Source: Tony Rinaudo, Principle, Natural Resources Advisor, World Vision Australia

Climate change adaptation

Climate adaptation (or resilience^{vi}) can be understood as the combined buffer effect of environmental and economic benefits of FMNR, including crop and livestock resilience to climatic shocks and diversification of income and food sources. These outcomes are referred to in detail throughout the rest of this study, but are summarised below.

- Annual crops' tolerance of hot and/or dry spells is improved by trees' steady provision of soil organic matter, mulching material and shade. Trees help increase water infiltration into soil, reduce soil evapotranspiration and reduce soil temperature.²²⁴
- Livestock in drylands benefit from selected trees' leaf growth that supplements grass fodder, especially in the dry season. In the Talensi FMNR Project in northern Ghana, this was found to not only sustain animal health, but also reduce labour requirements for herding animals long distances.²²⁵

- When drought and accompanying food shortages hit the regions of Maradi, Tahoua, Tillabéri, and Zinder in Niger in 2004-05, villages with high levels of adoption of FMNR fared much better than those devoid of trees. For example, villages in Aguié District were able to harvest regenerated trees for food, fodder and firewood to sell in exchange for grain. The inhabitants did not rely on emergency relief and did not have a single death of a malnourished child.²²⁶
- In Ghana, the Talensi FMNR Project end-of-project evaluation found that the effects that generated the greatest value to participating communities were firstly the value of new trees as assets, and secondly, the increase in availability and household consumption of consumable wild resources: especially wild foods (plant and animal) and construction materials (timber poles and thatch for fencing and roofing).²²⁷

vi “Resilience is the capacity of a system to experience shocks while retaining essentially the same function, structure, feedbacks, and therefore identity. It follows Holling’s (1973) notion of resilience as the amount of disturbance a system can absorb without shifting into an alternate regime.” See <http://www.ecologyandsociety.org/vol11/iss1/art13/>

Climate change mitigation

FMNR has great potential as a low cost technique for reducing carbon emissions from the atmosphere. Once tree stumps are protected from slashing and burning and foraging animals and are coppiced in the correct manner, the stumps quickly regrow into trees sequestering carbon both in above ground biomass such as the trunk, stems and leaves and below ground biomass in the roots and surrounding soil.

Rinaudo (2013) used the Keeling Curve (Figure 16) to demonstrate potential global CO₂ sequestration by reforesting tropical drylands.

*"In his book The Weather Makers, Tim Flannery calls it one of the most wonderful things he'd ever seen, for in it you can see our planet breathing. The troughs of the saw-tooth fluctuations correspond to spring time when the vast northern Boreal forests wake from winter sleep and begin taking in CO₂. We can see from the graph that the breathing of the forests has a measurable impact on global GHG concentrations. What's so exciting about this is that, while the boreal forests are vast, their growing season is very short and their growth rate relatively slow compared to that in the warmer, lower latitudes where FMNR is prevalent. So if an arctic forest can do that, presumably a low-latitude forest could actually bend the graph's trajectory downwards. World Vision works in 100 low-latitude and generally deforested countries. If we could reforest just 10 percent of this land mass – and there is no technical reason why we couldn't – we could start a movement that could significantly reduce greenhouse gas concentrations. This does not mean we should not endeavour to reduce our emissions."*²²⁸

Figure 16: Concentration of CO₂ in Earth's atmosphere

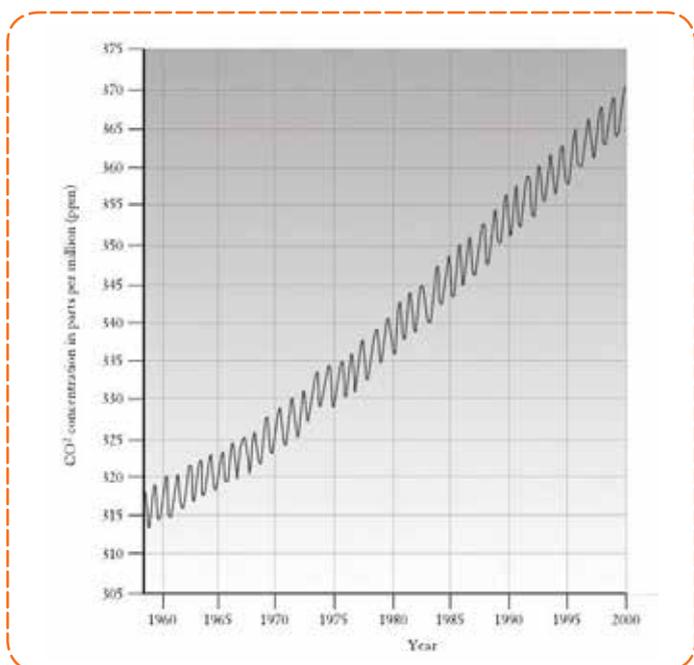


Figure 16: The Keeling Curve shows the concentration of CO₂ in the atmosphere as measured at Mt Mauna Loa, Hawaii between 1958 and 2000. The saw-tooth effect results from seasonal changes in northern hemisphere forests, but the rise is due to the burning of fossil fuels. Source: Flannery, T., 2005, *The Weather Makers: The History & Future Impact of Climate Change*, Text Publishing, Melbourne

- The Humbo Community Reforestation Project in Ethiopia demonstrates the results that can be achieved from FMNR as a low-cost technique for carbon abatement.
 - Between 2006 and 2011, 73,138 tonnes of CO₂ was sequestered across 2,728 hectares, which is equal to an annual sequestration rate of 5.4 tonnes of CO₂-e per year.²²⁹ Over the 30 year life of the project, it is estimated that 880,296 tonnes of CO₂-e will be sequestered by the project which is equal to 10.8 tonnes of CO₂-e per year. Based on current growth rates the project is expected to achieve this level of abatement by 2036. The estimated abatement per hectare from this project compares well with figures quoted in the literature. Trees in forests (including plantations), if well stocked, typically sequester between 6.7 and 17.3 tonnes of CO₂-e per hectare over a 30-year growth cycle.²³⁰
 - The cost per tonne of CO₂-e sequestered between 2006 and 2011 was calculated to be US\$15.25. However, as the project will continue until 2036 and only around eight percent of total estimated abatement has been achieved to date, the cost is expected to decrease to approximately US\$1.30 per tonne of CO₂-e sequestered by the end of the project.²³¹

Qualifier:

It is important to note that the Humbo reforestation project is an example of intensive reforestation using the FMNR technique (ie, more than 2,000 trees per hectare). However, it is also commonly applied by farmers with tree densities in the range of 50-100 trees per hectare in which case the carbon abatement potential will be much lower per hectare.

Economic benefits of FMNR

Sustainable livelihoods are the key factor in helping communities out of poverty. In Africa, most rural households grow food, both for their everyday needs and income. Agriculture contributes around 25 percent of GDP and provides jobs for 70 percent of the labour force, as well as a livelihood for more than 65 percent of the population.²³² Therefore local agricultural production is critical to both food security and economic development among the rural poor. The dominance of smallholder agriculture means that short- and medium-term agricultural growth and poverty reduction will be closely linked with the successful transformation of this sector.

Haglund et al (2011) found that FMNR adopters in the Maradi region of Niger were earning 37 percent more income than matched non-adopters and that the annual return on labour ratio to farmers practising FMNR is between 2.5 and 3:1 (see Table 2). Respondents reported that income and benefits were a result of increased wood supply (98 percent of respondents), improved soil fertility (98 percent), improved crop yields (92 percent), healthier animals (81 percent), increased revenues (78 percent) and improved food security (73 percent).²³³

On a macro-economic level, *“Because of FMNR, farmers in Niger are producing an estimated additional 500,000 tons of cereals a year. This additional production covers the requirements of 2.5 million people out of a total population of about 15 million in 2009.”*²³⁴ In the Maradi region of Niger, the widespread adoption of FMNR has resulted in additional local economic activity of an estimated US\$17-23 million per annum.²³⁵ On-farm this translates to increased income from the sale of tree products, and increased grain and livestock production of US\$250 per hectare.²³⁶

Given the difficulties of growing annual crops compared to trees, a strong case can be made for persuading farmers to grow trees as a cash crop individually and/or communally. Trees produce valuable products year after year and require

minimal maintenance. Having reliable income from sales of wood and other tree products enables farmers to buy food from other areas where rainfall is more reliable.²³⁷

Africa has the lowest productivity per hectare out of all the Earth's global regions.^{238 239} Yet, to date, “modern” or “conventional” agriculture has not served the African farmer well. Since “new world” cash crops were introduced into Africa in the 1830s, the consequent loss of long fallows to restore soils²⁴⁰ has either depleted soils from over-extraction of nutrients, or required farmers to purchase seeds and chemical inputs which extinguish locally adapted soil microbes, drive household debt, and force farmers to clear more forest.²⁴¹ Still, the cost and soil impact of commercial inputs is almost a moot point with only one in five African farmers able to access and afford such inputs.²⁴²

In the next 30 years, Africa's population is expected to double to 1.8 billion people and yet in the 30 years prior to the new millennium, food production per capita declined by 20 percent.²⁴³ Any gains in total quantity of production have primarily come from clearing more forest to supplement or replace older, degrading farmlands.²⁴⁴ Land holdings have consistently shrunk in size due to rapid population growth rates. Eighty percent of the continent's farms now occupy less than two hectares.²⁴⁵

To compound these dilemmas, the World Bank estimates that a two-degree global temperature rise anticipated by 2040 will result in Africa's cropping area being reduced by between 40 and 80 percent, and that water availability will reduce by 20 percent.²⁴⁶

Therefore, for agriculturally-led economic development to succeed in resource-constrained, small-farmer contexts, 20th century conventional agricultural advancement needs to be updated with solutions that are profitable, more productive than present, resilient to weather shocks, and that conserve or restore degraded land.

Table 2: Significant impacts of FMNR adoption

Variable	FMNR adopters	Matched non-adopters
Gross income per capita (CFA franc)	86,104	62,996
Value of crop production (CFA franc)	71,333	45,580
No. of crops/farm	4	3
Migrants per household	0.7	0.5
Trees per hectare	44	29

Source: Haglund et al, 2011, Dry land tree management for improved household livelihoods: Farmer managed natural regeneration in Niger, *Journal of Environmental Management*, 92, pp 1696-1705

19. Increases incomes through improved crop yields

"I estimated about US\$5 per tree and per year in terms of economic benefit ... [\$250/ha/yr], from a combination of:

- sales of wood and own use consumption
- sales of fodder and own use consumption
- sales of edible leaves, fruits and own use consumption
- contributions to increased crops yields ...
- contributions to increased livestock production and sales
- contributions to dry season gardening, from improved ground water recharge."

– Robert Winterbottom, Director, Ecosystem Services Initiative, World Resources Institute²⁴⁷

The presence of trees in crop fields has a positive effect on crop productivity, due to combinations of depositing mulch and nutrients, shade cover for exposed soils, reduced erosion, trapping airborne topsoil, and attracting animals and birds who deposit manure and urine.

A synthesis study by Garrity et al (2010) reported yield increases of between 50 and 200 percent in Zambia, up to 300 percent in Malawi, 200 percent in Niger and 115 percent in Burkina Faso where trees grow amongst crops.²⁴⁸

In an agroforestry project in Zambia, after a five-year period, farmers used 11 percent less labour but harvested 83 percent more maize. Net returns to land were over 20 times higher on the improved fallow plot, and net returns to labour were over twice as high. Improved fallow plantings had slightly higher returns to labour than fertilised maize and slightly lower returns to land.²⁴⁹

- A study of several FMNR sites in Niger, Mali, Burkina Faso and Senegal found that the effect of current trees on yields (direct and indirect) is significant in the range of 15-30 percent of observed yields. Accordingly, the study found that FMNR practitioner households have a higher gross annual income than others; however, marginal increases of yields from additional trees decreased as more trees were added.²⁵⁰
- Following a World Vision FMNR project in Kaffrine, Senegal, the volume of millet grown by FMNR adopters was 238 kilograms per hectare while the non-adopters produced 194 kilograms per hectare and this difference was significant at the 95 percent level.²⁵¹
- Data from the Ministère de l'Agriculture et de l'Élevage in Niger show cereal production rising steadily in parallel with the spread of FMNR. In 1980, Niger produced 1,770,700 metric tonnes of cereals, rising to 2,093,300 in 1995 and 2,319,800 in 2000. By 2006, when at least a quarter of cultivated land was converted to FMNR, production reached an impressive 4,055,984 metric tonnes.²⁵²

Qualifiers:

A four-country study found that a positive effect of trees on crop yields occurred in all countries. However, the magnitude depended on the species selection and farmer practices. They also found strong positive effects on sorghum and to some extent millet, but not maize.²⁵³

Likewise, a meta-analysis of impacts of (planted) "fertiliser shrubs" on crop yields across Sub-Saharan Africa found roughly a doubling of yield, but results were affected by tree species, soil type and climate.²⁵⁴

A survey of 300 farmers with *Faidherbia albida* trees in their maize fields found that 33 percent of farmers began to see significant benefits to their crops in 1-3 years, while another 43 percent found that it took 4-6 years before they observed the benefits.²⁵⁵

20. Increases incomes through sale of tree products

“In a reforested farm, diversification guarantees a harvest in any year, of one or more of the components in the system, including annual grains, livestock products, ‘wild’ vegetables, wood, honey, fodder, fruit, seeds and edible leaves. In addition, trees protect annual crops from strong winds, increase soil fertility and harbour natural predators of pests, thus contributing to increased annual grain yields.”

– Tony Rinaudo, Principal Advisor Natural Resources, World Vision Australia; Salifou Yaou, National Coordinator, Improved Cowpea Storage Project, World Vision Niger

FMNR trees on farms and community-managed forest reserves generate surpluses of natural resources that can be sold to diversify household income. These include firewood, construction timber and non-timber forest products.

The presence of multi-purpose trees on farms diversifies production and incomes and spreads a household’s risk exposure. For example, if an economic or weather shock reduces one income source (such as a cereal crop), others may remain robust (such as timber, firewood, livestock and artisan products, etc). In Senegal, World Vision monitoring revealed that trees provide saleable timber, firewood, food and medicinal products. Usually, such products are available when conventional agriculture is out-of-season, allowing activity and incomes to be spread across the year.²⁵⁶ In Niger, not only did FMNR expansion raise incomes across three regions of the country, the increased crop production also contributed to national exports by feeding markets for cereals and vegetables across the border in Nigeria. It also generated new land markets for local entrepreneurs buying degraded land, rehabilitating it with FMNR and reselling it for anywhere between 75 and 150 percent mark-up.²⁵⁷

- **Timber income**

FMNR pioneer, Tony Rinaudo, estimates that FMNR-adopting households can earn an additional US\$140 per year by rotationally harvesting timber poles from just 40 stumps per hectare.²⁵⁸ One-year-old poles can bring 30 CFA francs, and five-year-old poles up to 1,000 CFA francs.²⁵⁹ The average income per farmer

from wood sales in 1998 was 17,465 CFA francs, (equivalent to two months of food for one family), but some farmers earned more than 150,000 CFA francs depending on the intensity of their FMNR.²⁶⁰

- **Firewood income**

One of the more immediate and obvious benefits of FMNR is the availability of firewood from pruned tree branches. This is especially observed in Burkina Faso, Mali and Niger where the estimated values of harvested firewood vary from US\$56-170; US\$102-180 and US\$224-256 respectively, with an estimated average value of US\$127-154 per household in the Sahel.²⁶¹

- **Non-timber tree products**

Trees also yield direct non-timber benefits. While most non-timber tree products are consumed by households, some of them can generate significant income from their sale. In Mali, for example, species like *Vitellaria* (shea fruit) alone can return an average of US\$237 per year translating to an additional US\$0.66 per day per household.²⁶² In addition, farmers in Offaka, Uganda, significantly increased their income through maintaining beehives in forests restored and protected from fire through FMNR.

21. Increases incomes through improved livestock production

“The protection of the indigenous trees is providing good shelter to the animals, especially the goats and those farmers who are involved in protecting the trees have testified of the high increase in the number of goats because of the good pastures for the animals.”

– Presenter, FMNR workshop, Offaka, Uganda²⁶³

FMNR trees on farms and grazing lands provide fodder and shade for livestock, and improved pasture growth. This, in turn, increases animal condition and productivity, as well as survival rates during severe drought.

Trees provide leaves and pods for grazing and shade for animals. These are especially important for animal health and survival through the dry season when grasses are scarce and have reduced nutrient content.²⁶⁴

Studies on the effect of agroforestry fodder on dairy milk production in Kenya and Tanzania found that tree fodder adequately replaced commercial feed and labour requirements, and increased milk production by around 10 percent, as well as increasing animal weight.²⁶⁵

- In an end-of-project evaluation of a World Vision FMNR project in semi-arid northern Ghana, participants noted that FMNR combined with elimination of field burning generated more local fodder and nesting for livestock and guinea fowl. These factors increased numbers and health of stock. In the dry season, cattle values went from being unsaleable to around US\$300. Reducing the need for

livestock to wander also reduced thefts of animals.²⁶⁶ In the dry season, cattle values went from being unsaleable to around US\$300. Reducing the need for livestock to wander also reduced thefts of animals.²⁶⁶

- Pods and leaves for dry season fodder were also found to be an important contribution for livestock in Niger.²⁶⁷

22. Reduces expenditures and increases consumables

“On-farm trees and restored managed forests generate increased household access to construction materials, like poles and thatch; firewood; nutritionally diverse indigenous foods such as fruits, seeds, nuts, wild vegetables and bush meats; medicinal ingredients; and environmental farm services such as fertiliser, stock feed and pest control.”

– Peter Weston, Research and Evaluation Advisor, World Vision Australia

Natural resources generated by trees and restored habitats sustainably increase consumption by rural households and reduce expenditures on farm inputs and household needs.

Apart from increasing household consumption, availability of such consumables also reduces both time and expenditure required to access these products, and increases and diversifies dietary intake.²⁶⁸ Household savings from FMNR tend to be as a result of substituted farm inputs (organic soil nutrients and pest control), and increasing access to natural resources on-farm and in community-managed reforestation sites. These include wild plant and animal foods, construction material and firewood.^{269 270}

FMNR on farms and community-managed landscapes has provided communities with the following specific types of wild consumable products:

- **Purchase substitution for construction materials and firewood**

- Where FMNR has been adopted widely across Maradi, Niger, *“Firewood and building timber is readily available for personal use and for sale. Wood can be sold at any time of year according to need.”* Whereas trees had disappeared from the landscape by the early 1980s, these days 76 percent of households use wood from their own fields for cooking and 48 percent have surplus wood for sale.²⁷¹
- Following the three-year Talensi FMNR Project in dryland northern Ghana, 95 percent of FMNR adopters were harvesting some of their firewood from their own fields compared to only 21 percent of non-adopters. In total, only 50 percent of FMNR adopters’ total firewood needs were harvested from forest compared to 67 percent for non-adopters. Similarly, for construction poles, after just two years, 17 percent of FMNR adopters sourced poles from their own land compared to nine

percent for non-adopters.²⁷²

- **Purchase substitution for on-farm inputs (fertiliser, stock feed and pest control)**

- Fodder: *“Farmers’ trees have also yielded direct non-timber benefits in the form of fodder for livestock and edible leaves and seedpods to set aside for times of hunger.”* – Tony Rinaudo, Principal Advisor Natural Resources, World Vision Australia
- In the Talensi FMNR Project in dryland northern Ghana, focus groups reported that the additional fodder from tree leaf and grasses that remain in the agroforestry fields has fattened their livestock to such an extent that the dry season value has tripled, from less than GH¢100 (≈US\$53) to over GH¢300 (≈US\$159) and almost eliminated the need for boys to spend the day herding cattle long distances to find pasture. This was made possible by FMNR coupled with the elimination of field-burning and bushfires that enable FMNR shoots to regrow.²⁷³

“The animals have more feed than before because the grass is not burned off ... With more trees the surroundings are cooler so our health is improved. They look more healthy and fatter. You can bargain for a better price in the market. You could not sell the skinny ones in the dry season of maybe 100 GH¢, but the fatter one goes for 300 GH¢ at the lowest. Maybe more.” – Balungu women, Talensi, northern Ghana

- **Fertiliser**

- In northern Ghana, prior to the Talensi FMNR Project, farmers *“... expressed their frustration at having to cultivate ‘dead soils’”*.²⁷⁴ Following the

project, 94 percent of FMNR adopters observed that their soil fertility was improving, with 75 percent noting it was significant improvement, compared to six percent of non-adopters who felt their soils had significant improvement. Inversely, three percent of FMNR adopters felt their soils continued to degrade, compared to 21 percent of non-adopters. Project focus groups estimated that the soil improvement equated to approximately 50 percent of fertiliser applications per season (for those who use fertiliser) or GH¢18 (US\$10) per household per season after just two years.²⁷⁵

- Field trials in Mali by Bunch (2012) note that where trees cover 10 percent of the field, they contribute 25 tonnes per hectare per year of organic matter. Animals consume about a fifth, leaving 20 tonnes to gradually increase soil organic matter content over time. *“The resultant biomass would be plentiful enough, and have a high enough nitrogen content, to increase crop productivity over time by at least 100-200 percent (from an approximate average of 0.7 tons per hectare to about 2 tons per hectare over perhaps five years after the trees start producing seeds) ... Results from 152 farms show that agroforestry increased the yield of maize by 54-76 percent compared to unfertilized sole maize.”*²⁷⁶
- In an agroforestry project in Zambia, after a five-year period, farmers used 11 percent less labour but harvested 83 percent more maize.²⁷⁷

• **Pest and weed control**

- FMNR has been found to reduce the effort required to mitigate the impacts of pests and weeds. A meta-analysis of various sites across Sub-Saharan Africa found the presence of trees led to the suppression of insect pests and weeds.²⁷⁸ Trees attract predators that prey on crop-eating insects, like toads, lizards, birds and spiders, and provide alternative food sources for pests that would otherwise only have the crops to feed on.²⁷⁹ Technical reports speculate that the suppression of weeds is the result of trees' provision of mulch ground cover and healthier soils, given that weeds often colonise disturbed and degrading soil.²⁸⁰

• **Purchase substitutions for health and nutrition (foods, medicines and bush meats)**

“Even in dryland areas, many indigenous trees provide edible fruit, seeds, leaves and honey. Indigenous tree crops require less or no agricultural inputs other than the occasional pruning and harvesting.” – Peter Weston, Research and Evaluation Advisor, World Vision Australia

- Farmer testimonies in the Maradi region of Niger state that, as a result of the tree products associated with FMNR, many FMNR practitioners have a greater diversity of food sources. *“Some villagers in the Aguié district of Maradi, for example, harvest the leaves of a common scrubland tree, Maerua crassifolia, which are rich in vitamin A.”*²⁸¹ Access to bush meat also increased with a return of wild fauna, including hares, wild guinea fowls, squirrels and jackals.²⁸²

- In the Talensi district in dryland northern Ghana, a household survey of FMNR adopters found that 83 percent of all new trees in the landscape were edible fruit-bearing species. Furthermore, the return of indigenous trees in managed forests was increasing the availability of wild partridges and hares that were being caught and consumed, increasing children's protein intake. Overall, after just two years, 46 percent of households had experienced an increase in consumption of fruits and other wild foods.²⁸³

“The wild fruits, red, black berries, ebony and herbs ... There is now an excess. So anytime anyone wants fruit during three month fruiting season, it is available. We get shea nuts ... We eat the berries while farming and we have energy to keep farming. We sell these berries too (red, black and shea). All sell shea.”

– Tongo-Beo women, Talensi, Ghana

“We eat [fruits] any time we want to, and if our parents have not prepared food we can just go to the bush. I have had some fruit every day this week, since the beginning of the wet season. In the past ... we did not bother to look ... to check if there are berries or not. But now, it is a routine practice. Any time we are passing by, we make a brief stop-over to look for red berries to eat.” – Yameriga children, Talensi, Ghana

“[Community members] can get wildlife from there now that bush burning and destruction of forest has disappeared. They are even coming back to breed. This means meat. Animals include rabbits, partridge birds, antelopes, native rats, monitor lizards, snakes ... Before the land was so bare, there was nowhere for these animals. Now that there is natural regeneration of the shrubs, it is returning to how it was 100 years ago: forest.” – Edward Agumah, Ministry of Food and Agriculture, Ghana

23. Increases household assets

At both a household and community level, adoption of FMNR increases the stock of productive and saleable assets. These can be used to improve farm production, to sell in times of economic stress or as capital to secure loans.

The most common form of asset created by FMNR adoption is the increased stock of trees under a household's management. In every community across Africa, there is a ready demand for wood products. So the presence of trees is a form of "savings" or "insurance" that can be drawn upon when additional cash is required. Under the sustainable management process of FMNR, any tree harvested can be regrown to replenish the stocks. This "increase in assets" also provides a "fall-back" to buffer household nutritional and spending needs through lean times.²⁸⁴

Another form of asset value created by FMNR is the increased re-sale value of agricultural land. In Niger, some land entrepreneurs buy degraded land, rehabilitate it using FMNR and re-sell it for between 75 and 140 percent more than they acquired it.²⁸⁵

*"When drought and accompanying food shortages hit the regions of Maradi, Tahoua, Tillabéri, and Zinder in 2004–05, villages with high levels of adoption of FMNR fared much better than those devoid of trees. For example, villages in Aguié District were able to harvest regenerated trees for food, fodder and firewood to sell in exchange for grain. The inhabitants did not rely on emergency relief and did not have a single death of a malnourished child."*²⁸⁶

Increased assets have also taken the form of improved livestock values, due to the increased availability of fodder, shade to reduce animal stress, and reduced need for livestock to wander to find pasture.

- The end-of-project evaluation in the Talensi district of dryland northern Ghana found that reducing the need to herd animals for grazing reduces both the theft of animals and allows the animals to accumulate fat reserves. The increased cover also provided nesting locations for their guinea fowl to breed, and conceal chicks from hawks.²⁸⁷

"The animals no longer roam far for pasture because there is ample pasture around to feed." "The community forest has become an area for many animals from neighbouring villages that come to graze." – Tongo-Beo men, Talensi, Ghana

"Previously, our guinea fowl went far in search of shade to lay eggs. Now, there is shade cover." – Wakii men, Talensi, Ghana

24. Offers new income opportunities via carbon credit revenues

With careful mediation by NGOs, well-managed FMNR forest sites can generate significant revenues for community development as well as household incomes.

While more trees rapidly sequestering increasing amounts of atmospheric carbon is good for delaying the rate of global warming, it also represents a financial opportunity for rural communities. There is considerable interest in the creation of bio-carbon investment funds in Africa to channel carbon offset payments from developed countries to stimulate more carbon sequestration in African food crop systems while simultaneously enhancing the livelihoods of smallholders and the environment.²⁸⁸

- The World Vision-World Bank Humbo Community-based Natural Regeneration Project in Ethiopia has reforested approximately 2,728 hectares of community-managed land using FMNR. World Vision Australia brokered an arrangement between the participating communities and the World Bank Clean Development Mechanism. Brown et al (2011) estimate that this will earn the communities approximately US\$726,000 over the initial 10 years of the project.²⁸⁹
- Near Humbo, World Vision Australia and World Vision Ethiopia are also partnering in the Soddo Community Managed Reforestation Project to pursue carbon credit income via the voluntary carbon market for over 500 hectares of community-managed FMNR reforestation.

Gaps in evidence

While the benefits and limitations of FMNR have been clearly identified from the literature, including project evaluation reports, none of the 24 benefits listed above are currently proven by impact evaluation studies. As such, FMNR currently lacks an evidence base informed by counterfactual research trials in the field.^{vii} This level of evidence is required for acceptance of the benefits of FMNR by development research communities.

From this study we can deduce key impacts to evaluate and measure. Kabore et al (2012) break the findings down into five categories. They represent FMNR's contribution to:

- communities and farming systems;
- project contribution to positive change;
- unanticipated outcomes;
- partnerships and sustainability; and
- integration and cross-cutting themes.²⁹⁰

FMNR also currently lacks data on standard measurements over time relevant to its principal beneficial outcomes that can be measured in any location. This type of clear and concise evidence is particularly important to provide to potential funding bodies for further scale up of FMNR.

Using the three pillars of sustainability (social, environmental and economic) and relying on the expert contributions in this paper to date, a summary of the key output and outcome evaluation measurements for FMNR may include:

- **Social**

According to Grootaert and van Bastelaer (2001) social impacts and benefits are difficult to measure and it is necessary to use related indicators.

- Farmers/households practising FMNR, female or male household head
- Community awareness, women involved, women as leaders
- Household diet, nutrition, months of food insecurity
- Women's time required for firewood collection
- Number of groups and FMNR land management associations formed and active
- Membership and gender-mix of groups – numbers, community cross-section, attendances at meetings, participation in decision making, number of activities
- Informal networks, interconnectivity, cooperation (social capital)

- Trust between farmers and other stakeholders (eg, NGOs and extension agents)
- Partnerships with authorities, etc
- Stability and predictability of ownership/rights over land and trees
- Involvement and influence of community organisations in municipal, regional and support organisations
- FMNR coaches/champions/advocates – number, reach and effectiveness
- School attendance, children's knowledge of FMNR
- Marketing (eg, radio programs)
- Collective action

- **Environmental**

- Baseline appraisal of environment (eg, number of trees per hectare, physical condition of locality, soil fertility, soil moisture, depth of water table, etc)
- Physical spread of FMNR (hectares) over farmland and communal lands
- Number of regenerated trees (total and per hectare)
- Number of planted trees per hectare, costs of planted trees, failure rates
- Soil and wind erosion
- Soil organic matter and fertility
- Soil moisture, water tables
- Pasture growth, availability of stock feed
- Biodiversity (indigenous plants, animals and insects)
- Crop and pasture pests and diseases
- Edible native fruit and nut trees
- Pressures on surrounding environment

- **Economic**

- Baseline yields prior to the introduction of FMNR – crops, firewood, timber and livestock (averaged over previous years and most likely anecdotal)
- Yields from crops, firewood harvesting and timber harvesting from the commencement of FMNR
- Crop sales
- Fuelwood and timber sales
- Livestock condition

vii Counterfactual research trials establish what social, environmental and economic impacts occurred with FMNR intervention as opposed to what would have occurred otherwise. This can be achieved with one of a variety of impact evaluation methodologies.

- Livestock sales
- Off-farm income
- Income from micro-enterprises
- Less food, household, labour, education, health and other costs
- Yields of crops, fuelwood and timber from non-FMNR farmers

Because change in environmental and agricultural outcomes is a factor of human and climatic factors, building a strong evidence base requires comparing such results both:

- longitudinally (change within the partner communities over time); and
- laterally (change in the partner communities vs. change in similar non-participating communities).

Figure 17: Field visit, FMNR National Conference 2014, Timor-Leste. Source: Tony Rinaudo, Principal Advisor Natural Resources, World Vision Australia



Potential challenges

FMNR is outside mainstream practices

Potential challenges exist to building an evidence base and collecting data on standard measurements in response to the identified gaps in evidence.

Firstly, FMNR is outside the mainstream of agroforestry, agriculture and development practices in that it restores the environment mostly with naturally occurring vegetation, is holistic as it relies on integrated social, environmental and economic factors, and is also simple and inexpensive. This means that it may be more challenging for FMNR to be generally assessed and accepted by the appropriate research communities.

Experts in the areas of agroforestry, agriculture and development naturally tend to interpret the rationale and processes of FMNR through their area of expertise. Such reductionist perspectives can compromise understanding of FMNR as a holistic system. FMNR is a developmental response to deteriorating landscapes and livelihoods. It is:

- an agricultural intervention to increase farm yields;
- a livelihoods strategy to diversify and strengthen household resources and incomes;
- a community development strategy to increase social cohesion and empowerment;
- a method of environmental restoration;
- a form of agroforestry, but requires no tree to be planted; and
- it may be applied on-farm or in a forestry setting.

Land users may apply FMNR primarily for erosion control, soil fertility, timber production, food or fodder production, shade and wind protection, or water-table restoration. All of these applications are appropriate, but inadequate in isolation of one another.

FMNR occurs in the context of individual land users applying and adapting certain tree-management techniques, yet depends on cooperation of the land users' wider society and a conducive regulatory environment. The spread of FMNR relies first and foremost on changes in community attitudes through the recognition of a problem, motivation to change their situation, education, capacity building and reorganisation of collective decision making and action. FMNR is not just about trees or agroforestry or crop yields – it's about a transformation of attitudes, relationships between land users and landscapes, and social organisation.²⁹¹

FMNR is unique in that it restores the environment mostly with naturally occurring vegetation, which in turn is suited to each specific geo-climatic environment, tends to grow more quickly than planted tree seedlings, and restores the biodiversity of the local area. As explained by the Principal Research Scientist at the CSIRO, Richard Stirzaker, FMNR is quite “new” and tends to challenge conventional thinking on reforestation and sustainable farming practices. Stirzaker notes that, “*I do not think that any research program, no matter how well funded, would have come up with the idea, because it expertly combines the subtleties of location specific tree selection with farmer specific opportunities and constraints.*”²⁹² FMNR is thus “outside the square” of current thinking on agroforestry, while at the same time providing an effective method that optimally balances the land's resources and capacity with farmer input. Bringing agro-ecological approaches like FMNR into mainstream practices will be a crucial step in meeting global challenges such as degradation and desertification of land.²⁹³

Due to its holistic nature, a clear, working definition of FMNR does not currently exist. In recent times, debate has emerged about where the boundaries lie in relation to techniques that are or are not FMNR. Consensus exists in relation to selectively pruning and pollarding regrowth from the live stumps of felled trees. Beyond that, opinions diverge in relation to new growth from indigenous tree seeds.

- If land users identify and protect a spontaneously seeded sapling in their fields, is this also FMNR?
- If they dig pits to trap airborne tree seeds, organic waste and moisture with the intention of creating a micro-environment for seedlings to grow, is this FMNR?
- If they deliberately relocate a spontaneously growing sapling from one location into their fields, is this FMNR?
- If they purpose plant indigenous tree seeds across their fields in the expectation that some will germinate and, of those, some will survive to maturity, is this FMNR or just agroforestry?

Lack of coordinated research agenda

There is currently no guiding body or coordinated research strategy for building an evidence base for FMNR. Some hundreds of relevant methodologies for impact evaluation are available, such as the commonly employed Global Reporting Initiative, the SROI methodology recently successfully trialled by World Vision, and the International Fund for Agricultural Development's "Multidimensional poverty assessment tool" for measuring rural poverty.²⁹⁴ Some development practitioners prefer method selection according to individual project needs and others advocate selection of a common methodology to be applied across all FMNR projects.

There is a tendency in current monitoring and evaluation reports to use a divergence of measurement units of change – for example, individuals versus families or households. This can make it difficult to compare results between studies. A common model for evaluation and measurement of FMNR could potentially be applied across communities, regions and continents with the aim of making communicating the benefits of FMNR, comparative studies with other methodologies and revising FMNR practice more effective.

Given that most FMNR studies so far have drawn on householder and farmer perceptions (such as focus group discussions and household surveys that draw on individuals' recall) better bio-physical measurement is needed to measure change in crop productivity, soil fertility, moisture retention and erosion rates; and health sector measures of changes in child growth, food consumption and nutritional diversity.

Clear communication of evidence on FMNR to meet the information needs of three types of stakeholders is particularly important: partner (or potential partner) communities, implementing agencies and donors. This spread of stakeholders implies a spectrum of interests and research expectations, from biophysical, scientific measurement of change, to contextualised valuation of outcomes that are relative to the primary stakeholder community members' needs, aspirations and value systems.

In order to provide clear and effective communication, coordination is required so that overarching principles can guide further evaluation and measurement and required measurement units can be readily incorporated into these studies.

Conclusion and recommendation

FMNR is a method of restoring degraded natural environments to health and productivity. FMNR finely balances specific, local land restoration needs with farmers' objectives and capabilities.

The practice of FMNR is most prevalent across the Sahel region of Africa, and evidence in this region shows that on acceptance of the need to change, communities can transform their lives through the social and environmental impacts of FMNR leading to economic sustainability.

Literature on FMNR, produced up to the end of 2014, was collated and reviewed for this study, including nine project evaluations, 39 published research papers, 52 published expert reviews and opinions, 28 field reports, plus personal correspondence with FMNR experts and farmers as well as recorded anecdotes from the field.

This review identifies 24 broad ranging, key social, environmental and economic benefits of FMNR, as follows:

Social benefits

1. Fosters realisation, acceptance and the resolve to change
2. Creates an enabling environment
3. Builds collaboration, networks and partnerships
4. Fosters tree ownership and land tenure security for farmers
5. Increases education and training
6. Increases empowerment for women
7. Creates community advocates
8. Increases food security, health and resilience
9. Improves the environmental comfort of rural communities
10. Gives rise to hope and optimism which improves adaptive capacity
11. Reduces conflict

Environmental benefits

12. Widespread adoption of FMNR restores tree cover
13. Increases biodiversity
14. Reduces erosion
15. Enriches soils
16. Increases water availability
17. Reduces wind speed and temperatures
18. Increases climate change adaptation and mitigation

Economic benefits

19. Increases incomes through improved crop yields
20. Increases incomes through sale of tree products, including building timber, firewood, food, medicines, tool handles, furniture, etc
21. Increases incomes through improved livestock production
22. Reduces expenditures and increases consumables
23. Increases household assets
24. Offers new income opportunities via carbon credit revenues

One negative impact has been identified: the difficulty in collecting firewood during the lag time required for tree regeneration (1-2 years).

While the benefits and limitations of FMNR have been clearly identified from the literature, they are not currently proven by impact evaluation studies, which are required for acceptance by development research communities.

FMNR also currently lacks data on standard measurements over time relevant to its principal beneficial outcomes that would clearly communicate these outcomes to important stakeholders.

The potential challenges that exist to building an evidence base and collecting data on standard measurements are that FMNR is outside the mainstream agroforestry, agriculture and development practices and there is currently no coordinated research strategy for building an evidence base. Currently, differing views exist on how to achieve this as well as hundreds of possible impact evaluation methodologies that incorporate varying units of measurement.

The key recommendation from this study is the development of a coordinated research strategy that determines the next steps in building an evidence base for FMNR, including an approach for impact evaluation and identifying standard measurements to record over time.

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