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Assisted Natural Regeneration with Fencing in the Central and Northern Zones of Burkina Faso

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Summary

Despite their socio-economic importance, forests and other woodland vegetation are declining rapidly in Africa. In the Sahel, climate change and desertification intensify this problem and the local population is lacking woodland resources for daily life. Therefore, there is a need for improved and long-term restoration of degraded ecosystems. The present article investigates an approach of sustainable forest restoration by Assisted Natural Regeneration (ANR) with fencing, a technique adopted by newTree, a Swiss NGO, since 2003 in the Central and Northern zones of Burkina Faso. The present article investigates the effects of ANR on vegetation restoration and on population's livelihood. Methods include vegetation inventories, literature review, analysis of newTree technical reports from 2003 to 2012, stakeholders' interviews and cost-benefit examination. Results show a striking development of vegetation within only nine years of protection. Inventories of trees inside and outside fences show that variety of tree species and number of trees is much higher inside the protected areas than outside fencing. Moreover the approach of newTree contributes to farmers' livelihood improvement by the valorization of non-wood forest products (NWFP) and sustainable agriculture. Costs for fencing are relatively high but on the other hand the approach is very effective by involving the population in a participatory way. The double objective – biodiversity conservation and poverty reduction - can be effectively achieved by the whole approach of newTree using ANR technique. ANR could be applied in areas where tree planting is made difficult by the poverty and the lack of water for the creation of nurseries.

Résumé

Régénération naturelle assistée par la mise en défense dans les zones centrale et nord du Burkina Faso

Malgré leur importance, les forêts et les autres ressources végétales sont en déclin rapide en Afrique. Dans le Sahel, les changements climatiques et la désertification accentuent ce problème et les communautés se trouvent dépourvues de ressources pour soutenir leur vie quotidienne. Par conséquent, il est nécessaire d'assurer à long terme la restauration des écosystèmes dégradés. Le présent article examine les effets de la Régénération Naturelle Assistée (RNA) sur la restauration de la végétation et sur l'amélioration des conditions de vie des populations au Centre et au Nord du Burkina Faso. Les méthodes d'évaluation incluent la revue de la littérature intégrant l'analyse des rapports techniques de newTree depuis 2003 à 2012, les inventaires de la végétation ligneuse, les interviews des acteurs et enfin l'examen des coûts-avantages liés à l'application de la RNA. Les résultats montrent que le nombre des espèces du point de vue botanique et le nombre d'arbres sont plus élevés à l'intérieur des clôtures qu'à l'extérieur. En outre, l'approche de newTree contribue à l'amélioration des moyens de subsistance des producteurs. Bien que les coûts d'installation des clôtures soient relativement élevés, l'approche demeure efficace en impliquant la population. La conservation de la biodiversité et la réduction de la pauvreté peuvent être atteintes par l'application de la démarche de newTree. La RNA pourrait être appliquée dans les zones où la plantation des arbres est rendue difficile à cause de la pauvreté des communautés et le manque d'eau pour la création de pépinières.

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Introduction

In Africa, forests and trees are major contributors to food and pharmacological security, on one hand through providing edible fruits and leaves and protection of agricultural soils and water resources and on the other hand through income generating activities for the purchase of food for the most poor and vulnerable people (14, 16, 28).

Despite this importance, forests are degrading and lead to biodiversity loss (12). Forests of Burkina Faso including woodlands and savannahs cover 21% of the land (5,649,000 ha) and the average annual forest loss is 1.03% or 60,000 ha (13). Forest is determined both by the presence of trees and the absence of other predominant land uses. The trees should be able to reach a minimum height of 5 meters. Forest includes areas with young trees that have not yet reached but which are expected to reach a canopy cover of at least 10 percent and tree height of 5 meters or more. It also includes areas that are temporarily unstocked due to clear-cutting as part of a forest management practice or natural disasters, and which are expected to be regenerated within 5 years. Wooded land is land not defined as “Forest”, spanning more than 0.5 hectares; with trees higher than 5 meters and a canopy cover of 5-10 percent, or trees able to reach these thresholds; or with a combined cover of shrubs, bushes and trees above 10 percent. It does not include land that is predominantly under agricultural or urban land use (13).

Climate change (recurrent droughts), forest clearing for agriculture, trees and shrubs cutting for firewood and construction, animal browsing and unsustainable non wood forest products (NWFP) harvesting are the main causes of land and forest degradation (36). Indirect causes include poverty (16), which is a widespread phenomenon in Burkina Faso, 43.9 percent of the inhabitants live below the absolute poverty line.

In order to sustain the population’s livelihood, the government of Burkina Faso, through the Forest Investment Program (29), supports policies, measures and scales up financing in order to facilitate the reduction of deforestation and forest degradation and promotes a sustainable forest management, resulting in emission reduction, protection of carbon stocks and control of desertification and poverty. This program is in compliance with the country’s Strategy for Accelerated Growth and Sustainable Development (21) for the achievement of the Millennium Development Goals and the Global Strategy for Plant Conservation (8).

Biodiversity conservation in Burkina Faso is based on preservation of forests and woodlands through the establishment of State forests (23, 41, 43) and tree planting during the rainy season, from June to September. But besides these methods, Assisted Natural Regeneration (ANR) is a viable technique that contributes to restore vegetation.

Natural Regeneration is the process by which plants recolonize land where the vegetation has been partly or totally destroyed. Besides the capacity to germinate from available seeds, some tree species are able to regenerate by shooting, suckering or by coppicing (1, 2, 3, 4, 5, 24, 32, 42).

This natural process of tree regeneration can be assisted with fencing of degraded areas as undertaken in Ethiopia, Nigeria (35) and Burkina Faso (10). Especially when animal browsing is one of the key factors for vegetation degradation, ANR with fencing may be a viable alternative for biodiversity conservation. But despite its practical advantages, the technique remains underutilized due to lack of awareness and research results demonstrating its effectiveness (35).

The present article proposes to contribute to fill this gap by describing and discussing the experiences of newTree, a Swiss NGO adopting ANR with fencing in Burkina Faso since 2003. More specifically, we seek to analyse the success of the newTree approach by its effects on plant conservation and impact on population livelihood in the sudanian and sahelian ecosystems in West Africa in general and Burkina Faso particularly.

Study sites

newTree intervention areas in Burkina Faso include the sudano-sahelian central region with five provinces (Boulkiemdé, Kadiogo, Kourwéogo, Oubritenga and Sanmatenga) and the sahelian northern region, with two provinces (Soum and Loroum) (Figure 1). The sudano-sahelian central region is characterized by an average annual rainfall of 600 to 900 mm and a rainy season lasting about 4 months from June to September. The strain on land utilization is very high in this part of the country due to the high population density of 50 - 100 and more inhabitants per km^2 (22). Farming methods remain traditional and are essentially orientated towards food crops, dominated by sorghum (*Sorghum bicolor* L.) and millet (*Pennisetum glaucum* (L.) R.Br. Parkland tree species include *Vitellaria paradoxa* C.F.Gaertn., *Parkia biglobosa* (Jacq.) R.Br. ex G. Don, *Tamarindus indica* L., *Adansonia digitata* L., *Bombax costatum* Pellegr. & Vuill.. Erratic rainfalls, deforestation, and livestock grazing result in vegetation and land degradation, which are the main constraints for a sustainabl e development in that region.

The sahelian northern region is characterized by an annual average rainfall less than 600 mm with a short rainy season (4 months maximum).

In this zone, the population density is less than 50 inhabitants per km^2 (22). Crop-based farming coexists with agro-pastoral livestock production. Main tree and shrubs include *Balanites aegyptiaca* (L.) *Delile, Acacia nilotica* (L.) Willd. ex Delile, *A. senegal* (L.) Willd, A. raddiana Savi, *Euphorbia balsamifera* Aiton, *Faidherbia albida* (Delile) A. Chev., *Leptadania pyrotechnica* (Forssk.) Decne.

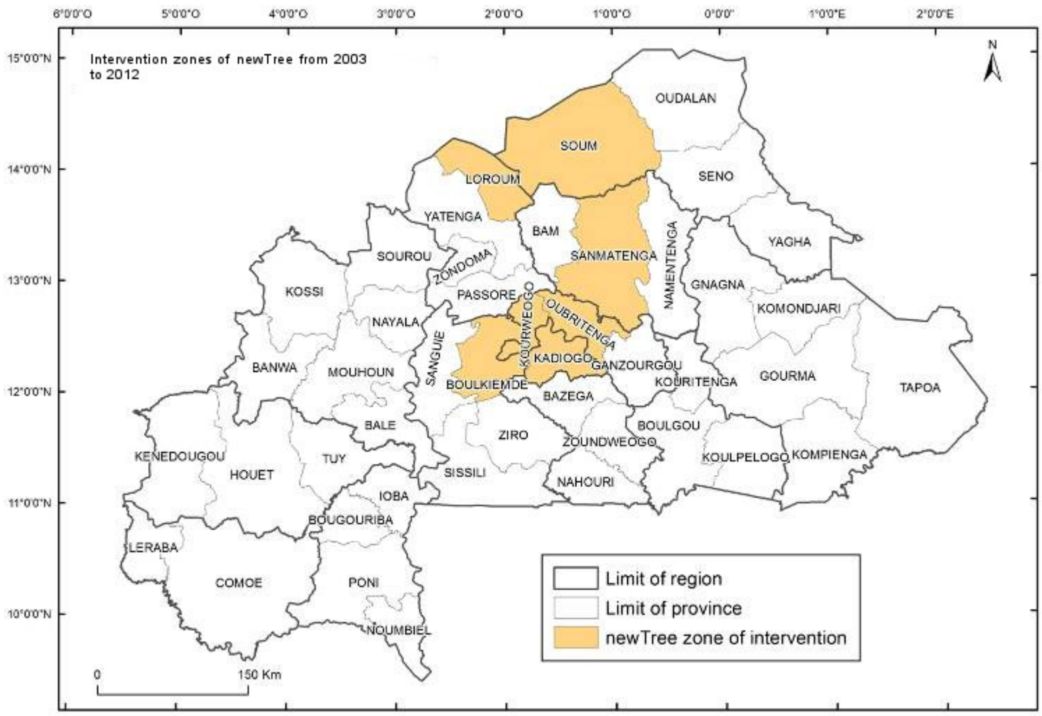

Figure 1: Intervention zones of newTree (source: newTree).

Insufficient or irregular rainfall and low soil fertility are serious constraints for agricultural development. Drought and livestock pressure seriously affect the survival of plant species (36).

These zones are selected by newtree to undertake a participatory degraded land restauration with fencing.

NewTree Approach

In Burkina Faso, the overall goal of newTree is to sustainably restore degraded ecosystems while contributing to livelihood improvement of the rural population (Figure 2). One of the main activities of the program is the protection of degraded land by a wire fence to prevent animal browsing. This protection is necessary as during the dry season, animals are roaming freely and browse unprotected plant species. Besides protecting degraded ecosystems by fencing the approach is accompanied by the creation of income generating activities through the promotion of non-wood forest products (NWFP) like bee-keeping, harvesting of fodder, transformation of seeds (e.g. *B. aegyptiaca* (L.) Del.) to oil, etc. Promotion of improved cooking stoves to reduce fuel wood consumption is a also a component of the approach. The organization provides education of the local population through a centre for agro-ecological training and a centre for transformation of NWFP (Photo 1). Since 2011 newTree is also conducting a Farmer Managed Natural Regeneration (FMNR) project in the Soum province. This is another effective method to regenerate degraded ecosystems without fencing. Results are not yet available from this activity but there exist a lot of experiences from Niger where FMNR has been a wide spread method since 30 years (26, 33, 34).

newTree's interventions are based on a participatory approach to rural development and environmental conservation (19). For all these activities newTree sets a high value on the training, awareness building, capacity enhancement and empowerment of farmers and women in particular. This provides for long-term responsibility and therefore sustainability of the approach, and enables independent chain reactions. newTree has ten years of experience of ANR with fencing so therefore the present article is assessing the impact and the general results of this approach, including effects of income generating activities and the accompanying capacity building and training from 2003 to 2012.

Site management for the protected degraded land with fencing is clearly established through a contract agreement between newTree and the farmers. This contract includes traditional and government land rights and clarifies each other's responsibilities and rights, contributing to avoid conflicts on land rights and between resource users.

The contracting farmers are bound to contribute by providing labor for the construction of fences (e.g. hole digging, pole installation, fabrication of chain-linked fence materials and maintenance) and locally available fence construction components (sand, gravel, rock and water). newTree contributes by delivering other material like iron poles, wire, cement and technical support.

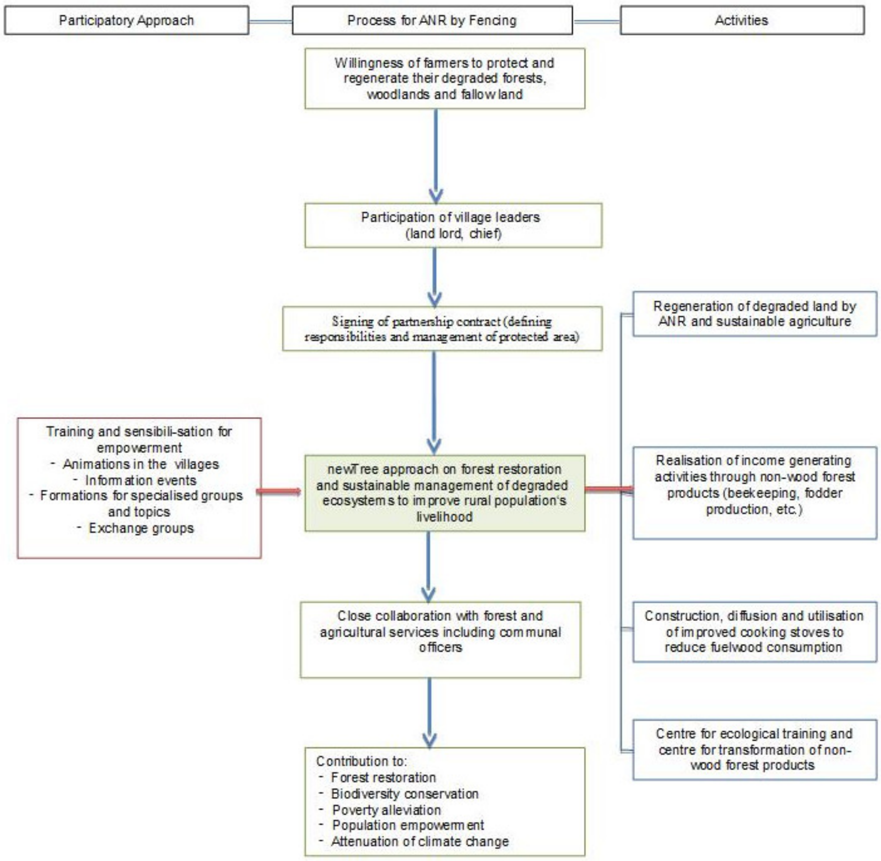

Figure 2: NewTree approach.

Photo 1: Fodder production: one of multiple income generating activities at Djibo, Northern Burkina Faso (Photo F. Kaguembèga).

In each village, efforts are made to foster women's participation in the program in order to strengthen sustainability and gender diversity.

Each protected site is divided into a surrounding layer of 10 meters called cultivation band where agroforestry technologies are applied (e.g. improved ploughs, soil fertilization with compost) and an inner protected core without any agricultural activities. The expected results of the ANR with fencing are presented in table 1.

Methods

Methods used to assess the impact of the approach of ANR with fencing include inventories of the protected sites, analysis of newTree annual reports from 2003 to 2012 (31), participatory SWOT analysis, and cost-benefit examination.

Inventories of protected sites

In the beginning, newTree inventories tree and shrubs of all fenced sites. Subsequently, each site is generally inventoried every five years. From 2003 to 2005 all installed sites have been fully inventoried whereas from 2006 onwards, only half of all fenced sites have been inventoried with samples due to the highly increased number of protected sites as well as limited financial and human resources.

Inventories take place from March to June before the rainy season.

At each site, the inventory is carried out in one sample plot which is a circle covering a quarter of the area. Example: since the area of the protected site is 28,000 m^2 or 2.8 ha, a circle of a radius of 49.6 m is adopted. Outside each protected site, the same area is randomly selected. The outside sample plot is defined by projecting the inside sample plot outside of the fence on the opposite site of the entry point to the protected site. Thus, both plots are established at the same distance from the cultivated strip.

Within the plots, all trees, shrubs and lianas with a height ≥20 cm were recorded. Plant scientifical names follow (37).

Data include kind of species (genus and family), height (h), Diameter at Breath Height (DBH). They were analyzed with the Excel 2013 to perform data analysis and graphical presentation.

Participatory SWOT analysis

newTree's approach has been analysed through stakeholders' interviews, participatory monitoring and evaluation of newTree partners and staff with participatory SWOT analyses.

The SWOT method evaluates the Strengths, Weaknesses, Opportunities and Threats involved in the project implementation. For stakeholders, the advantages they have in collaborating with newTree, the interest of participating to the program implementation and main constraints were assessed.

Table 1

Expected results of the ANR with fencing.

Short-term	Mid and long-term
-Conservation of plant species -Increasing biomass and biodiversity (seedlings, stump sprouts, root suckers of endangered native tree species) -Soil improvement (increasing organic matter, applying compost in cultivation band) and water conservation (stone bunds) -Increasing income for farmers: -Production of wood and NWFP (e.g. honey production and increasing grass biomass for roof tops, mats and	-Restoration of degraded ecosystems, village forests, woodlands and fallows -Restoration of soil fertility -Increasing availability of fuel wood and construction wood -Increasing availability of sustainably produced NWFP -Diversification of plant based products to meet local people's needs -Poverty alleviation by improving farmers' livelihood -Attenuation of climate change

Costs and benefits

Benefits for the farmers have been analyzed by following the earnings of ten farmers with protected sites along different activities (agriculture, cattle breeding, ANR, secondary activities) (6). Data include the contribution of ANR to the total gross profit (%), the total gross profit with ANR (FCFA), the total gross profit without ANR (FCFA) and the average annual income per farmer provided by resources from ANR.

Expansion of ANR with fencing

From 2003 to 2012, a total of 198 sites have been fenced in collaboration with families and groups of farmers in seven provinces and protect currently 560 hectares of degraded lands (Figure 3, Table 2). About 40% of the protected sites occur in the central sudano-sahelien region and about 60% are implemented in the northern sahelian region. The mean, the minimum and the maximum protected area per fenced site are 0.28 - 0.41 and 10.4 ha respectively.

Each year, newTree is confronted with numerous demands from villages and farmers for installing protected sites of which only a part can be realized due to the limited capacities of the NGO. For example, for 2013 newTree received 209 demands of which only 30 could be granted. This high number of demands shows the utility of the program for the farmers and is a sign that the program is meeting their needs in a right way.

Evolution of tree species diversity within protected areas

The inventory results until 2012 show that 68,683 trees belonging to 103 different species grow on the inventoried samples (inventory surface = 92.8 ha; 740.12 trees/ha). By extrapolating on the whole protected area (560.1 ha), there is a total number of 414,540 trees throughout the seven provinces. The average number of species and trees per hectare is generally increasing with age of fencing (number of years since fencing), so the longer the degraded land is protected the higher the number of species and trees.

Results in figure 4 demonstrate clearly the positive impact of fencing on tree species diversity: across both central and northern regions, the average number of tree species per hectare is around double within the fenced areas compared to outside the fenced areas (Photo 2). In the central region, the impact is even 30-40% higher compared to the Northern region, which is due to climate differences. The number of trees, inside the fence is around five to six times higher than outside of the protected area (Figure 5). In appendix 1 are presented the main tree and shrubs species recorded in and outside fencing both in the central and northern zone in the inventory of 2011; carried out after eight of fencing.

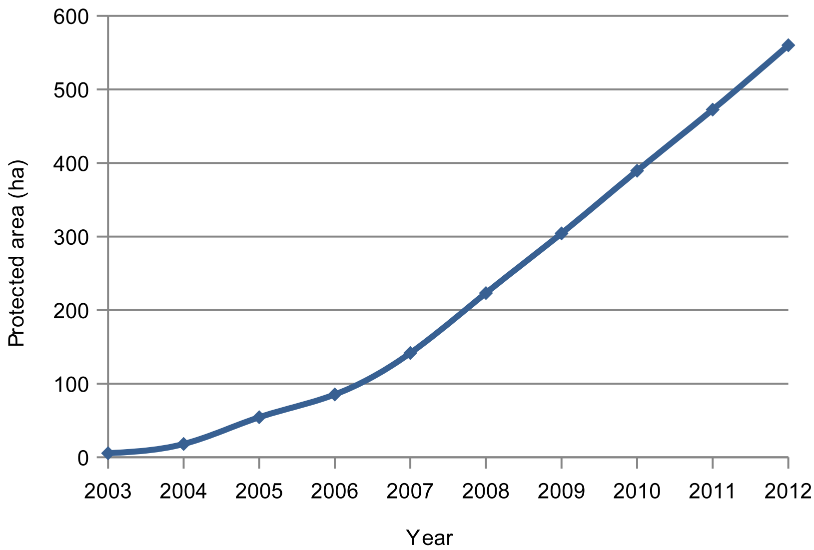

Figure 3: Increase of protected area with fencing since the beginning of newTree activities.

Table 2
Protected (fenced) sites until 2012.

Designation	Centre	North	Total
Province	5	2	7
Number of protected sites	82	116	198
Total protected area (hectares)	245	315	560

Swot analysis assessment of the ARN with fencing

SWOT analysis (Table 3) shows that farmers are satisfied with the protection and restoration of their degraded lands. They are experiencing a relatively fast development of vegetation, hence that trees grow better within the protected sites and produce more fruits than outside the fence. They also remark that seedlings are abundant within the protected sites. As main constraints, the NGO lists the limited number of appropriate partners, misunderstanding between neighbors, the lack of water and the limited period available for tree growing.

Costs and benefits of ANR

Overall, natural resources from ANR constitute around 20% of the total gross profit per farmer per year besides agriculture, cattle breeding and secondary activities. This translates to an average annual income per farmer provided by resources from ANR of CFA Franc 95,400 (= EUR 145) in the North ad 41,200 CFA (~ EUR 63) in the Central region respectively. Farmers use a high variety of products like honey, construction wood, straw, root and bark, fruits, leaves, hay, fire wood and charcoal. Around 70% of the products from ANR are self-consumed. From the given 20% one can roughly calculate the income from the area without fencing.

For the detailed numbers see an overview in table 4. The absolute poverty line in Burkina Faso is approximately CFA Franc 108,454 (= EUR 165.35) per year (21). Hence especially in the North the valorization of the protection site through NWFP can highly contribute to reduce poverty. We can therefore conclude that ANR with enrichment planting combined with income generating activities contributes to Burkina Faso's poverty reduction strategy.

The establishment of one protected site of 3 ha costs around CFA Franc 2,250,124 (= EUR 3,420), of which 33% are borne by the land users, mainly in form of labor. The most expensive elements are the components for fence construction (e.g. poles, wire).

Advantages and drawbacks of ANR

By working directly with farmers and focusing on capacity building, as well as its aim for biodiversity conservation and increasing revenues of farmers, the newTree approach is in line with Burkina Faso's development strategy.

The newTree approach contributes to policy at national and international levels by using field projects to derive learnings to feed into the policy debate. Example is given by the establishment of a local convention to ensure that all stakeholders agree that the land is used for biodiversity conservation and that this conservation meets the needs of the communities in each village (see also 17). Results of the analysis of the newTree approach to restore degraded ecosystems through ANR with fencing show a striking development of vegetation within only nine years. The fence together with a cultivation band where agroforestry is adopted effectively prevents disturbances such as grazing, fire and illegal wood cutting. Inventories show that inside protected areas the number of trees is around three to four times higher than outside the protected areas. The newTree approach enables farmers to get revenues from NWFP which helps as well to protect trees in future.

Table 5 compares various reforestation approaches (by planting of tree seedlings and reforestation by ANR techniques) and their merits. One constraint of tree planting methods is the high labor and financial inputs required (25). Assisted natural regeneration (ANR) however is a simple, low-cost forest restoration method that can effectively convert degraded deforested lands to more productive forests (20; 38, 39; 15, 40). The method aims to accelerate, rather than replace, natural processes by removing or reducing barriers to natural forest regeneration such as soil degradation, competition with weedy species, and recurring disturbances (e.g., fire, grazing, and unregulated wood harvesting) (2, 9, 35). Forest restored through ANR will have sometimes little commercial value in terms of timber, but it will support greater biodiversity and often more effectively provide products for subsistence needs of the local people as compared to commercial plantations. These disadvantages can be overcome by enrichment planting with local endangered trees, fruit trees, medicinal plant species, and tree species for fodder or beekeeping development (27, 30). Compared to reforestation by plantation, ANR methods offer some financial advantages because the costs associated with seed collection, nursery setting, seedlings' watering / irrigation and planting seedlings are eliminated or reduced. By adopting ANR with fencing however these advantages are reduced because of costs for the installation of the fence.

In addition the ANR method is a bottom-up approach where the population is included in the process in a participative way. Hence the approach is much better accepted and therefore success more sustainable. Another advantage is that ANR techniques are often adopted on land where the farmer has an approved usage right.

This is often not the case for reforestation by plantation where land belongs mostly to the state. The newTree approach is embedded in the ANR techniques with enrichment planting but with the special characteristic of fencing. This fact is increasing costs compared to ANR techniques without fencing and is one main constraint of the approach.

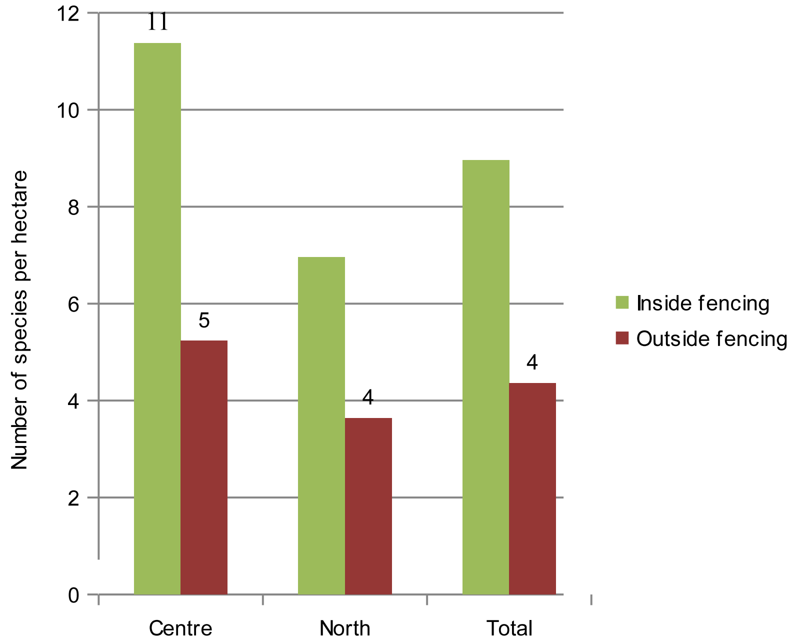

Figure 4: Average number of species per hectare both central and northern region.

Photo 2: newTree protects degraded ecosystems in central and northern Burkina Faso by fencing.

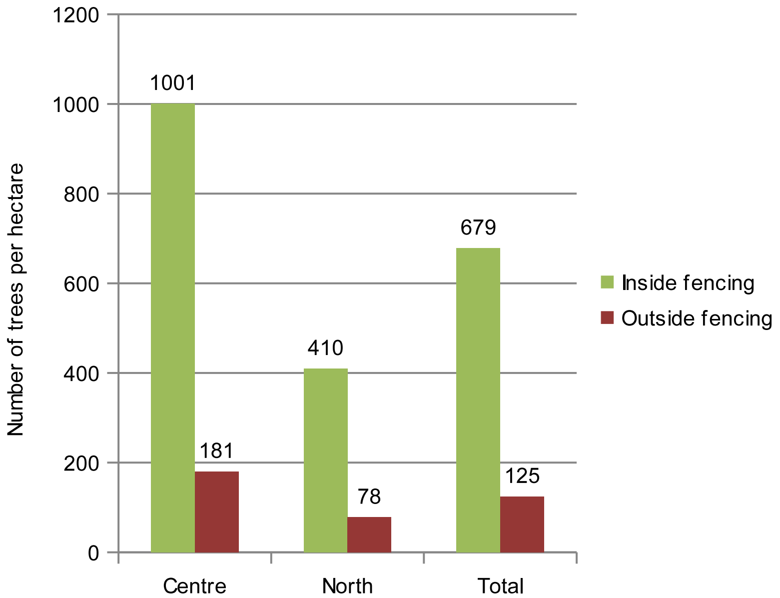

Figure 5: Average number of trees per hectare inside and outside of the protected area both central and northern region.

Table 3
Results of SWOT analysis.

Activities	Opportunities	Constraints	Solutions
Identification and selection of partners	Interest of farmers to restore their degraded lands; Availability of labor	Insufficient number of future partners Surface to protect by fencing too small (less than 3 ha)	Increase the number of appropriate partners (selection criteria)
Administrative validation of selected sites	Full participation of both modern and traditional local authorities Land tenure is not generally a problem	Political involvement in the partnership agreement	Reduce political interference
Delineation ofsites and fixing fences	Availability of local labor	Misunderstanding with neighbors	Information of all the farmers
Raising saplings in nurseries for enrichment planting and live fences	Availability of land, seeds and labor	Lack of water supply Limited period for tree growing in nursery	Create water resources Appropriate choice of appropriate seedlings for planting (seedlings must be grown in nursery during 4-6 months before planting)
Practice of agro-forestry technologies	Availability of a portion of the site	Plants attacked by termites	Training farmers on agroforestry Increase the area to cultivate crops

Table 4
Overview over the income with and without ANR.

Designation	Burkina North	Burkina Central
Contribution of ANR to the total gross profit (%)	23	21
Total gross profit with ANR (FCFA)	414783	196190
Total gross profit without ANR (FCFA)	319383	154990
Average annual income per farmer provided by resources from ANR (FCFA)	95400	41200
Total gross profit with ANR (EUR)	630	298
Total gross profit without ANR (EUR)	485	235
Average annual income per farmer provided by resources from ANR (EUR)	145	63

Table 5
Various reforestation approaches and their merits [adapted (35)].

Reforestation Approach	Costs (Labor and Capital)	Conditions of success	Bio-diversity	Time for forest development	Social aspect in rural area
Commercial monoculture plantation	High	Fast growing selected species Rich soils	Low	Fast	Top down approach (land generally owned by the state)
ANR (seedlings, root suckers, ground layers, stump sprouts)	Very low	High availability of tree, shrub and herbaceous seeds	Low to medium	Medium	Bottom up approach (land is owned by local people)
ANR with enrichment planting	Low to medium	Planted trees must not compete with existing ones	Medium	Medium	Bottom up approach (land is owned by local people)

It impedes a future independent approach; this means farmers are remaining dependent on this first investment by a sponsor. Furthermore this implies that ANR with fencing cannot be adopted to protect large areas.

On the other hand, the newTree approach is demonstrating diverse advantages compared to other forest restoration methods. With its participatory bottom-up focus, degraded areas are restored very effectively. Famers are involved from the beginning and take their responsibility within the process, which contributes to the inherent interest of the population in protecting the degraded areas. Illegal wood cutting, depletion and mismanagement are reduced to a minimum. Moreover ANR with fencing and with population‘s involvement is very effective and forest restoration is possible after a few years already. The fence prevents animals from entering and the cultivation band protects the site from fire. Therefore the main causes for tree and forest destruction in the Sahel are interrupted and vegetation development is enabled. Finally, sites protected by fencing can be assimilated to conventional protected areas if sustainable management principles and practices are applied. Regrowth of trees as a result of effective protection and adaptive management of protected areas also lead to conservation of biodiversity and reduced vulnerability to climate change (11).

Conclusion and recommendations

Villagers have shown a strong interest in biodiversity conservation and are the direct stakeholders of newTree activities in terms of capacity building. The double objective – biodiversity conservation and poverty reduction – can be effectively achieved by combining ANR and fencing, especially when participatory forest management is applied by devolving ownership and management of forest resources to local communities. Additional benefits including Non Wood Forest Products are likely to be achieved by applying agroforestry technologies in the protected sites.

ANR could be applied in areas where tree planting is made difficult by the poverty and the lack of water for the creation of nurseries. The future challenge is to work towards helping stakeholders from communities, government, civil society and disadvantaged groups to gain the skills and abilities needed to better manage and utilize their natural resources. In this respect, the setting up of knowledge, sharing and learning networks to link actors are key elements to promote.

Although the ANR method does not require significant research inputs before implementation, it is critical that monitoring and research are a part of the ANR process, so that changes in the vegetation can be evaluated and techniques can be improved as the amount of knowledge increases. Therefore, future research could include:

Undertaking a cost benefit analysis of ANR with fencing with the purpose of improving the cost-benefit ratio and calculating an overall index by which project feasibility and achievements can be judged comparing the “with project” and “without project” situations (7, 18);

Analysis of the capacity for in situ regeneration from seeds and vegetative organs of trees, shrubs and herbaceous plant species growing in the protected sites;

Assess the biological impact (recruitment of trees and other plants, making habitat for fauna and birds, soil fertility restoration) of fencing compared to tree planting.

Analyses and research about best strategies for the long-term valorization of the reduced emissions by the project through carbon credits (small-scale project, NWFP)

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Appendix 1

Botanical name of the main species recorded in the protected sites and outside (inventory of 2011) ANR.

Species	**Family**	**Central zone**		**Northern zone**	
		NSiPS	NSoPS	NSiPS	NSoPS
Acacia erythrocalyx Brenan	Fabaceae-Mimosoideae	108	6	0	0
Acacia gourmaensis A. Chev.	Fabaceae-Mimosoideae	241	38	0	0
Acacia hockii De Wild	Fabaceae-Mimosoideae	533	0	0	0
Acacia laeta R. Br. ex Benth.	Fabaceae-Mimosoideae	12	1	0	0
Acacia macrostachya Reichenb. ex DC	Fabaceae-Mimosoideae	665	82	21	1
Acacia *nilotica* subsp. *adstringens* (Schumach. & Thonn.) Roberty	Fabaceae-Mimosoideae	50	30	4313	688
Acacia tortilis (Forssk.) Hayne	Fabaceae-Mimosoideae	0	0	291	191
Acacia senegal (L.) Willd.	Fabaceae-Mimosoideae	13	12	1085	162
Acacia seyal Del.	Fabaceae-Mimosoideae	1613	541	3142	656
Acacia sieberiana DC.	Fabaceae-Mimosoideae	16	6	0	0
Adansonia digitata L.	Malvaceae	41	15	177	3
Afzelia africana Smith ex Pers.	Fabaceae-Caesalpinioideae	8	0	0	0
Albizia chevalieri Harms	Fabaceae-Mimosoideae	102	0	3	0
Anacardium occidentale L.	Anacardiaceae	7	0	0	0
Annona senegalensis Pers.	Annonaceae	580	112	0	0
Anogeissus leiocarpa (DC.) Guill. & Perr.	Combretaceae	836	89	42	0
Balanites aegyptiaca (L.) Delile	Zygophyllaceae	631	143	5375	1844
Bauhinia rufescens Lam.	Fabaceae-Caesalpinioideae	18		347	34
Bombax costatutm Pellegr. et Vuillet	Malvaceae	124	19	0	0
Boscia angustifolia A. Rich.	Capparaceae	83	8	4	0
Boscia senegalensis (Pers) Lam ex Poir.	Capparaceae	139	33	0	0
Boswellia dalzielii Hutch.	Burseraceae	12	4	0	0
Bridelia ferruginea Benth.	Phyllanthaceae	287	4	0	0
Calotropis procera (Ait) Ait. f.	Capparaceae	9	7	50	14
Capparis sepiaria L.	Capparaceae	85	9	54	14
Cassia sieberiana DC.	Fabaceae-Caesalpinioideae	674	67	54	2
Ceiba pentandra (L.) Gaertn.	Malvaceae	40	0	0	0
Combretum aculeatum Vent.	Combretaceae	1493	272	866	211
Combretum glutinosum Perr. ex DC.	Combretaceae	7575	1114	197	207
Combretum micranthum G. Don	Combretaceae	4708	965	533	312
Combretum nigricans Lepr. ex Guill. et Perr.	Combretaceae	538	336	55	4
Commiphora Africana (A.Rich.) Engl.	Burseraceae	118	8	1	1
Crossopteryx febrifuga (Afzel. ex G. Don) Benth.	Rubiaceae	671	0	0	0
Daniellia oliveri (Rofe) Hutch. et dalz.	Fabaceae-Caesalpinioideae	5	0	0	0
Detarium microcarpum Guill. et Perr.	Fabaceae-Caesalpinioideae	1852	0	0	0
Dichrostachys cinerea (L.) w ight et Arn.	Fabaceae-Mimosoideae	770	13	137	14
Diospyros mespiliformis Hoscht. ex A. Rich.	Ebenaceae	3676	901	33	0
Entada africana Guill. Et Perr.	Fabaceae-Mimosoideae	589	1	0	0
Faidherbia albida (Del.) A. Chev.	Fabaceae-Mimosoideae	56	77	72	16
Feretia apodanthera Del.	Rubiaceae	2753	134	93	3
Gardenia erubescens Stapf et Hutch.	Rubiaceae	1398	20	1	
Gardenia sokotensis Hutch.	Rubiaceae	288	94	14	0
Gardenia ternifolia Schumach. et Thonn.	Rubiaceae	155	0	11	0

Grewia bicolor Juss.	Malvaceae	203	15	7	5
Grewia flavescens Juss.	Malvaceae	45	11	2	0
Grewia mollis Juss.	Malvaceae	530	17	4	2
Guiera senegalensis J.F. Gmel.	Combretaceae	17761	4203	5515	2945
Holarrhena floribunda (G. Don) Dur. et Schinz	Apocynaceae	216	16	0	0
Hyphaene thebaica (L.) Mart.	Arecaceae	28	3	0	0
Khaya senegalensis (Desr.) A. Juss	Meliaceae	93	5	0	0
Lannea acida A. Rich	Anacardiaceae	400	11	0	0
Lannea microcarpa Engl. & K. Krause	Anacardiaceae	1730	318	23	3
Lannea schimperi (Hochst. ex A. Rich.) Engl.	Anacardiaceae	173	0	0	0
Maerua angolensis DC.	Capparaceae	233	7	192	6
Maerua crassifolia Forssk.	Capparaceae	16	3	568	152
Gymnosporia senegalensis (Lam.) Loes.	Celastraceae	1076	95	0	0
Ozoroa insignis Del.	Anacardiaceae	404	11	0	0
Parkia biglobosa (Jacq.) R. Br. ex G. Don	Fabaceae-Mimosoideae	110	5	1	0
Piliostigma recticulatum (DC.) Hochst.	Fabaceae-Caesalpinioideae	10324	3226	2553	501
Piliostigma thonningii (Schumach.) Mine-Redh.	Fabaceae-Caesalpinioideae	1050	125	0	0
Pteleopsis suberosa Engl. Et Diels	Combretaceae	564	20	0	0
Pterocarpus erinaceus Poir.	Fabaceae-Faboideae	48	6	1	0
Saba senegalensis (A. DC) Pichon	Apocynaceae	360	8	0	0
Sclerocarya birrea (A. Rich.) Hochst.	Anacardiaceae	587	149	163	32
Securidaca longepedunculata Fres.	Polygalaceae	7	20	0	0
Flueggea virosa (Roxb. ex Willd) Voigt.	Phyllantaceae	390	7	1	0
Senna singueana (Del.) Lock	Fabaceae-Caesalpinioideae	1040	41	2	0
Sterculia setigera Del.	Malvaceae	146	17	0	0
Stereospermum kunthianum Cham.	Bignoniaceae	1686	61	13	0
Tamarindus indica L.	Fabaceae-Caesalpinioideae	96	20	4	1
Terminalia avicenoides Guill. et Perr.	Combretaceae	2241	32	2	
Terminalia macroptera Guill. et Perr.	Combretaceae	11	5	0	0
Vitellaria paradoxa Gaertn. F.	Sapotaceae	3498	695	8	0
Vitex doniana Sw eet	Lamiaceae	119	0	0	0
Ximenia americana L.	Ximeniacaceae	1311	157	27	0
Ziziphus mauritiana Lam.	Rhamnaceae	2117	642	2065	411

Legend
NSiPS: Number of species in the protected sites
NSoPS: Number of species outside the protected sites