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# SAHEL RESILIENCE LEARNING PROJECT (SAREL)

## Farmer Managed Natural Regeneration in the Sahel: A Literature Review

September, 2016

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### **DISCLAIMER**

The authors' views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

## **ACKNOWLEDGEMENTS**

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## Acronyms

DCI	Desert Community Initiative
FMNR	Farmer Managed Natural Regeneration
ICRAF	World Agroforestry Centre
MARP	<i>Méthodes Actives de Recherche et de Planification Participatives au Burkina (Réseau MARP)</i>
NDVI	Normalized Difference Vegetation Index
NGO	Nongovernmental organization
OASIS	Organizing for the Advancement of Solutions in the Sahel
RISE	Resilience in the Sahel Enhanced
RNA	Régénération Naturelle Assistée
SAREL	Sahel Resilience Learning project
SIM	Serving in Mission
SROI	Social return on investment
USAID	United States Agency for International Development

## Executive Summary

Farmer managed natural regeneration (FMNR) has been hailed as a highly effective and sustainable practice for enhancing community resilience in the Sahel region of Africa. Based on the centuries-old practices of coppicing and pollarding, its strategic use increased in Niger in the 1980's and has since appeared to contribute to a vast greening of the Sahel (Rinaudo, 2011). FMNR involves protecting the growth of selected shoots from living tree stumps and existing root systems and pruning the rest in a way that encourages the shoots' growth into straight tree trunks. The reported benefits of the practice are broad and range from environmental to economic to social (Francis & Weston, 2015).

**Purpose and methods.** This literature review aims to gather a variety of information about FMNR into a single document that can be used to provide information about research results, challenges and opportunities for implementation, and lessons learned to inform future strategies and policies. Commissioned by SAREL as part of USAID's RISE initiative, this review was conducted by University of California (UC) Berkeley's Organizing to Advance Solutions in the Sahel (OASIS) Initiative. Comprehensive literature reviews of research findings have already been completed that were based on studies and reports published through 2014. This review builds on that previous work, adding results from new studies and organizing results to respond to specific questions about the practice raised by RISE stakeholders. It also brings together recommendations for implementation and future research reported by various researchers and practitioners. Information for this review was gathered via searches of scholarly databases, NGO archives and Google, along with reviewing the bibliographies of relevant publications.

**Results.** Research findings about the practice have shown overwhelmingly positive results. Measured benefits have included increased tree cover, increased crop yields, and contributions to household income and local economic value. Economic benefits have resulted from sales from firewood, tree leaves, and other non-wood forest products. Per hectare profits have been reported to be greater for poorer farmers compared to their wealthier counterparts, though gross benefits are greater for richer farmers (Reij & Winterbottom, 2015). Some determinants of FMNR adoption are soil type, market access, and education (Haglund, Ndjeunga, Snook, & Pasternak, 2011). Asset building, health outcomes and psychosocial well-being are additional areas where research has begun to show positive impacts (Weston, Hong, Kaboré, & Kull, 2015). Farmers report experiencing many benefits, with some fears about negative consequences being cited as barriers to adoption. Benefits to women have been noted, particularly around the time saved from collected firewood (Reij 2006, as cited by Stickler, 2012).

**Factors for success.** Common factors that have been observed to contribute to the success of FMNR include:

- Favorable policy environments that address land tenure issues and tree user rights
- Farmer awareness of the immediate benefits that can be achieved from the practice
- A change in the mindset from tree-planting to tree protection as more effective and sustainable
- The inclusion of all stakeholders – particularly farmers and local communities – in adapting FMNR to local contexts and deciding on strategies for scaling up

- Environmental conditions such as soil type, level of rainfall and population density
- A sense of crisis that increases community investment in making innovative changes

**Challenges.** Challenges that have been described around implementation and scaling up are:

- A mentality that tree-planting is a better solution than protecting existing systems
- Long-held beliefs by farmers that trees on farmland will attract pests and/or reduce yields, and so trees should be completely cleared
- Low levels of awareness about the diverse and immediate benefits that arise from FMNR adoption
- Environmental obstacles
- Determining who will finance the scaling up of FMNR

**Recommendations for implementation and scaling up.** Recommendations for increasing the impact of FMNR have been defined for specific localities as well as for large-scale implementation. A six-step framework developed by Reij and Winterbottom (2015, p. 7) suggests the following for scaling up the practice:

1. *Identify and analyze existing greening successes.*
2. *Build a grassroots movement for greening and mobilize partner organizations.*
3. *Address policy and legal issues and improve enabling conditions for greening.*
4. *Develop and implement a communication strategy.*
5. *Develop or strengthen agroforestry value chains.*
6. *Expand research activities.*

**Conclusions and limitations.** This literature review summarizes evidence that reinforces the view that FMNR has had significant benefits for local communities. FMNR's community-led orientation as well as the low cost of adoption have been shown to provide unique advantages over other, externally-driven development initiatives. Limitations for this review include its reliance on published findings that are available online via scholarly databases or are publicly searchable, and only those that are written in English or French. Possible reporting biases from institutions that are already funding FMNR programs, as well as by this author, should also be acknowledged.

**Recommendations for future research.**

- Development of a coordinated research strategy and selection of standard measurements that can be used to measure impact over time
- Continued and expanded use of participatory approaches to evaluation that further integrate community members throughout the evaluation process
- Additional research that measures the non-monetary benefits of FMNR
- Cost-benefit analyses that compare tree-planting approaches that have been tried, or other similar interventions, to FMNR

## Introduction

The narrative surrounding environmental changes in the Sahel formerly focused on the crisis of desertification. This was said to be caused by overexploitation of land and natural resources in addition to the effects of climate change (Stith, Giannini, Corral, Adamo, & de Sherbinin, 2016). The analysis of satellite images, however, has provided alternative evidence showing that in fact, vast areas of land in this region have been “regreened” over the past few decades. Given the many benefits of tree growth for communities, including for agricultural production, attention has turned to emphasizing how this regreening has been achieved and how to sustain it (Sendzimir, Reij, & Magnuszewski, 2011). One practice that is said to have significantly contributed to regreening of the landscape is Farmer Managed Natural Regeneration (FMNR) (Weston et al., 2015). The reported benefits of FMNR for rural communities are numerous and range from environmental to economic to social (Francis & Weston, 2015). FMNR is considered to be a promising practice for increasing community resilience in the face of shocks exacerbated by climate change in the Sahel, such as droughts and floods, as well as food price shocks (Reij & Winterbottom, 2015).

## Purpose

This literature review on FMNR seeks to provide a summary of current findings about the practice regarding its impact on enhancing household and community resilience. Additionally, it aims to answer some key questions by consolidating the wisdom and experiences reported by communities as well as by implementers of FMNR programs in the field that can inform future efforts to scale up the practice. This review was conducted by UC Berkeley’s OASIS Initiative on behalf of the Sahel Resilience Learning project (SAREL). SAREL is a project of USAID’s larger Resilience in the Sahel Enhanced (RISE) Initiative that seeks to test, expand and accelerate the adoption of proven resilience-enhancing methods and innovations. FMNR was selected for closer review to better understand the potential impacts of this acclaimed practice on Sahelian rural households and communities, and to analyze the conditions necessary for its widespread adoption.

This review’s objectives are to:

- 1) build on a previous literature review conducted by Weston, Hong, Kaboré, and Kull (2015) to summarize the latest findings on the impacts of FMNR
- 2) highlight the perspectives of farmers and communities to assess whether FMNR is meeting their needs
- 3) review the opportunities and challenges faced during implementation so that the lessons learned can be applied to ongoing efforts for FMNR expansion in Niger and Burkina Faso

## Methods

Data for this literature review was gathered using the scholarly databases of CAB Abstracts, AGRIS, and SCOPUS, Google searches, NGO archives, and reviewing the bibliographies of relevant articles for additional sources. Documents were searched for in English and in French using the term FMNR or the French translation, *Régénération Naturelle Assistée* (RNA). Given that a comprehensive literature review was conducted by Weston et al. in 2015 that included literature published through 2014, this document picks up where Weston et al. left off in reviewing scientific articles. After providing a summary of their findings along with the results of

subsequent research on FMNR, this review answers a series of questions about how FMNR is experienced and discusses factors contributing to its success. This is followed by a synthesis of the advantages and challenges reported in implementing FMNR along with recommendations for strengthening and scaling up the practice. The conclusion discusses the limitations of this review and provides recommendation for future research.

## Background

### Terminology

**Farmer managed natural regeneration** is “the practice of actively managing and protecting non-planted trees and shrubs with the goal of increasing the value or quantity of woody vegetation on farmland” (Binam et al., 2015, p. 545). The process involves identifying and protecting the most “vigorous” stems that are growing from living tree stumps, removing the remaining stems, and tying together the selected stems so that they grow straight into a new trunk (Weston et al., 2015). FMNR is considered an **agroforestry** strategy. Agroforestry is a land use system involving the joint use of woody perennials (such as trees or shrubs) and agricultural crops in the same area of land, resulting in ecological and economical interactions (Lundgren & Raintree, 1983). Unlike some agroforestry practices, it does not rely on planting new trees. Instead, FMNR makes use of the existing root systems and tree stumps that are already growing there.

As an agroforestry practice, FMNR leads to the “regreening” of landscapes. **Regreening** is achieved by “increasing the number of both on-farm trees and, in some countries, off-farm trees through natural forest management and for the protection and management of natural regeneration on degraded land” (Reij, 2012). Agroforestry and regreening can be considered larger umbrella terms, with FMNR being a specific technique, albeit one that has a great deal of flexibility and adaptability.

### Origins and evolution of FMNR

FMNR is not a new technique; it is considered to be a modern version of the centuries-old practice of “coppicing and pollarding” (Rinaudo, 2011). Coppicing involves strategically cutting off young tree stems near the ground to encourage regrowth, and pollarding requires cutting tree stems or branches at a height of two to three meters from the ground with the same objective.

Various forms of FMNR have been practiced for centuries around the world. It gained greater international attention after Nigerien communities in the Maradi region began using the practice in 1983. Tony Rinaudo is described as having facilitated the practice’s expansion at that time while working there under the missionary organization, Serving in Mission (SIM). There is anecdotal evidence that FMNR was also spontaneously “rediscovered” in Niger and neighboring countries around the time that it began to spread in the Maradi region through SIM (Francis & Weston, 2015).

Given that Niger was a focal area for the development and scaling up of FMNR, much of current research covers Niger and neighboring countries like Burkina Faso. In 2008, World

Resources Institute reported that over a span of 27 years – since FMNR was introduced in Niger – it has been practiced on more than half of Niger’s farmland (5 million hectares) with minimal NGO or government intervention (Rinaudo, 2011). Francis and Weston report that over a 20-year period, the average reforestation rate for Niger’s farmland was 250,000 hectares per year. A brief by Stickler (2012) provides a detailed description of the historical context in which FMNR arose in Niger. It discusses changes in land tenure and degradation of natural resources in the Sahel as a result of French colonial policies in the 19<sup>th</sup> century and recent shifts that have facilitated FMNR’s success.

## Results

Initial research on FMNR tended to focus primarily on Niger, but newer studies and reports are also coming from countries like Ethiopia, Ghana, and Uganda. The benefits of the practice have been shown to be numerous and diverse, with the only major area of mixed results concerning FMNR’s direct impact in increasing crop yields. After discussing the impact of FMNR, this section synthesizes information from studies and reports about farmer perspectives on FMNR, incentives to adopt FMNR, as well as factors that have reportedly contributed to its success.

### What is the impact of FMNR?

#### Peer-reviewed results

Weston et al. (2015) determined that the majority of publications about FMNR were based on 10 studies with original research. They organize the findings of these 10 studies into three general categories: *increased tree cover*, *increased crop yields*, and *household income and local economic value*. All the findings they discussed were described as having favorable results in these areas. Six new peer-reviewed studies with original research published after 2014, or not included in Weston et al.’s literature review, were found by this author. The findings of these new studies will be briefly described below using the same three categories identified by Weston, plus *livelihood impact*. Inclusion of livelihood impact responds to a perceived research gap based on research from Weston et al. A table modeled after that in Weston et al.’s literature review can be found in the Appendix that summarizes information about these six additional studies.

**Increased tree cover.** A 2016 study by Stith, Giannini, Corral, Adamo and de Sherbinin provides additional evidence that FMNR increases tree cover where it is practiced. The researchers conducted a spatial analysis of Burkina Faso, Mali, Niger and Senegal to ascertain whether human influences have been effective in combatting land degradation in the Sahel. The researchers did this by overlaying three variables on a map: the number of donor-funded environmental development projects per *région*, the population density, and NDVI, which measures the density of vegetation in an area (taking corresponding precipitation into account). While their study refers to “regreening” and not FMNR specifically, they find that their analysis “lends partial quantitative support” to the theory that the regreening of the Sahel has indeed been assisted by human intervention (as opposed to the possibility that regreening occurred independent of anthropogenic activity.)

In Niger, Baggian, Adamou Mahaman, Adam, and Mahamane (2013) measure changes in tree density in farmers’ fields over time. This study was not included in Weston et al.’s review.

Bagnian et al. found that tree density in Maradi increased in the village of Dan Saga (from 146 to 151 trees per hectare) and El Guiéza (from 60 to 109 trees per hectare). In Zinder, tree density in fields increased from 32 to 79 trees per hectare where there was leadership in managing FMNR; conversely, where the authors describe there not being an oversight committee or leadership in managing FMNR, tree density decreased from 650 to 65 trees per hectare. These results are further discussed in the “What factors make FMNR most effective?” section below.

Another study by many of the same authors came out a year later that assesses the status of specific species of trees that were protected through FMNR (Bagnian, Adam, Adamou, Chaibou, & Mahamane, 2014). In the northern zone of Maradi, two species were found to be in a poor state, and two species in southern Maradi were determined to be vulnerable as young plants. In the Zinder region, only one tree species (*faidherbia albida*) among the five that were studied appeared to be stable in regeneration. The researchers determined that the stability of only one particular tree species was due to the communities’ perception that it was valuable and worthy of being actively protected. This finding can be useful in determining which tree species have the greatest chance of success for regeneration.

Badji, Sanogo, Coly, Diatta and Akpo (2015) conducted a study in Senegal, specifically in the Khatre Sy area, to compare tree growth in farmer fields where FMNR was being practiced to protected land where neither agriculture, livestock grazing, nor FMNR was practiced. They found that trees were less dense in farmer fields than in protected areas, but that this had two explanations: there was a need to clear more trees in farmland to make room for plowing, and with FMNR there was pruning of shoots to encourage new growth. The other tree dimensions, though, e.g. diameter, height, and basal area were found to be better for trees where FMNR was practiced compared to protected land where FMNR was not utilized.

**Increased crop yields.** No additional peer-reviewed studies after 2014 were found that measure the impact of FMNR on crop yields. However, a study mentioned in Weston et al.’s literature review includes findings about crop yields that were not included. Haglund, Ndjeunga, Snook, and Pasternak (2011) found that FMNR did not appear to result in increased cereal production yields, nor to decrease the duration of perceived food shortages. However, they found that FMNR did appear to increase crop diversity, which they say may explain how FMNR supported an 18-24% increase in income for practitioners.

**Household income and local economic value.** Binam et al. (2015) add to the evidence base showing that FMNR increases income as well as food security. Their economic analysis of a sample of 1080 households in Burkina Faso, Mali, Niger and Senegal found that an average household in the Sahel practicing FMNR continuously would gain a gross income increase of \$72 USD per year. They found specifically that the value of products harvested from trees increased by about 34-38% for households that were actively implementing FMNR compared with those that were not.

**Livelihood impact.** In the second half of the Weston et al. literature review, the authors present their original research using a “social return on investment” (SROI) methodology to study FMNR in the Talensi community in Northern Ghana. This study was also the focus of a

World Vision report, with more detail provided about the SROI methodology and additional results found (Weston & Hong, 2013).

Weston et al. stated that theirs is the first study that aims to quantify non-monetary benefits of the FMNR, like health and psychosocial benefits, which they cited as a gap in existing literature based on their review. From the data they gathered, Weston et al. estimate that the livelihood impact per household from the FMNR project there was between \$655 USD and \$887 USD per year, including the social, health, environmental, and economic values. Through their interviews with farmers, they found that the most valuable outcomes from the perspective of farmers were:

*(1) increased assets in the form of tree stocks and improved livestock; (2) increased wild resources (especially wild foods and construction inputs) for household consumption and sale and associated dietary health benefits; (3) improved psycho-social wellbeing as a result of a more aesthetically pleasing and comfortable community and work environment, enhanced leadership capacity of FMNR group members, and a more positive outlook; and (4) improved soil fertility and crop yields" (Weston et al., 2015, p. 1415).*

Regarding household dietary diversity, Binam et al.'s study measured an increase of 12-14% in Burkina Faso, Mali, Niger and Senegal among those practicing FMNR.

### **Grey literature**

In addition to the scientific literature that seeks to quantitatively measure the benefits of FMNR, numerous NGO reports have been published on the topic that also discuss the advantages of the practice for communities. One of the most comprehensive documents is a World Vision literature review that articulates 24 different benefits to the practice, backed by their findings from research and reports (Francis & Weston, 2015). The authors categorized the benefits as social, environmental, or economic in nature. These benefits are elaborated upon in the World Vision report and documented widely elsewhere, so they are not enumerated here. The only potential negative impact of FMNR that Francis and Weston reported was difficulty in collecting firewood during the one to two-year timespan that it takes for regeneration to occur.

### **Who is participating in and benefiting from FMNR?**

Most of the information in the literature about which segments of the population are practicing and benefiting from FMNR is anecdotal. However, Haglund et al.'s study includes a description of their sample population as well as a regression analysis that looks at determinants of FMNR uptake. Based on their sample of 410 households (10 households from 41 different villages), they found that adopters of FMNR were more likely to be able to read and write and to be female. The finding on literacy is consistent with research on characteristics of adopters of new farming technologies that shows that higher education levels tend to lead to greater willingness to innovate and take risks (Knight, Weir, & Woldehanna, 2003). Haglund et al.'s sampled households that adopted FMNR tended to live farther from markets and disproportionately in areas with non-sandy soils. FMNR-adopters appeared to have higher incomes, greater assets, and increased cereal production. The researchers found that adoption of FMNR appeared to be determined largely by three variables: soil type, market access and education. Probability of adoption increased the farther the household lived from the market, up to a distance of about 15 kilometers; after 15 kilometers, adoption decreased. Explanations for this were a series of

possible competing incentives and disincentives related to distance from the market. For every year of schooling for the head of household, the probability of adopting FMNR increased by 2.8%. The researchers' data showed no significant effect on the probability of adopting FMNR based on whether an individual lived in a community that had hosted an FMNR-promoting project or program.

Women are said to benefit substantially from the adoption of FMNR, with one advantage being the reduced amount of time they spend collecting firewood once the wood supply has increased. Stickler cites Reij (2006) in saying that the time women spend collecting firewood where FMNR is not adopted averages 2.5 hours compared to 30 minutes where FMNR is practiced. Another benefit cited for women in Niger's Zinder region is that they can make up to \$210 per year selling leaves from baobab trees that they own; Reij et al. (2009) also say that farmers report that women engaged in FMNR hold better positions economically and are better able to provide a nutritious and diverse diet to their families.

In terms of wealth, Reij and Winterbottom say that in some cases it may be that poorer farmers in Niger have higher tree densities on their farms than do rich farmers (Yamba & Sambo, 2012, as cited in Reij & Winterbottom, 2015). They suggest this may be due to the strong dependence of poor farmers on their lands to maintain their livelihood. A study they cite by Sambo (2008) indicated that wealthier farmers generated greater incomes from FMNR than poorer farmers, but that this could be explained by the greater amounts of land maintained by wealthier farmers. When broken down on a per hectare level, "poor and extremely poor farm families" earned higher incomes from FMNR than did wealthier families.

Quantitative data on who is practicing and benefiting from FMNR is relatively limited. What has been reported so far in the literature is that women in particular have received benefits; a certain income level is not required in order to adopt and benefit from FMNR; and some determinants of uptake include soil type, market access, and education level of the head of household.

### **What do farmers think of FMNR?**

Farmers in Niger were quoted as discussing the significant improvements in soil fertility and crop yields that result from having gao trees (*faidherbia*) in their fields, according to a World Agroforestry Centre report (Pye-Smith, 2013). The report says that most farmers describe multiple reasons why they practice FMNR and that the reasons may vary between villages, but that a common theme is the impact on crop yields. Farmers talked about how *faidherbia* drops its leaves before the rainy season, which makes soils fertile, and how the trees grow back the leaves during the dry season, providing shade.

Weston et al.'s study found that what was most important to the Ghanaian farmers was not necessarily the increase in income, but rather the nonmarket benefits such as asset development, health improvements, and psychosocial well-being. Their study used a social return on investment (SROI) approach, which they define as "conceptualizing proxy values for social benefits of an initiative" (p. 1403). The advantage of the SROI methodology as a research approach is that its participatory nature allows it to measure hard-to-quantify benefits in a way that is relevant and useful to the stakeholders. It relies on the perceptions and experiences of

the stakeholders themselves in assessing the value of financial returns (Brouwers, Prins, & Salverda, 2010). Weston et al.'s findings provide insight into benefits that had not previously been quantified regarding FMNR.

The USAID report by Larwanou, Abdoulaye and Reij (2006) classifies how Nigerien farmers perceive benefits of FMNR into eight categories. They reported benefits on revenue, the environment, agriculture, livestock-raising, food security, nutrition, women and youth. More details on each of the benefits can be found in their report.

Various videos have been created by World Vision, Réseau MARP, Sahel ECO and other entities that highlight farmer experiences and perspectives on FMNR. These are publicly available for viewing online (World Vision, 2013). Farmers are featured talking about how FMNR has yielded multiple benefits for themselves and their communities.

Some fears of possible negative consequences of FMNR that are held by some farmers were described by Reij and Winterbottom (2015). They mentioned that some farmers worried that certain species of trees may lead to declines in crop yield; that trees may attract birds that can damage crops; that the snake population may increase with the expansion of vegetation; and that conflicts between sedentary farmers and semi-nomadic herders may increase as tree growth expands. These worries were both acknowledged as potential consequences (such as how the shea butter tree can indeed have a negative impact on crop yields) and countered by descriptions of how farmers have innovated to deal with them, or how the consequences are outweighed by the net benefits.

One challenge described in the literature was farmers' fears of being labeled as foolish or not competent if they practice FMNR where it has not yet been widely accepted (Rinaudo, 2012). The literature talked about how in some communities, fully clearing fields of trees was perceived as a good farming practice (Tougiani, Guero, & Rinaudo, 2009). When this is the case, the decision to begin strategically protecting trees in farm fields can be considered a social risk by some farmers, even if they believe in its value.

### **What encourages farmers' engagement?**

Larwanou et al. (2006) conducted a study for USAID to determine what led communities in the Zinder region of Niger to invest in FMNR. They categorized the motivations broadly as 1) the ecological crisis of the 70's and 80's, 2) demographic pressure and changes in production, 3) state involvement and changes in forest policies, and 4) interventions from development partners. Regarding the ecological crisis, the researchers say that community members they interviewed often mentioned the word "Sahara", referring to strong winds. These winds were no longer blocked by trees and they displaced sand and dust. The sand would mow over young millet and sorghum plants, in some cases requiring them to plant their crops three times before the crop would survive.

Rinaudo (2011) suggests that the breakthrough that encouraged the spread of FMNR to more than half of Niger's farmland was social rather than technical: it involved changing the collective mindset from one in which trees on farmlands were considered 'weeds' that needed removing

as well as altering the laws that took the ownership and authority to manage of trees out of the hands of communities and placed it under the government's purview.

The importance of farmers having an incentive for practicing FMNR is another theme arising from the literature. Rinaudo (2011) says that this does not have to be in the form of cash or a subsidy, but rather an assurance that farmers have something to gain from their efforts. Reij, Tappan and Smale (2009) posit that farmers have a greater likelihood of adopting "resource conservation innovations" if significant benefits are achieved in the first or second year. In their study of FMNR in the Maradi region, Haglund et al. attribute the practice's widespread adoption to the benefits that are achieved at a low cost to farmers. Labor is the only requirement; there are no other expenditures required for the practice, which makes it more accessible to more farmers.

### **What factors make FMNR most effective?**

Success stories of FMNR in Niger, Burkina Faso, and elsewhere in the Sahel abound. Various authors have sought to highlight what specifically has yielded positive results when implementing FMNR. Bagnian et al. (2013) conclude that management methods of FMNR have contributed to increasing ecosystem resilience in Niger. Management could be through the establishment of village oversight committees or by the quality of the leadership of village heads. The researchers determined this impact by observing tree density in fields in Maradi and Zinder. In Maradi, where there was an oversight committee from 2005-2012, tree density increased over time; the same was true for the Zinder sites where there was effective leadership. They compare this to the decrease in density of trees at Zinder sites where there was no oversight committee or leadership. They do note that there is a positive trend in tree stands for all sites, but recommend continued awareness-raising among communities about FMNR so that it can be effectively managed to achieve benefits.

Reij, Tappan, and Smale say that the projects that became successful in the Sahel often started out small in scale and involved close collaboration with local farmers in the identification of solutions. They also describe the important role played by "charismatic leaders" from inside and outside the community who act as role models through their decisions and their actions. Reij et al. say that several stories that were recounted to them portrayed a leader "willing to take socially risky actions that diverged from customary behavior" (p. 57). Tougiani et al. (2009) write about the Desert Community Initiative (DCI) in the Aigué department of Niger, whose success they say was largely due to its inclusion of all stakeholders. DCI recognized and built on local knowledge and experiences, creating a collaborative environment where scientific and local knowledge could be combined.

In describing the reasons for success of FMNR in the Maradi region, Cunningham and Abasse (2005) cite multiple factors, including the change in perspective of trees as nuisances or "crop competitors" to one in which trees are seen as beneficial for crop yields, sustainable farming, and income generation. Others factors for success were:

- *The desperate need for wood*

- *Wide exposure in the district through teaching and demonstration via Food for Work programs and trust in the MIDP [Maradi Integrated Development Project] extension staff*
- *FMNR spread from farmer to farmer without dependence on projects*
- *Farmers were given ownership of trees on their own land*
- *The development of a culturally appropriate and community-based regulatory system ensured farmers' trees were protected*
- *The FMNR is simple, profitable and required only the farmer's labour*
- *Trees were quickly recognized as useful and crop yields improved*
- *There was increased fodder available for livestock (Cunningham & Abasse, 2005, p. 5)*

Rinaudo (2011) offers seven factors for the success of FMNR: 1) community-felt need; 2) building capacity, either farmer-to-farmer or via an external agency; 3) establishment of organizational structures with locally developed by-laws or regulations; 4) favorable policy environment; 5) access to markets for wood and non-timber forest products; 6) broad spectrum buy-in from a wide swath of stakeholders; and 7) a long-term view of implementing the practice that recognizes that adoption takes time and that encouragement and consultation should be offered for at least five years, if not eight. (p. 192-193). He also describes two ways that farmer-led reforestation has been facilitated on a large-scale: returning ownership of trees to the farmers who protect them, or giving farmers tree user rights. Stickler describes how farmers in Niger did not always have legal rights to the use of trees. Legislation like the Aubreville Decree of 1935 nationalized all vegetation, which made it necessary for Nigeriens to purchase permits in order to harvest and use wood. The post-colonial government also maintained state ownership over all forest resources. Policies like these discouraged farmers from actively protecting and managing trees. In such a setting, FMNR cannot be freely practiced. Stickler describes how, in recent decades, policy and institutional reforms like the 2004 Forest Code have eased restrictions on farmers as governance of natural resources becomes more decentralized in Niger. While she acknowledges the importance of these changes in helping to increase FMNR adoption, Stickler argues that they are other factors that may be even more impactful in changing farmers' incentives to take care of the trees on their land. Among the factors she cites are:

*the wide dissemination of the Rural Code in local languages and at regional workshops, the consensual development at the local level of informal rules and institutions to manage private property rights to trees, and the transformation of the Forest Service from a paramilitary institution that punished farmers for cutting trees into an extension service that helped farmers adopt simple tree management practices (p. 6).*

Reij and Winterbottom (2015) look at the experiences of large-scale on-farm greening in Niger and Mali to determine what factors have contributed to positive and quick results. They suggest that a combination of the following factors would likely result in farmers more readily investing in on-farm greening: "A sense of crisis because of drought and erratic rainfall, land degradation, and declining crop yields; low on-farm tree densities and scarcity of fuelwood and fodder; high population densities, reduced fallow periods for cropland, and expansion of agricultural land use; ...rainfall in excess of 400 mm/year;" and "sandy soils" (p. 54).

### **Are there any instances where FMNR hasn't worked?**

This author found no instances found where FMNR adoption “failed” and was desisted in a particular community; this does not mean that FMNR is necessarily implemented successfully on the first try everywhere. Negative results may not have been documented, may not have been found by this author, or may have been overcome with time and eventually led to positive impacts.

The previously-mentioned study by Bagnian et al. (2014) showed that regeneration success varied among the five species that were the focus of protection efforts via FMNR. The researchers say that their findings contradict those of Ouédraogo (2006) and Traoré (2012) who found that in east and west Burkina Faso, the young tree populations were stable (a characteristic of good regeneration). However, Bagnian et al. do note that the composition and structure of woody vegetation varies considerably from one location to another, so it may be difficult to accurately compare results from Niger and Burkina Faso. The findings from Bagnian et al. about the poor regeneration of certain species do not necessarily indicate that FMNR was not effective in those cases, but they do suggest that some species may yield more positive results than others for various reasons. One example is how the intentional efforts to protect shoots of *faidherbia albida* in Zinder resulted in strong growth of that species, compared to the poor growth resulting from other species that were perhaps less intentionally protected.

## **Discussion**

The results from FMNR evaluations and studies are overwhelmingly positive, with a variety of benefits being cited that are accessible to farmers regardless of income-level. This section discusses the unique contributions brought by FMNR compared to other practices that have similar objectives, as well as the challenges that are faced with implementation. Also reviewed is the literature about scaling up of FMNR and the opportunities for the practice in Niger and Burkina Faso.

### **What are the advantages of FMNR over other practices?**

Frequently discussed in the literature is the low-cost nature of FMNR combined with its farmer-driven orientation. Past efforts to plant thousands of trees in an effort to avoid desertification, with a higher value placed on introducing non-native species, led to little improvement at a very high financial cost (Rinaudo, 2011, 2012). FMNR takes advantage of the existing “underground forest”, which has led to significantly greater success in regreening the Sahel. There is no cost to farmers to practice FMNR beyond the additional labor that it requires (Haglund et al., 2011). The knowledge on how to undertake FMNR can be passed on from farmer to farmer, and it relies on farmers using their own knowledge and experience to make decisions about which trees are most useful to them and how they can best tailor the practice to meet their own needs. The flexibility and grassroots nature of FMNR are key factors that make FMNR a more sustainable practice because farmers are using locally available and known techniques and resources (Reij et al., 2009).

### What challenges are faced in implementation of FMNR?

**The dominant mentality.** Several authors discuss the importance of changing the mentality around FMNR and integrating agroforestry into the “dominant agricultural development paradigm” (Reij & Winterbottom, 2015, p. 57). Some farmers fear that having trees on their farmland will both lower crop yields and attract pests that would damage their crops (Rinaudo, 2011). In addition to fears, Rinaudo talks about how the prevalence of a tree-planting mentality is an obstacle to FMNR because there is a mindset that planting new trees is a better intervention than cultivating and protecting existing vegetation.

**Level of awareness.** Related to mentality is the level of awareness about FMNR and its potential. Lack of awareness of the benefits of FMNR is an obstacle to effective implementation, as is absence of government promotion of it as an effective intervention (Rinaudo, 2011).

**Environmental obstacles.** Cunningham and Abasse cite some environmental challenges faced in implementing FMNR. These include the need for live stumps of the tree species to be used for FMNR in the fields; the occurrence of droughts, which can reduce FMNR impact if farmers are forced to cut down the trees to gain income in the face of famine; and climate, such as in areas with lower rainfalls where trees may grow more slowly and immediate benefits to farmers may take longer to manifest.

**Financial barriers.** Reij and Winterbottom (2015) pose the general question of who is going to finance the scaling up of greening. They talk about how the low cost of implementing FMNR can actually be a barrier to obtaining funding for it in some cases because donors may be more attracted to high-cost projects. In terms of reporting on FMNR benefits, it can be challenging to quantify the many improvements that greening can bring to communities, which is important for donors when soliciting their funds. Regarding government financing, a perception of FMNR’s inability to produce revenue may deter government departments from funding it (Rinaudo, 2011).

**Legal/political context.** Unfavorable land ownership and tree user rights legislation has been cited as an obstacle to effective implementation (Rinaudo, 2011). As was discussed previously, though, this has begun to shift positively over time in the region. A lingering result of unfavorable laws has been farmers fearing that they will not benefit from taking care of trees, which reduces their incentive to engage in FMNR.

**Additional challenges.** Some additional challenges cited in the literature are: monitoring/mapping systems that are unsuited for measuring tree growth outside of forests (Reij & Winterbottom, 2015); and cultural values - such as around innovation, individuality, and respect for property – which can affect uptake of the practice (Cunningham & Abasse, 2005).

### What does the literature say about scaling up FMNR?

This author did not read any studies that countered proposals for FMNR to be scaled up; scaling up is a common theme in reports on the practice. Reij and Winterbottom (2015) provide a 6-step framework for scaling up “greening”. Each step in their report includes a list of on-the-ground activities to be carried out. The steps are listed below, with additional information on each step available in the Reij and Winterbottom report (p. 7).

1. *Identify and analyze existing greening successes.*
2. *Build a grassroots movement for greening and mobilize partner organizations.*
3. *Address policy and legal issues and improve enabling conditions for greening.*
4. *Develop and implement a communication strategy.*
5. *Develop or strengthen agroforestry value chains.*
6. *Expand research activities.*

A 2012 brief by Reij details 14 steps to help scale up greening, which he says were identified through lessons learned from the African Greening Initiative that started in 2009. One lesson about greening, reported on by Reij et al. (2009), was that while a single technique may not be enough to fully achieve the desired economic and environmental impacts, it may be a catalyst for other innovations that can magnify the impact. The way that this informs strategies for scaling up is that rather than proposing one rigid strategy on how to attain large-scale adoption of FMNR, a menu of options should be proposed that are “flexible, adaptable, and testable by farmers” so that they reflect the unique context and conditions of different regions, communities, and individual farmers.

### **What are the opportunities for FMNR in Niger and Burkina Faso?**

As was shown in the results section of this paper, FMNR has seen significant success in Niger and is continuing to expand its reach. The legal environment has become more favorable to the practice over time through the changes in tree user rights and the shift from forestry agents “policing” tree use to facilitating their conservation by collaborating with communities (Stickler, 2012). FMNR can be successfully spread from farmer-to-farmer and is not dependent on the establishment of costly, long-term development projects whose departure will then result in a stopping of the practice. Farmers reap initial benefits just one to two years after starting to practice FMNR, which facilitates its uptake and continued use.

Many organizations and research agencies continue to fund FMNR in the region. World Vision created an online “FMNR Hub” where reports and information about the practice around the world are collected and made easily accessible to the public (World Vision, 2013). Included are a series of videos that have been shared by agencies about FMNR in practice. Many organizations that work in Niger and Burkina Faso are including FMNR in their program strategies, such as Mercy Corps (Mercy Corps, n.d.), and Ecosystem Alliance (Farmer-Managed Natural Regeneration programme in Burkina Faso and Mali: Lessons learned by the Ecosystem Alliance, n.d.). Méthodes Actives de Recherche et de Planification Participatives au Burkina (Réseau MARP), a network established in 1992 in Burkina Faso for the promotion of participatory approaches, uses FMNR as the strategy for their Initiative Reverdir le Sahel (Réseau MARP, 2012). Research institutions including World Resources Institute, International Food Policy Research Institute, and World Agroforestry Centre (ICRAF) have investigated the practice and have proposed policies that incorporate FMNR for large-scale change. In 2016 the World Bank approved \$111 million for the Niger Climate-Smart Agriculture (CSA) Support project, which will include among its activities expanding agroforestry (The World Bank, 2016). USAID has funded an evaluation of FMNR in Niger (Larwanou et al., 2006) and it is part of the best resilience practices promoted by several RISE Initiative partners including the Resilience and Economic Growth in the Sahel – Enhanced Resilience project (REGIS-ER).

## Recommendations

**For scaling up.** As discussed in the previous section, Reij and Winterbottom's 2015 “Six steps for greening” report offer specific steps and strategies for scaling up FMNR and serve as good references for practitioners engaging in this work. Reij and Winterbottom (2015) write that scaling up of greening necessitates “flexibility, transparency, and minimum bureaucracy”, in addition to a change in donor expectations for immediate and predictable program outcomes (p. 55). Donors must be willing to accept that predicting the outcomes of a “participatory development process” 5 or 10 years down the road is not possible.

Binam et al. recommend the establishment of a platform that would facilitate increased dialogue so that local leaders and technicians from different government departments who manage forestry resources can collaborate in creating the most effective institutions and processes to support better tree management. This reflects the literature’s emphasis on the importance of including farmers, farmer groups, community organizations and grassroots development projects in all aspects of the process, especially given that FMNR is farmer-based (Cunningham & Abasse, 2005). Binam et al. also cite capacity building for local institutions that are involved in forest/agroforestry resource management as necessary for supporting “joint forestry management” (p. 569).

**For specific localities.** Seven recommendations for FMNR in the **Zinder region of Niger** were put forward in Larwanou et al.'s 2006 USAID report. They were: 1) In forest policy, emphasize FMNR over tree planting; 2) State in the new environmental code that farmers have exclusive rights to the trees in their fields; 3) Avoid creating a rural forestry market because farmers are perfectly capable of exploiting the trees in their fields and organizing to sell them when they need to. Fiscal policy should be local; 4) Implement a demographic policy to reduce population growth; 5) Rehabilitate the basins in the Zinder region; 6) Stimulate intensive livestock raising in the region, which will better fertilize fields; and 7) Support exchange visits and field trips for producers to see local innovations and best practices in surrounding areas.

A national **Burkina Faso** FMNR workshop in 2013 held by Réseau MARP produced a table suggesting short, medium and long-term recommendations for strengthening and expanding the practice in Burkina Faso (*Rapport provisoire de l'atelier national de plaidoyer sur la régénération naturelle assistée*, 2013, p. 17-19). In a “lessons learned” report on FMNR in Burkina Faso and Mali from the Ecosystem Alliance, recommendations are provided for policy makers specifically for scaling up (*Farmer-Managed Natural Regeneration programme in Burkina Faso and Mali: Lessons learned by the Ecosystem Alliance*, n.d.). Among them are giving land titles to farmers, decentralizing the administration of land titles, and including FMNR in a multi-year governmental national strategy.

## Conclusion

Results from studies with original research have shown that FMNR offers many benefits, including increasing tree cover, possibly increasing crop yields, and contributing to household income and local economic value. There are also additional livelihood benefits around asset building and health outcomes about which more research could strengthen our understanding. Farmers themselves have reported experiencing multiple positive benefits, though some have cited fears or concerns that may have contributed to hesitation to adopt the practice. Some common factors that contribute to the success of FMNR have been observed, including favorable policy environments that address land tenure issues and tree user rights, farmer awareness of the immediate benefits that can be achieved from the practice, a change in the mindset from tree-planting to tree protection as more effective and sustainable, and the inclusion of all stakeholders – particularly farmers and local communities – in adapting it to local contexts and deciding on strategies for scaling up. Some environmental conditions also appear to affect its success, including soil type, level of rainfall, population density, and as well as a sense of crisis that increases community investment in innovating. While it has not been reported to be unsuccessful anywhere found by this author, some studies have shown that how FMNR is managed may impact its success, along with which type of tree is being protected. As with any practice or strategy, there are obstacles to its adoption and scaling up. Despite these, FMNR has been shown to have many advantages over previous practices or interventions that have attempted to achieve the same impact of strengthening community resilience to environmental shocks.

While FMNR has become an increasingly researched practice in the past few decades and FMNR programs are being evaluated by implementing agencies, there are still gaps in our understanding that can be addressed by future research efforts. The extensive literature review conducted by Francis and Weston for World Vision found that the 24 benefits they identified in their report are not currently backed by impact evaluation studies, although they have been clearly described in the literature. They also note an absence of data using standard measurements that can be used to track beneficial outcomes over time so that the results can be shared with key stakeholders. In their report, Francis and Weston propose a series of possible indicators and outputs that could be used by researchers and agencies to measure the social, environmental, and economic outcomes of FMNR adoption (p. 34-35). In framing the available impact results in terms of measuring five forms of capital (human, physical, social, financial, and natural), the literature review by Weston et al. determined that existing studies on FMNR focused on financial and natural capital gains. They felt that non-economic livelihood benefits had not been measured in terms of their impact, and their study in Ghana sought to address that gap using an SROI approach. However, additional research that seeks to measure the non-monetary benefits would advance the research base given that FMNR has such broad impacts.

### Limitations of this review

This literature review relied heavily on the previous work surveying existing studies and reports that has been conducted by experts in the field, including Reij, Winterbottom, Rinaudo and Weston. Therefore, the review of original research published through 2014 was not conducted as intensively by this author as it would have been had previous literature reviews not already been conducted. Another limitation is that only literature written in French or English and

available online through publicly-searchable web engines or scholarly databases was included. Thus, the findings from communities or organizations that may be practicing FMNR but that are publishing in another language or that do not have the resources to report on their findings are not included. The quality of the data included in this review may vary as not all evidence has been subject to peer-review; some of the documentation was produced by agencies or were commissioned by institutions that are funding these programs, creating a risk of reporting bias. Lastly, this author's own biases should be acknowledged, regardless of her efforts to maintain neutrality.

### **Recommendations for future research**

- The primary recommendation for future research from Francis and Weston is the development of a coordinated research strategy so that partners can identify the next steps for generating an evidence base for FMNR. They specifically suggest determining an impact evaluation approach as well as selecting standard measurements to be used to determine impact.
- This author proposes continued and expanded use of participatory approaches to evaluation that further integrate community members throughout the evaluation process. This not only has the benefit of building capacity but can also increase the relevance and impact of the results. Use of SROI - the approach used by Weston and Hong's evaluation in Ghana that seeks to measure change as seen by the target community as opposed to the hypothesis driving the project design - as well as Community-Based Participatory Research or Participatory Action Research approaches can facilitate this.
- Additional evidence that measures the non-monetary benefits of FMNR, such as those measured by Weston and Hong, can also contribute to the existing body of literature that has thus far focused on measuring tree cover, crop yields, and income benefits.
- Cost-benefit analyses that compare tree-planting approaches that have been tried, or other similar interventions, to FMNR can also provide valuable data for soliciting greater support from governments and external sources.

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## Appendix

### Table of peer-reviewed research findings not included in Weston et al. (2015) literature review<sup>1</sup>

Author	Peer-reviewed?	Location	Type of benefit	Quantification?
Bagnian Adamou Mahaman, Adam & Mahamane (2013)	Yes	Maradi & Zinder regions, Niger	Increased tree density in fields	<ul style="list-style-type: none"> <li>- Maradi: tree density in fields increased (146-151 trees ha<sup>-1</sup> in Dan Saga; 60-109 trees ha<sup>-1</sup> in El Guiéza). Maradi had an FMNR oversight committee between 2005-2012</li> <li>- Zinder: tree density in fields increased (32-79 trees ha<sup>-1</sup>) where there was strong leadership and decreased where there was no committee or leadership (650-65 trees ha<sup>-1</sup>)</li> </ul>
Bagnian Adam, Adamou, Chaibou & Mahamane (2014)	Yes	Maradi & Zinder regions, Niger	Poorly stabilized regeneration; relatively weak survival rate for some plants from first stratum of growth (0 – 0.5m) to second stratum (0.5 – 1m).	Some cases of a mortality rate of up to 30% of plants from first stratum of growth (0 – 0.5m) to second stratum (0.5 – 1m)
Badji, Sanogo, Coly, Diatta & Akpo (2015)	Yes	Khatre Sy, Senegal	Improved dendometric characteristics (diameter, height & basal area) of trees in fields using FMNR compared to protected areas where FMNR was not used; lower tree density explained by clearing of some trees for farming	FMNR fields vs protected areas: <ul style="list-style-type: none"> <li>- Average density of 29N/ha vs 49N/ha</li> <li>- Average diameter of 22.26cm vs 14.01cm</li> <li>- Average height of 5.89m vs 4.4m</li> <li>- Total basal area of 23.71m<sup>2</sup>/ha vs 8.71m<sup>2</sup>/ha</li> </ul>
Binam, Place, et al. (2015)	Yes	Burkina Faso, Mali, Niger, Senegal	<ul style="list-style-type: none"> <li>- Increased gross income</li> <li>- Increased value of products harvested from trees</li> <li>- Increased dietary diversity</li> </ul>	<ul style="list-style-type: none"> <li>- Increase in gross income by USD 72 per year for continuous FMNR practitioners</li> <li>- Increase in the value of the products harvested from trees among active FMNR practitioners (Burkina Faso: 36%; Mali: 38%; Niger: 36%; Senegal: 34 %)</li> <li>- Increase of dietary diversity of households by about 12–14 % (Burkina Faso: 14%; Mali: 13%; Niger: 10%; Senegal: 13%)</li> </ul>
Weston, Hong, Kaboré & Kull (2015)	Yes	Talensi district, Ghana	<ul style="list-style-type: none"> <li>- Increased assets (tree stocks &amp; improved livestock)</li> <li>- Increased wild resources (especially wild foods &amp; construction inputs)</li> <li>- Improved psycho-social wellbeing</li> <li>- Improved soil fertility &amp; crop yields</li> </ul>	Livelihood impact per household: social, health, environmental & economic values between USD 655 and USD 887 per year
Stith, Gianini, Corral, del Adamo, de Sherbinin (2016)	Yes	Burkina Faso, Mali, Niger, Senegal	Regreening as a result of intentional human activity as opposed to attributing it solely to environmental factors	Some areas identified with higher than average population density & regreening where donor interventions have been present

<sup>1</sup> This table was modeled after the table included in Weston et al.'s (2015) literature review, which contained the 10 studies they found on FMNR that had original research and were published through 2014.