Rehabilitation and sustainable management by AGED of degraded pastures in the Sahel region of Burkina Faso

Plan Vivo Project Design Document (PDD)

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Project Coordinator: AGED

Executive Summary

This Project Design Document describes the project “Rehabilitation and sustainable management by AGED of degraded pastures in the Sahel region of Burkina Faso”. The project was initiated in 2014 as an innovative component of the program BKF/017 “Livestock Improvement Project of the Zebu Azawak and sustainable management of pastoral resources” implemented by the Ministry in charge of Animal Resources in Burkina Faso with finance from Lux Dev aiming to rehabilitate a total pasture surface of 7250 hectares.

AGED, long-standing local NGO based in the North of Burkina Faso, is coordinating the project. The project is being developed under auspices of the BKF/017 program. The project utilises the Plan Vivo System and Standard as a framework to link ecosystem services generated by rural communities, to payment mechanisms and markets. CO2logic provides knowledge transfer and support in the development of the Plan Vivo dossier.

The project’s intervention consists of restoring degraded pastures in the Burkinabe Sahel in close collaboration with local rural communities by re-establishing its structure, productivity and tree and grass species diversity originally present in order to enhance the productivity of the vegetation as pasture for the benefit of the pastoralists and agro-pastoralists. Sustainable land-use management of the pastures are promoted through the introduction of local land charters.

The project is located in the Sahel in the North of Burkina Faso. In the first stage of the project three villages in the province of Dori are involved with a total of 626 ha and in a later stage other villages in the provinces of Séno and Namentenga.

This project has a crediting period of thirty years and a payment period of ten years. Funding has been secured for the implementation of the activities. Certificates will be issued ex-post, after annual reporting to the Plan Vivo Foundation. After each successful monitoring period, payments will be made to participants. The certifiable carbon benefits from the activity are 49 tCO2e/ha.

Contents

Part A: Aims and objectives

A1 Aims and objectives of the project and the problem(s) that the project will address

Most of traditional livestock production systems in the Sahel region of Burkina Faso are based on an extensive use of natural pastures. However, access and sustainable management of these natural pastures are becoming more severely limited by various constraints and anthropogenic pressure. Among others figure overexploitation of grazing resources, land insecurity limiting access for herds to pasture resources and nutritional deficits for livestock, mainly during the dry season. These factors are periodically exacerbated by adverse effects associated with climate variability and climate change.

The objective of the project "Rehabilitation and sustainable management by AGED of degraded pastures in the Sahel region of Burkina Faso" is to reverse degradation of pastures and foster sustainable land management of the pastures in the Sahel region of Burkina Faso. The project is part of a larger program BKF/017 "Livestock Improvement Project of the Zebu Azawak and sustainable management of pastoral resources" implemented by the Ministry in charge of Animal Resources in Burkina Faso with finance from Lux Dev aiming to rehabilitate a total pasture surface of 7250 hectares. The NGO AGED together with another NGO, REACH Italia, are involved in the implementation of the BKF/017 program. In order to enhance the sustainability of the project's impact in the longer term at the end of the BKF/017 program, a Plan Vivo project has been formulated for each of the NGO's REACH Italia and AGED. Both Plan Vivo projects will include the communities with which each NGO collaborated within the framework of the BKF/017 program. Natural rehabilitation of degraded pastures will include working with communities to identify and demarcate community pasture areas and the direct seeding of naturalized tree, shrub and herbaceous species. Based on the new Rural Land Tenure Law (N°034-2009/AN) enabling legal recognition of rights legitimated by customary rules and practices, local land charters will be defined. These local land charters will allow capacity building of communities to develop and implement appropriate controls of pasture use.

Part B: Site Information

B1 Project location and boundaries

The municipalities involved in the rehabilitation of degraded pastures by AGED are Bani and Dori in the province of Séno, and Yalgo in the province of Namentenga (Figure 1 and Figure 2).

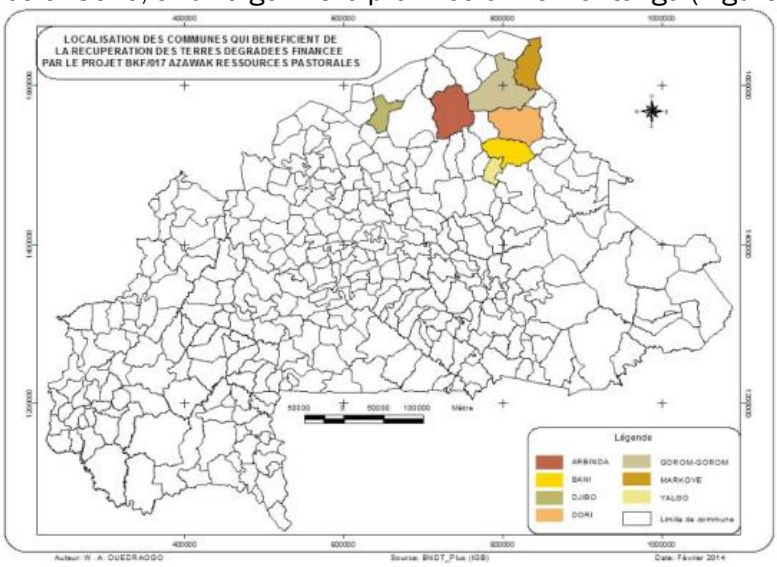


Figure 1: Map of Burkina Faso with the seven municipalities included in the program BKF/017

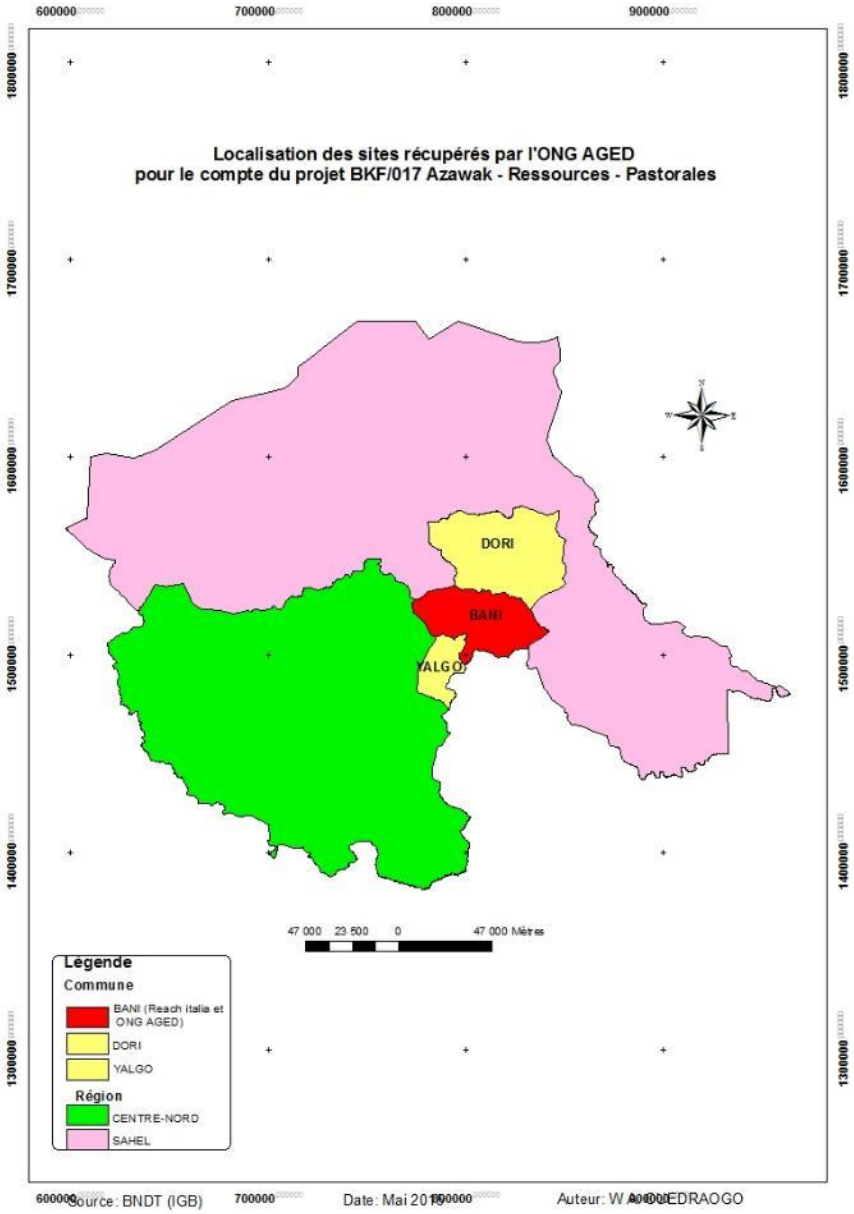


Figure 2: Detailed map of the Sahel Region in the North of Burkina Faso with the three municipalities involved in the Plan Vivo project of AGED

In the first phase, the following villages with their different sites will be included in the project (Figure 3):

- Village Djigo in the municipality of Dori in the province of Séno (Figure 4);
- Village Toukabayel in the municipality of Dori in the province of Séno (Figure 5);
- Village Toukakorno in the municipality of Dori in the province of Séno (Figure 6);

Figure 3: Location of the three villages included in the pilot phase

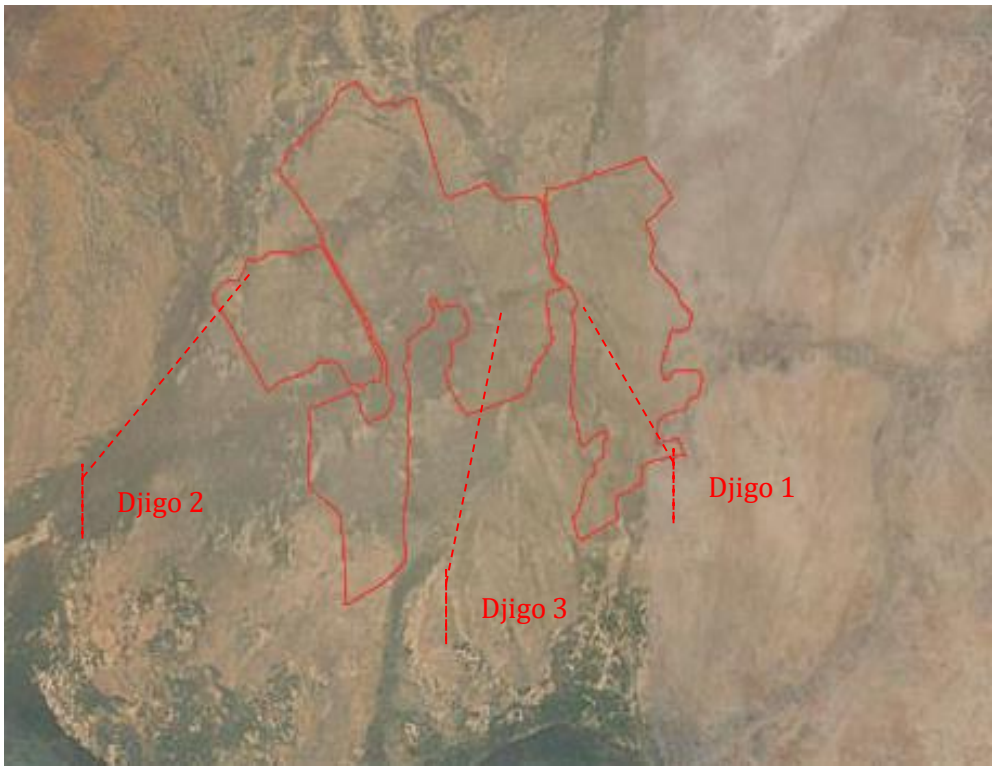


Figure 4: Sites of the village of Djigo in municipality of Dori in the province of Séno

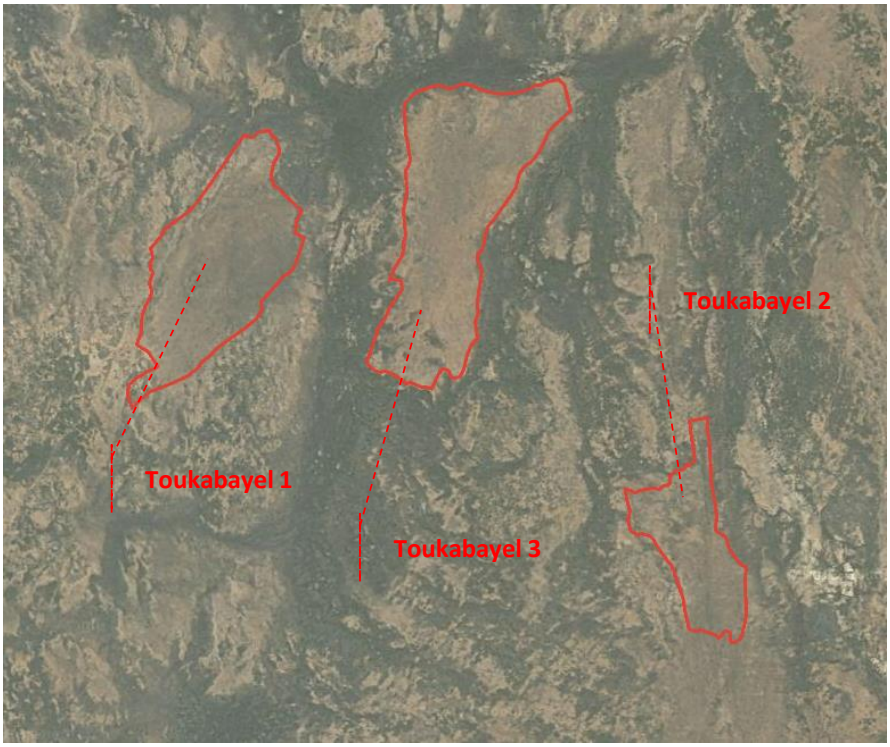


Figure 5: Sites of the Village Toukabayel in the municipality of Dori in the province of Séno

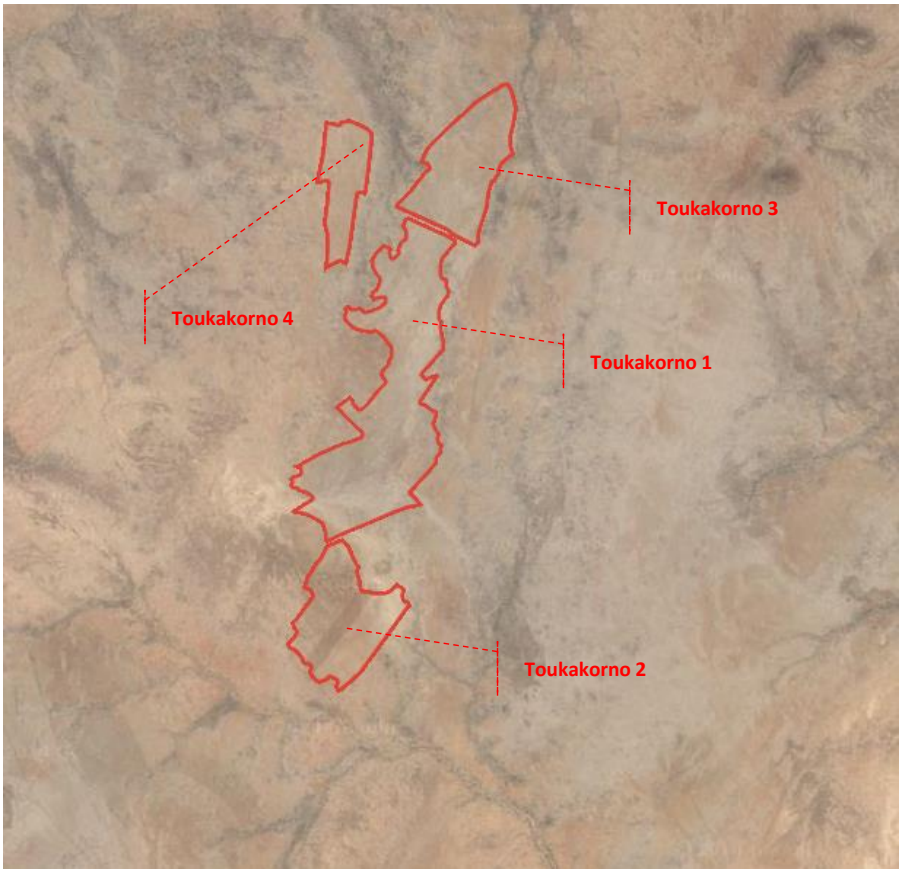


Figure 6: Sites of the village of Toukakomo in the municipality of Dori in the province of Séno

In each village different sites will be rehabilitated, which are presented in the table below:

Province	Municipality	Village	Site	Hectares
Séno	Dori	Djigo	Site 1	103
			Site 2	57
			Site 3	137
			Subtotal:	**297**
Séno	Dori	Toukabayel	Site 1	42
			Site 2	55
			Site 3	22
			Subtotal:	**119**
Séno	Dori	Toukakomo	Site 1	102
			Site 2	42
			Site 3	43
			Site 4	23
			Subtotal:	**210**

Table 1: Overview of the rehabilitated sites in the different villages of the pilot phase

B2 Description of the project area

The proposed project areas are located in the nature reserve of the Sahel in the North of Burkina Faso, denominated "Reserve sylvo-pastorale et partielle de faune du Sahel". It covers a surface of 1.600.000 hectares and was created by Ordonnance n°70/302/PRES/AGRI-EL of 9 December 1970. In the reserve, pastoral activities are conducted on natural pastures and hunting activities are allowed.

The provinces of Séno, and Namentega are characterized by North-Sahelian climate (annual rainfall < 400 mm, number of dry months > 9). The climatic limiting factor for plant growth is rainfall which is generally tending to diminish, with increasing variations between years and the migration of isohyets to the South as shown in the figure below.

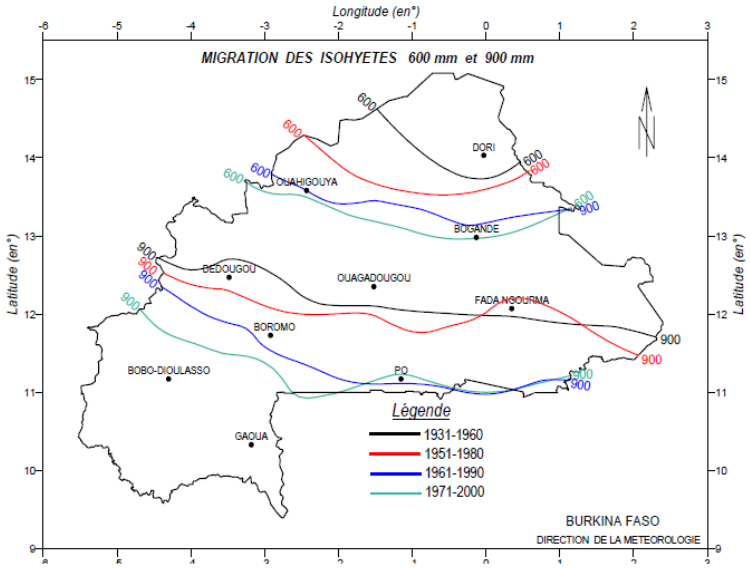


Figure 7: Migration of isohyets in Burkina Faso[1]

[1] Source: [1] MECV (2007) « Programme d'action national d'adaptation à la variabilité et aux changements climatiques (Pana du Burkina Faso) » http://unfccc.int/resource/docs/napa/bfa01f.pdf

The farmlands, grasslands and woodlands of the Sahel are important wintering and staging areas for a wide variety of birds migrating from Europe. Many species undertake this migration, including waterfowl, waders, birds of prey and songbirds: over 2 billion songbirds migrate from Europe to sub-Saharan Africa each year. Birds that winter in the Sahel use landscapes intensively managed by farmers and livestock keepers. Some examples of endangered species present in the nature reserve of the Sahel in the North of Burkina Faso are the black crowned crane (*Balearica pavonina*), the great snipe (*Gallinago media*) and the black-tailed godwit (*Limosa limosa*)[2].

The rainy season in the Sahel is characterized by heavy rain fall in a very short period. An annual rainfall of 2-400mm falls in only three months during the northern hemisphere summer. For this reason, some villages included in the project might not be accessible during some periods of the rainy season.

The soils in the Sahel are mainly characterized by the following types: (i) sandy soils in most areas of the Sahel; (ii) sandy clay soils that can be found in the floodplains and lowlands; (iii) gravelly soils; and (iv) glacis which are bare soils with low water infiltration.

B3 Recent changes in land use and environment conditions

The combined effects of successive droughts and human activities have resulted in a strong destruction of the vegetation cover, a significant drop in the water table and excessive denudation of soils mainly in the Sahelian part of Burkina Faso[3]. These bare soils become very vulnerable to wind and water erosion, leading to land degradation. The figure below shows that land degradation is very present in the Sahel.

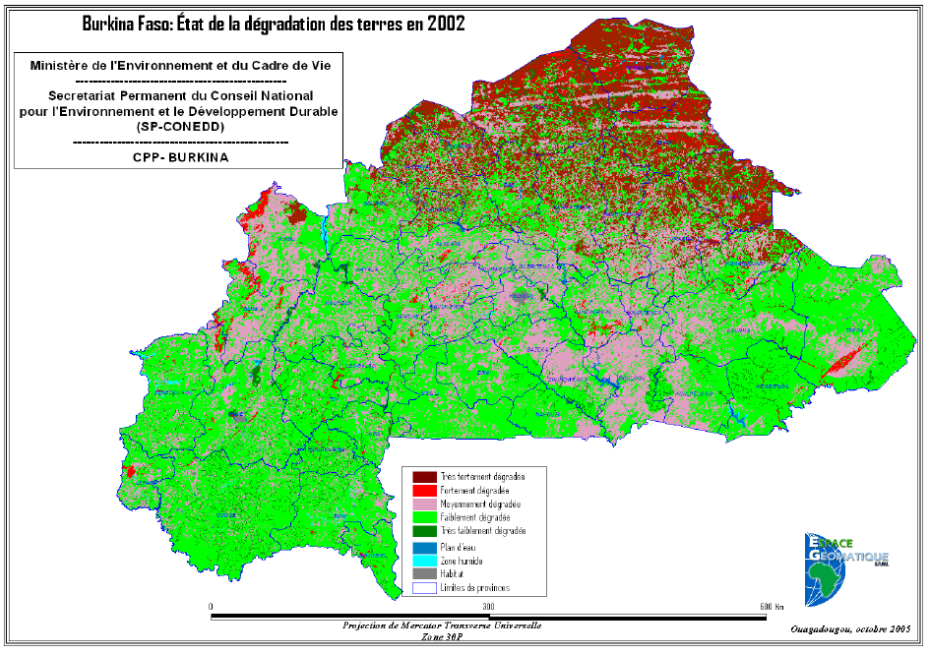


Figure 8: Land degradation in Burkina Faso (Source MECV (2006))
Dark red: very high / Red: high / Purple: Moderate / Green: Low

It appears that the provinces where degradation evolves more quickly are those of the Sahelian climate zone (Figure 9). The provinces Séno and Namentenga of the project intervention zone (out of the 45 provinces of Burkina Faso) have seen almost 50% of their surface degrading at a very high rate between 1992 and 2002. These provinces are characterized by low rainfall causing a high mortality of species on top of the other factors of land degradation mentioned

[2] SANOU Y. et al (2008) Zones d'Importances pour la Conservation des Oiseaux (ZICO) du Burkina Faso Statuts et Tendances 2008
[3] Source: MECV (2006) Revue scientifique sur l'état de la dégradation des terres au Burkina Faso

in the section below.

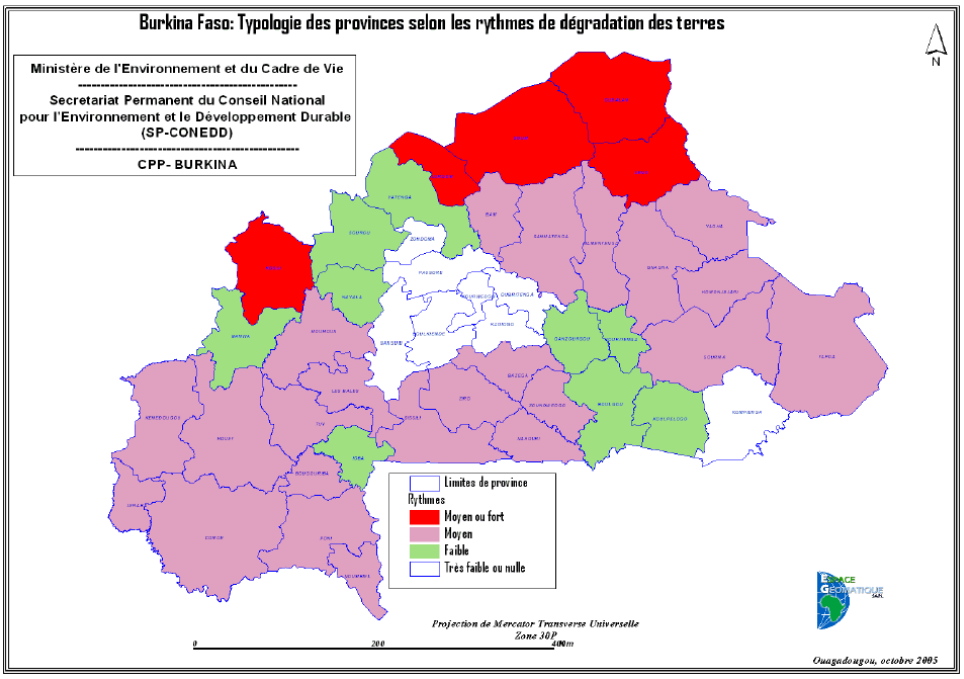


Figure 9: Rate of land degradation per province between 1992 and 2002 (Source MECV (2006))

(Red: High / Purple: Moderate / Green: Low)

The consequences of land degradation can be summarized as follows:

- Regression or loss of vegetation cover and ecosystem fragility due to a significant drop in the water table. Examples of trees species highly affected and near to extinction: *Pterocarpus lucens*, *Balanites aegyptiaca*, ... ;
- Reduction in pasture zones leads to depletion or disappearance of some grass forage species, like e.g. *Andropogon gayanus;*
- Dwindling water resources: due to lack of water points some animals migrate to other regions like the giraffe and ostrich;
- High temperatures of surface layers of soil prevent the proliferation of wildlife and inhibits the biodegradation of organic matter;
- Impoverishment of the local communities with increased pressure on remaining natural resources, as bare soils are unsuitable for production and vulnerable to wind and water erosion, and thus leads to loss of productive capacity;
- Increased conflicts between pastoralists and farmers.

B4 Drivers of degradation

Land degradation has multiple causes. Direct human pressures, such as overgrazing, excessive land cultivation, and deforestation reduce the vegetation cover. Soils become vulnerable to erosion and hence affect water regimes and freshwater ecosystems. The semiarid soils (silt and clay) appear to be more vulnerable than sandy arid soils. These pressures also lead to a change in the vegetation cover (plants), a decrease of diversity (inter-species and genetic), and a loss of the integrity of the wildlife habitat.

These direct human pressures are linked mainly to population growth, poverty and cultivation and livestock methods: the need for land (migration) in order to satisfy the needs for energy (biomass) and food (human and animal). More in particular, intensive grazing of natural pastureland leads to the degradation of pasturelands with low production. Indeed, based on data of the ministry in charge of animal resources, the rate

of the average annual growth since 1961 of sheep, goats and cattle are respectively 5.1%, 4.4% and 2.4%, whereas the pasture productivity is steadily declining and so the soil fertility.

Part C: Community and Livelihoods Information

C1 Description of the participating communities/groups

The target communities live in poverty, both income and resource poverty, and they depend on subsistence and modest income-generating crop and livestock farming activities for their survival.

- Village Djigo in the municipality of Dori in the province of Séno (Figure 4);
- Village Toukabayel in the municipality of Dori in the province of Séno (Figure 5);
- Village Toukakomo in the municipality of Dori in the province of Séno (Figure 6);

The project will in the first stage target the villages of Djigo, Toukabayel and Toukakorno in the municipality of Dori in the province of Séno. At a later stage, other villages will be involved in the project, which are located in the municipalities of Bani and Dori in the province of Séno, and Yalgo in the province of Namentenga. All these municipalities are located in and around the nature reserve of the Sahel in the North of Burkina Faso, denominated "Reserve sylvo-pastorale et partielle de faune du Sahel". Population data of the pilot villages can be found in the table below[4].

Village	Population	Households
Djigo	1035	254
Toukakomo	591	129
Toukabayel	1802	392

The rural villages of Djigo, Toukakomo and Toukabayel in the province of Séno, are, to the image of the province, characterized by a high population growth (Table 2).

Provinces	1996	2006	
	Population	Population	Growth 96-06
Séno	201,760	264,991	3.14%

Table 2: Population growth of the province of Séno (Source: MEF (2008)

Almost half the inhabitants of both municipalities are under 15 years of age. The population density is lower than the national average, which is 52 inhabitants/km2 (MEF 2008).

Population	Dori
Households	23,267
Population	106,808
Under 15 years of age	42%
Women	50%
Population density (inh./km2)	42

Table 3: Age and gender distribution and population density

Islam is the dominant religion in the municipality of Dori as it is practiced by more than 95% of the population. The main ethnic group is the Fulani group (Peuhls) followed by the Mossi and

[4] MEF (2008): Recensement général de la population et de l'habitation de 2006 – RGPH-3

the Sonrai group.[5].

Healthcare centres in the Sahel are on a remote distance of most households. In 2007, only 12.7% of the households in the Sahel were within a range of 30 minutes of nearest healthcare centre. The municipality of Dori has 9 healthcare centres.

The school enrolment rate in the Sahel is amongst the lowest in Burkina Faso (44% compared to the national average of 67%). Factors negatively influencing the school enrolment rate, are among others socio-cultural and religious burdens (early marriage, preference of Koranic schools), local migrations, cost of tuition and lack of infrastructure.

C2 Description of the Socio-economic context

The Sahel region takes the last place in terms of GDP / inhabitants in Burkina Faso, which is 582 US$ PP / inhabitant[6]. The main towns in the Sahel region and Séno province are medium-sized cities where activities other than agriculture are poorly developed. More than 85% of the populations in the Sahel are agro-pastoralists. In addition, the agriculture does not benefit from an advantageous rainfall which causes migration of especially young workforce to the South. Less than 2% of the households in the Sahel region have access to electricity. More than 50% uses oil lamps as most important light source. In rural areas lamp torches and biomass are also often used.

The analysis of the situation of poverty in the Sahel zone in Burkina Faso shows that more than 33% of the households live below the poverty line[7]. The poorest households consist of agro-pastoralists who do not have cattle, agro-pastoralists looking after entrusted animals, agro-pastoralists practicing small scale transhumance, children, women and other actors of small livestock trades (like salaried shepherds and others). During the implementation of the project attention has been paid to gender issues. The various socio-cultural groups in the Sahel have very different men – women relationships and human – animal relationships. For Fulani, main ethnic nomad group in the Sahel, it is common that women own the animals that they received as dowry and that remain under their control. Men are taking responsibility of the herd, but the women will do the milking and are in charge of the commercialization of the milk. For other ethnic groups rearing cattle, the respective roles of women and men are less clear.

C3 Description of land tenure & ownership of carbon rights

Burkina Faso adopted a new Rural Land Tenure Law (Act. No. 034 on The Rural Land Tenure System) in June 2009. The law recognizes customary rules and practices, and reinforces the decentralization and devolution of authority over land matter. The goals of the new law include: (i) ensuring equitable access to rural land; (ii) promoting investments in agriculture, forestry and pastoralism in Burkina Faso; (iii) reducing poverty in rural areas; and (iv) promoting sustainable management of natural resources. In addition to these goals, the new Rural Tenure Law is meant to protect property and land user rights, prevent and manage land conflicts, and build a framework for ensuring rural land tenure security.

The law promotes decentralization in Burkina Faso and codifies principles of customary rights by enabling communities to draft local land charters, which are local conventions based on the customs and land uses. These land charters contain rules relating to conservation of shared natural resources, the process of giving and receiving land loan, and managing land disputes. They are created at the village level in a participatory manner that includes a representative group of stakeholders (including women, forest users, pastoralists, and youth), and is aided by the state. They are adopted at the village level, validated at the municipal court, and recorded

[5] http://www.anciveneto.it/documenti/documenti/PCD%20Dori%20final_07[1].10.08.pdf
[6] PNUD (2012) « Rapport National sur le Développement Humain Burkina Faso 2012 » http://www.bf.undp.org/content/burkina_faso/fr/home/library/human_development/rapnatdh12/
[7] MRA (2005) « Initiative Elevage Pauvreté et Croissance (IEPC) » http://hubrural.org/IMG/pdf/burkina_iepc.pdf

in the register of local land charters. Communities are engaged to participate in safeguarding the application of these local land charters.

Pastoralists and sedentary farmers are also sometimes in conflict. Transhumance has been practiced in the Burkinabe Sahel for centuries, and there are clear local understanding regarding northern herding routes. Expanded cultivation is blocking traditional access routes to pasture and watering holes. Also, more pastoralists are seeking to become sedentary agro-pastoralist, and more farmers are raising livestock, exacerbating competition between the populations and minimizing complementarity. Farmers have less incentive to invite pastoralist onto their land when their own livestock have already provided manure and milk. The 2009 land Law reinforces the jurisdiction of local authorities in resolving land disputes, per procedures set forth in local land charters.

The rehabilitated pasture sites are managed by the Village Development Committee (or CVD) through the local land charter. The local land charters are developed according a methodological guide for the implementation of the Rural Land Tenure Law 2009-034[8]. AGED was responsible for the elaboration of the land charters in the municipality of Dori and has developed a roadmap based on the methodological guide[9]. It includes different phases conducted at different levels of actors, like all population groups within the village, Village Development Committee (CVD), Village clusters and Municipal council: (i) preparation phase with sensitization on the Rural Land Tenure Law; (ii) diagnostic phase; (iii) negotiation phase; (iv) adaptation/validation phase of the local land charter; and (v) implementation support. Additional attention has been paid that all socio-economic groups of the villages (including women and youth) have the possibility to express their concerns during the village meeting on the elaboration of the local land charter. The local land charter process has been finalized in the municipality of Dori (with the pilot villages Djigo, Toukabayel and Toukakomo)[10]. Through these local land charters land user rights of the rehabilitated sites as well as the carbon rights are owed by the local communities.

Part D: Project Interventions & Activities

D1 Summary of the project interventions

Project activities undertaken in the project area include: ecosystem restoration and improved land use management.

Restoration of degraded pastures

The project's intervention consists of restoring degraded pastures in the Burkinabe Sahel by re-establishing its structure, productivity and tree and grass species diversity originally present in order to enhance the productivity of the vegetation as pasture for the benefit of the pastoralists and agro-pastoralists. The sites are old degraded grazing lands of which the topsoil is characterized by a clogged, hardened and impenetrable surface. Degraded pastures identified for restoration in close collaboration with local communities are worked using the Vallerani system with the Delfino plow. The plow creates micro-catchments in "half-moon shape" 4 m long and 0.5 m wide with a volume of about 1000 litres, disposed across the contour-line. The micro-basins collect rainwater, over flow and other resources available like fine soil, organic matter, seeds, etc. The natural regeneration of vegetation on ripped land is assisted by direct seeding of grass and tree species. The seed collection, conservation and direct seeding are organized with and by the local communities.

Land use management

All villages included in the project's activity of restoring degraded pastures are involved in the

[8] Document Guides méthodologiques de mise en œuvre de la loi 034-2009 /an du 16 juin 2009 portant régime foncier rural : p.23 Guide méthodologique d'élaboration des chartres foncières locales

[9] AGED, Feuille de route_Elaboration Charte Foncier Local

[10] AGED 2015 : Rapport Dori - Elaboration CFL

implementation of local land charters. These local land charters, based on the new Rural Land Tenure Law (Act. No. 034/2009), enable communities to sustainably manage the restored pastures. Local land charters are created at the village level in a participatory manner that includes a representative group of stakeholders (including women, forest users, pastoralists, and youth). These land charters, which are local conventions based on the custom and land uses, contain rules relating to conservation of shared natural resources.

Capacity building

Capacity development sessions are provided to the project participants on (i) the management of natural resources; (ii) the collection and treatment of seeds; (iii) the management of funds; (iv) the conflict handling; and (v) the inventory, assessment and monitoring of their rehabilitated sites.

D2 Summary of the project activities for each intervention

Table D2 – Description of activities				
Intervention type	**Project Activity**	**Description**	**Target group**	**Eligible for PV accreditation**
Ecosystem restoration	Restoration of degraded pastures	Direct seeding of native tree species	Community groups	Yes
Improved land management	Land use management	Implementation of local land charters	Community groups	No
Improved land management	Capacity building	Capacity development sessions e.g. collection and treatment of seeds	Community groups	No

Table 4: Summary of the project activities

D3 Effects of activities on biodiversity and the environment

The micro-catchments created through the Vallerani system with the Delfino plough collects water runoff and improves the infiltration of water into the soil and the retention of water for the plants growing in them. They also serve to loosen the soil and improve the plants access to nutrients. Water is stored in the upper part of the soil, which is the root zone. Part of the water can be used by the restoring vegetation. As the system of micro-catchments is used over a wide area, there will be a significant groundwater recharge.

Tree and grass seeds are trapped in the micro-catchments, which helps to build up the natural vegetation cover. Realized studies[11] shows the positive impact on the dynamics of herbaceous and woody vegetation in terms of plant diversity, density and forage production. A study from INERA[12] for the BKF/017 program showed that the average additional output of dry matter in the form of herbaceous biomass was approximately 790 kg/ha, compared with less than 180 kg/ha on land where the technique was not applied. The biodiversity also increased in terms of grass diversity as after two years of project activity the average number of grass species increased in average from 7 to 10 species per hectare. In addition the usage of native trees and grass species encourage pollinators and other animals into the area, increasing biodiversity.

[11] GROUZIS M., NIZINSKI J., AKPO E., IVe Congrès International des Terres de Parcours Montpellier – France – 22-26 Avril 1991, « L'arbre et l'herbe au Sahel : Influence de l'arbre sur la structure spécifique et la production de la strate herbacée, et sur la régénération des espèces ligneuses »

[12] INERA (2014 et 2015) : Rapports techniques d'état d'avancement du Protocole d'accord entre l'INERA et le Projet Azawak : Suivi scientifique des sites de récupération de terres dégradées réalisées par le Projet BKF/017 « Azawak Ressources Pastorales » notamment dans les communes de Gorom Gorom, Markoye, Dori et Bani.

Part E: Community participation

E1 Participatory project design

The community groups participating to the project are villages, which are organized through a governance structure that is already in place, i.e. the Village Development Committees (Conseils Villageois de Développement CVD). Within a process of decentralization of state services in Burkina Faso, the Village Development Committee has been established in 2007 (Decree N° 2007-032/PRES/PM/MATD) as an official authority to give villages a unique and official structure to organize and develop local initiatives. Organized under the auspices of the Municipal Council, which oversees its implementation, the Village Development Committee is the consolidation of all the "lifeblood of the village". It therefore represents grassroots communities that include rural populations and other development actors at the level of the village. The role of the Village Development Committee consists of among others (i) initiating micro-projects for local development, land management or decentralized rural development; (ii) acting as contracting authority for the implementation of local projects; and (iii) collaborative management of local resources (like grasslands) on the territory of the village.

The project is being developed under auspices of the BKF/017 program supervised by the Ministry in charge of Animal Resources in Burkina Faso with finance from Lux Dev. AGED has been appointed by the Ministry in charge of Animal Resources in Burkina Faso and Lux Dev for its implementation in the municipality of Dori of the following activities: the rehabilitation of the degraded pastures, the facilitation in the elaboration of the land charters and taking up the role of coordinator of the Plan Vivo project. Within this role AGED has facilitated the development of the project through a participatory and inclusive approach. During local meetings, all members of the community have been involved in the decision-making process in terms of site selection, specious selection, benefit sharing and land use management. They decided which trees and grasses to seed and how the sites should be managed based on the local land charters. The sharing and awareness sessions helped local communities to understand the objectives of the rehabilitation of degraded pastures and to get involved in making decisions and to be responsible for the selection of species and management of these sites.

Opinions of all members of the community were taken in to account during the consultation process using the focus group technique. Some groups (like women and youth) are in some villages not allowed to speak publically in presence of men and elderly. Stakeholders were grouped in homogeneous groups in order to foster free and conscious expression, to collect opinions and to enhance the consideration of the concerns of vulnerable groups. After exchange in focus groups, the point of views were shared in a plenary session and consensus was found during the decision making process. This approach allowed to guarantee that, for example, the needs of the women were taken into account when choosing the tree and grass species for the rehabilitated pastures.

E2 Community-led implementation

The initial sites and villages were selected by the project coordinator based on a number of criteria, like: (i) identification of the potential of the area with the local technical services (Decentralized Forest Services, Decentralized Animal Resource Services and Decentralized Agriculture Services and the municipality); (ii) quality of the soil (ex. presence of rocks in the soil); (iii) tenure analyse (ex. land disputes); and (iv) pastoral land use. During community consultation with the CVD, the final sites were selected according the priorities of the community group.

A pre-selection was done by the project coordinator in close collaboration with the local technical services (Decentralized Forest Services, Decentralized Animal Resource Services

and Decentralized Agriculture Services) of the potential grass and tree species in order to ensure the successful establishment of vegetation cover, taking the following factors into consideration:

- needs of livestock keepers and/or agro-pastoralists;
- species suited to environmental conditions, taking into account climate changes;
- palatability and nutritive value of the grass species and any secondary uses they may have;
- livelihood benefits of tree species (fodder, fruit, medicinal value, etc.)
- ecosystem functions (soil structure and fertility improvement, production of leaf litter, etc.)
- availability of seeds;
- potential for marketing products.

Different meetings took place within the local villages to discuss the final choice of grass and tree species that would meet local livelihood needs and would improve aspects of local ecosystems.
The implementation of land management system for the Plan Vivos are based on local land charters. As described in section C.3 the local land charters are designed according the New Rural Land Tenure Law 034/2009 and include consultation and validation at different levels: all population groups within the village, Village Development Committee (CVD), Village clusters and Municipal council. These local land charters contain rules relating to the conservation of the village pastures, like it is forbidden to cut fresh wood, to install crop fields in the zone of village pastures, to collect dried grasses for commercial purposes and cut green wood in the rehabilitated land for pasture, etc. During the development of the Plan Vivo of one village, reference is made to the rules and land management system of pastures elaborated in the local land charter that the village has signed. AGED provides technical assistance in the set-up of the supervisory committee of the application of the rules described in the local land charter.
Boundary GPS coordinates are recorded for all rehabilitated pasture sites. Each village specifies its Plan Vivo through the establishment of a hand-drawn map with the location of the rehabilitated pasture sites, and with the specification of the tree and grass species and the land use rules of the rehabilitated pasture sites. Meeting minutes include the description of the Plan Vivo of the village and AGED as project coordinator keeps a directory per Plan Vivo/village with all necessary information of the Plan Vivo of a particular village: meeting minutes with pictures and list of participants, hand-drawn map of the Plan Vivo, GPS coordinates of the Plan Vivo (i.e. the rehabilitated pastures sites), signed contract between AGED and the village, forest inventory data, monitoring data of the socio-economic surveys and other data related to the payments.

E3 Community-level project governance

Community participation represents a key factor for the achievement of the expected results and for guaranteeing the sustainability of the project. The project coordinator has already a long track-record of involvement with the local communities. Continued community consultation, participation and involvement is central in the project approach. Local animation meetings will be organized on a quarterly basis on follow-up and advisory on land-use management, PES fund management,… in order to create transparency and involvement. The focus group technique will allow having the opinion of all members of the community.

Participants are able to raise grievances with the project coordinator based on community meetings using focus group techniques and/or through personal communication. These grievances will be recorded and dealt with in a transparent, fair and timely manner. A summary of grievances received, the manner in which these are dealt with, and details of outstanding grievances will be reported to the Plan Vivo Foundation through the periodic reporting process.

Part F: Ecosystem Services & Other Project Benefits

F1 Carbon benefits

Table F1 – Carbon benefits					
	1	2	3	4	2-(1+3+4)
Intervention type (technical specification)	Baseline carbon uptake / emissions i.e. without project (t CO_2e/ha)	Carbon uptake/emissions reductions with project (t CO_2e/ha)	Expected losses from leakage (t CO_2e/ha)	Deduction of risk buffer (t CO_2e/ha)	Net carbon benefit (t CO_2e/ha)
Restoration of degraded pastures (283 ha)	0 tCO2e	61tCO2e	0 tCO2e	12 tCO2e	49 tCO2e

Table 5: Carbon benefits of the project

The carbon uptake during the crediting period of 30 years has been estimated using a CO2fix model. The baseline carbon uptake as well as the expected losses from leakage are assumed to be 0 tCO_2e per ha, whereas the risk buffer 20%. The net carbon benefit during the crediting period of 30 years is estimated at 49 tCO2e. . After 5 years the CO2fix growth model will be updated based on new inventory monitoring data. Please see the technical specifications of the rehabilitation of degraded pastures in the Burkinabe Sahelian zone in Part G.

F2 Livelihoods benefits

The project will have a range of beneficial effects on the livelihoods of participating community groups, which are summarized in the Table below.

Table F2 – Livelihoods benefits							
Food and agricultural production	Financial assets and incomes	Environ-mental services (water, soil, etc.)	Energy	Timber & non-timber forest products (incl. forest food)	Land & tenure security	Use-rights to natural resources	Social and cultural assets
Increased forage for animal production	Increased animal productivity	Restoration of degraded pastures	Increased fuel materials such as: (i) dead wood ; (ii) rods from herbaceous species; and; (iii) cow dung.	Fruits; Acacia gum; Leaves; Pharmacopoeia.	Local land charters formalise the management of pasture areas	Local land charters allows to avoid potential conflicts between pastoralists and agriculturalists	Sedentarisation and decrease the rural exodus;
Herbaceous species and NTFP and fruits of woody species for human consumption;	Increased income-generating activities				Local land charters increase land & tenure security and resource access rights		Increased school enrollment rates

Reducing malnutrition through increased availability of milk							Social cohesion

The rehabilitation of degraded pastures through direct seeding of herbaceous and woody species will affect the food and agricultural production. In the Sahel, local communities in rural areas depend on livestock, a few crops and wild plants for survival. In daily life the Sahelian communities complement the diet through a collection of wild fruits and leaves for sauce, which are important supplements of vitamins and minerals to an otherwise monotonous diet[13]. Wild fruits from woody plants are particularly important, because they are available in the dry season where other food products are insufficient. As an example ripe fruits of the woody specie *Balanites Aegyptiaca* are picked for their bitter-sweet flesh, while oil, used for frying, is extracted from the kernels and fresh new shoots may be cooked with leaves like cabbage during drought and periods of food scarcity.

Woody plants promote the development of herbaceous plants, crops and woody regeneration during the rainy season by ameliorating microclimate and soil fertility. An evaluation study of the herbaceous biomass on rehabilitated pasture sites as well as degraded pasture sites has shown that rehabilitated sites have a positive impact on forage production[14]. Indeed, the dry matter or fodder production increased by fivefold and in the same extent the carrying capacity of the pasture sites. These figures are in line with another study evaluating the impact of half-moon technique on the fodder production in Sahelian Burkina Faso[15]. Since forage for livestock will increase, it is anticipated that the increased milk availability will diminish the malnutrition among children. As according the local land charter the access to the rehabilitated pasture sites are free to all stakeholders. Nevertheless supervisory committee is set in place in order to supervise the application of the land management rules defined in the local land charter (e.g. no cutting trees or grass fodder collection for commercial purposes),

The table below presents the major product uses of the native woody species that will mainly grow on the rehabilitated sites. *Acacia Tortilis* is the main specie, as it is a pioneer species which easily regenerate from seed and contribute to the rehabilitation of the pasture sites through nitrogen fixation in the soil. In addition, it provides forage browse especially for goats, and provides shade for animals. It's also known that some of the most palatable grass species do grow beneath its canopy. Besides the human food uses of the *Balanites Aegyptiaca* specie mentioned above, the leaves and fruits are also widely consumed by animals. The *Ziziphus Mauritania* provides tasty fruits, which are highly valued by the local communities. The arabic gum of the *Acacia Senegal* is used for preparation in food, in human and veterinary medicine, in crafts, and as a cosmetic, whereas its dried and preserved seeds are used as vegetables.

Scientific name of woody species	Products & uses
Balanites Aegyptiaca	(i) Fruits and oil; (ii) construction wood ;(iii) Medicinal uses; (iv) nitrogen fixation in the soil;
Ziziphus Mauritiana	(i) Fruits; (ii) Leave as forage; (iii) Soil stabilization
Acacia Nilotica	(i) Pods and leaves as forage and fodder; (ii) Construction of hedges;
Acacia Tortilis subsp. Raddiana	(i) Foliage and seedpods as forage; (ii) (ii) Construction of hedges; (iii) Firewood;

[13] LYKKE, A.M., et al. 2004, Valuation of local use and dynamics of 56 woody species in the Sahel
[14] INERA 2014 and 2015, Suivi scientifique des sites de récupération de terres dégradées réalisées par le Projet BKF/017 « Azawak Ressources Pastorales » notamment dans les communes de Gorom Gorom, Markoye, Dori et Bani
[15] Kiéma A., et al., 2012, Effets des demi-lunes associées au scarifiage sur les productions fourragères en région sahélienne du Burkina Faso

Acacia Sénégal	(i) Foliage as forage; (ii) Arabic gum; (iii) Medicinal uses;
Acacia Seyal	(i) Foliage as forage; (ii) Arabic gum; (iii) Medicinal uses;

Table 5: Overview of woody species

The herbaceous species provide, as explained above to a great extent, forage to the livestock, but are also essential for multiple parts of the daily life of the local communities. *Panicum laetum* is collected from the wild for human consumption on a regular basis and especially in times of food shortage. Its grain is crushed and made into porridge and cakes, which can be sold on local markets. Further *Panicum laetum* is much appreciated by animals for grazing and is suitable for making hay or silage. It is considered to have potential for the restoration of degraded pastures. The leaves of the *Cassia tora* specie is used for human consumption, whereas the rods are used for the construction of roofs, doors and fences and are also used as fuel. In the same way rods of *Andropogon gayanus* are used for the construction of decorated mats, which can be sold on the local market.

The uses of some herbaceous species are presented as an example in the table below.

Name of herbaceous specie	Medicine	Nutrition	Fodder	Firewood	Construction	Tool craft	Ornamental
Alysicarpus ovalifolius	X		X				
Andropogon gayanus	X		X		X	X	
Aristida adscensionis			X		X	X	
Bohereria diffusa	X	X	X				
Cassia tora		X	X	X	X		
Cyperus rotundus	X	X	X				
Dactyloctenium aegyptium	X	X	X			X	X
Indigofera tinctorium	X		X				
Mollugo nudicaulis	X						
Panicum laetum		X	X				
Schoenefeldia gracilis	X		X		X		

Table 6: Overview of herbaceous species

In addition, the usage of tree and herbaceous species as pharmacopoeia is an important element in the Sahelian society, as most of the population relies almost entirely on traditional remedies for health care[16]. The application of plants as remedies is deeply anchored in the social structure of the communities. Most of the grass species mentioned in the table above have a medicine use. As an example the grass specie *Bohereria diffusa* is used for pain relief, anti-inflammation, and treating indigestion.

Through increased food and forage availability the project will decrease the rural exodus. Income-generating activities through the selling of milk, seeds, soap and handcrafts such as mats and brooms in local markets, and time gained as animals can roam freely, will increase the school enrolment rate. Local land charters will formalize the land-use management rules of the pastures. In addition the local land charters will avoid potential conflicts between pastoralists and agriculturalists as they specify after a long consultation process for clusters of villages the pasture sites and agricultural land.

F3 Ecosystem & biodiversity benefits

As tree cover increases, it is anticipated that the ecosystem services of water availability and soil conservation will be enhanced. Watersheds will be protected as reduced run-off will diminish sedimentation of the watersheds. The abundant and deep root system will help maintaining the soil structure.

[16] Zizka A., et al. (2015) Traditional plant use in Burkina Faso (West Africa): a national-scale analysis with focus on traditional medicine

In the hot Sahelian climate, shade is an important function of trees for people working in the fields and compounds as well as for herders and livestock in the bush.

Table F3 – Ecosystem impacts				
Intervention type (technical specification)	**Biodiversity impacts**	**Water/watershed impacts**	**Soil productivity/conservation impacts**	**Other impacts**
Restoration of pastures	Increase biodiversity (ligneous, herbaceous and faunal)	Protection of watershed	Prevention of soil erosion Improve soil structure and fertility	Shade

Table 7: Overview of ecosystem impacts

Part G: Technical Specifications

G1 Project intervention and activities

The Plan Vivo technical specification is applicable to degraded pastures in the Sahelian zone of Burkina Faso. The sites are old degraded grazing lands of which the topsoil is characterized by a clogged, hardened and impenetrable surface.

Degraded pastures identified for restoration in close collaboration with local communities are worked using the Vallerani system with the Delfino plough. The plough creates micro-catchments in "half-moon shape" 4 m long and 0.5 m wide with a volume of about 1000 litres, disposed across the contour-line. The micro-basins collect rainwater, over flow and other resources available like fine soil, organic matter, seeds, etc. The natural regeneration of vegetation on ripped land is assisted by direct seeding of grass and tree species. The seed collection, conservation and direct seeding are organized with and by the local communities. The long term effect of the project intervention is established with the implementation of the local land charters which includes the land managed rules for the rehabilitated pasture sites and are integrated in the Plan Vivo of each participating CVD.

G2 Additionality and Environmental Integrity

The project "Rehabilitation and sustainable management of degraded pastures in the Sahel region of Burkina Faso" is not the product of a legislative degree. Project activities aim to reverse degradation of pastures and foster sustainable land management of the pastures, and could not be considered a commercial land-use initiative that would be economically viable in their own right. The revenues related to Plan Vivo certificates will allow to put in place an incentive mechanism to sustain sustainable pasture management.

Barriers to sustainable management of pastures and how the proposed project will overcome them are presented in the table below.

Barrier	Action to overcome the barrier
Financial Target communities lack financial resources to support rehabilitation and sustainable land management of pastures. Poverty is still forcing many resource users to embark on short-term coping strategies rather than long-term investment in land and resources.	Finance from program BKF/017, funded by Lux Dev, is used to support the establishment of project activities. The sales of Plan Vivo certificates provides a potential source of support in order to foster sustainable management of pastures in the longer term, that will deliver quantifiable climate benefits.

Technical Target communities lack knowledge of practices that could improve land management and/or the technical expertise to implement them.	Rehabilitation and land management practices are introduced to communities during participatory land use planning workshops exercises.
Institutional The implementation of the Land Tenure Law has been difficult. It has been argued that the rules and regulations for securing property rights and promoting sustainable management of natural resources are not really known by local communities.	The set-up of Local Land Charters based on consultation with the full range of rural actors is foreseen in the project. Facilitation and training to guide and strengthen community groups and structures like CVD will allow ensuring rural land tenure security.

Table 8: Additionality analysis

The project sites, which are degraded pasture sites, have not been negatively altered (e.g. cleared of other vegetation or deforested), prior to the start of the project activities for the purpose of increasing the payments for ecosystem services that the participants or CVD's can claim.

The project coordinator monitors any risks of double counting in this project, specifically determining whether any of the Plan Vivos of this project are counted in another project or initiative. At this time, to the best of knowledge of the project coordinator, there are no other Plan Vivo projects or other registered GHG reduction projects in Burkina Faso claiming the carbon benefits of the Plan Vivos included in this project. The project coordinator is aware of other Plan Vivo projects in the Burkinabe Sahel aiming registration at the Plan Vivo Foundation, but the project coordinator will make every effort, in close collaboration with the other project coordinators, to ensure that there is no overlap.

G3 Project Period

This project has a crediting period of thirty (30) years and a payment period of ten (10) years.

The quantification period over which ecosystem services are accounted is determined based on the following reasoning. The precise age of the mature trees is unknown. However, communities and national forestry experts have informed us that the mature size is acquired around 30 years. Dendrochronology studies carried out in Senegal have shown a mean maturity age of a few sahelian species from 21 to 32 years old[17]. To be conservative, a period of time of simulation to 30 years has been chosen.

G4 Baseline scenario

Food and Agriculture Organisation (FAO) has estimated the changes in vegetation cover in Burkina Faso over the last 20 years (1990-2010) as shown in the next Table. The average rate of deforestation was estimated at 1% per year (with varying rates depending on the period).

Year	1990	2000	2005	2010
Naturally regenerated forests (ha)	6 840 000	6 190 000	5 871 000	5 540 000
Planted forests (ha)	6 600	57 800	78 300	109 000
Total	6 847 000	6 248 000	5 949 000	5 649 000

[17] Mbow C. et al (2013): Potential of dendrochronology to assess annual rates of biomass productivity in savanna trees of West Africa. In Dendrochronologia 31 (2013) 41– 51.

Table 9: Trends in forest cover (deforestation) from 1990 to 2010 (FAO)

The project area belongs to the Sahelian climate zone (Figure 10). The vegetation belongs mainly to grassland ecosystems such as steppe with very scattered shrubs, sometimes a dense thicket. These forests types have lost large areas at national level as shown in the table below.

The land where activities will be implemented is much degraded, and was dominated by transhumance, seasonal migration of livestock and pastoralists between higher and lower pastures. The severe droughts (70's and 80's) have dramatically decreased the tree population. Nowadays, there are few, if any trees.

Figure 10: Climate zones and administrative provinces in Burkina Faso (Source: CIFOR, 2015)[18]

Land cover / land use	Area 92 (ha)	Area 2002 (ha)	% national area (2002)	Area 2002 - Area 1992 (ha)	Land cover change / year	
					(ha)	(%)
Agricultural areas with presence of large natural areas	3 268 654	3 437 511	12,59	168 857	16 886	0,52
Agroforestry	2 038 779	2 305 603	8,45	266 824	26 682	1,31
Rainfed crops	7 403 296	8 016 867	29,37	613 571	61 357	0,83
Woodland	53 359	50 249	0,18	-3 110	-311	-0,58
Gallery forests	851 830	834 265	3,06	-17 565	-1 757	-0,21

[18] Kambire HW, Djenontin INS, Kabore A, Djoudi H, Balinga MPB, Zida M et Assembe-Mvondo S. 2015. La REDD+ et l'adaptation aux changements climatiques au Burkina Faso : causes, agents et institutions. Document occasionnel 123. Bogor, Indonésie : CIFOR.

Savanna	9 678 434	8 737 394	32	-941 040	-94 104	-2,04
Steppe	3 826 665	3 683 330	13	-143 335	-14 334	-1,21

Table 10: Evolution of forest and agricultural land from 1992 to 2002 in Burkina Faso (Source: CIFOR, 2015)

During the three decades (1970's, 2000's), marked by the droughts of 1973 and 1984, the Sahel was characterized by the severity of the degradation of natural resources. This deterioration has accelerated under the effects of various human activities (crop and livestock production system) and climate, which results in a decrease in plant biodiversity (Kiéma et al, 2008)[19]. Kadeba et al (2015)[20] has evaluated land covers changes in the Gourouol catchment in Northern Burkina Faso. They have estimated that between 1992 and 2010, the class of land covers "shrub-steppes" has lost about 49% of their area, due to due to the expansion of crop and bared lands.

Land covers	1992		2002		2010		Chanae Change (%) ~ (%) " (%)		
	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	1992-2002	2002-2010	1992-2010
Cultivated lands	115299	29.75	121726	31.41	208288	53.79	+1.66	+22.38	+24.04
Shrub-steppes	211956	54.69	205636	53.06	18856	4.87	-1.63	-48.19	-49.82
Bared lands	4895	1.26	5109	1.32	23593	6.09	+0.06	+4.77	+4.83
Grass lands	44855	11.57	43948	11.34	41515	10.71	-0.23	-0.63	-0.86
Lowlands	9739	2.51	11183	2.88	94643	24.42	+0.37	+21.54	+21.91
Water bodies	383	0.10	930	0.24	289	0.07	+0.14	-0.17	-0.03
Others	409	0.11	596	0.15	191	0.05	+0.04	-0.10	-0.06

Table 11: Land covers change in the Gourouol catchment

The increase of crop and bared areas can be explained by the exponential growth of the human population and pressures from livestock grazing. In many areas, the livestock has surpassed the livestock grazing capacity of the pastures, as shown in the table below.

Sahelian area	Pasture areas (ha)	Livestock grazing capacity (in Tropical Livestock unit or TLU per ha)	Livestock grazing capacity (TLU)
	1 467 800	0.2	293 560

Sahelian area	Cattle (head)	Sheep (head)	Goats (head)	Asins (head)	Equins (head)	Camels (head)	TLU
Livestock Statistics	599 040	784 821	1 817 811	54 912	1 928	14 697	807 881

Table 12: Estimated pasture areas of Sahelian area and feed balance (source: Ministry of livestock, 2000)

The expansion of bare soils causing degradation of land covers is also due to the regression of some species in the area (Kiéma et al. 2008). These authors underlined that the degradation of land cover in the sahelian zone is explained by the regression of the plant species such as *Balanites aegyptiaca*, *Pterocarpus lucens*, *Maerua crassifolia*, *Andropogon gayanus*, *Echinochloa stagnina*, *Vossia cuspidate*.

The carbon pools selected for the quantification of forest carbon stocks are above-ground

19 Kiéma A., Nianogo A.J., Ouedraogo T., 2008. Effets des cordons pierreux sur la régénération d'un pâturage naturel de glacis au sahel [Effect of rock bunds on the regeneration of the vegetation of a natural pasture on open glacis in the Sahelian region of Burkina Faso]. Cahiers d'Agriculture 17(3): 281-288.

20 Kadeba A. et al. (2015): Land covers change and plants diversity in the Sahel: A case study from northern Burkina Faso. In Ann. For. Res. 58(1): 109-123, 2015.

biomass, and below-ground biomass. Carbon pools were excluded from the survey when the cost and/or effort required for assessment or monitoring were likely to be disproportionate to the potential carbon benefits, and if their exclusion contributed to a conservative estimate of carbon benefits from project activities.

Carbon pool	Included (yes/no)	Explanation
Above-ground biomass	Yes	This is the main carbon pool and is expected to increase with the project's activities. This stock is estimated using allometric equations form the last Burkina Faso National Forests Survey (2015) and the model CO2FIX.
Below-ground biomass	Yes	Also a significant carbon pool. This stock is estimated using IPCC default root-shoot rations and also the model CO2FIX.
Dead wood	No	This pool can be neglected in the villages landscape due to low tree density. The use of dead wood is for fuel.
Litter	No	Due to low number of trees the villages' landscape, litter is not taken into account in the calculation of carbon.
Soil organic carbon	No	The "Bureau National des sols" (BUNASOL) - *Soil National Desk* - has data on initial soil carbon stocks but at a broader scale. Concerning carbon dynamics in Northern Burkina Faso soils, the extrapolation of data from literature to project specific sites would contain risks and be criticisable according to some IRD, CIRAD and BUNASOL scientists. It would have been needed to * realise sampling in ex-ante evaluation * anticipate a regular follow-up Both of them are costly. In addition: (i) according to the same scientists, carbon evolution in Sahel regenerated soils is too slow to have a significant impact in the carbon assessment; (ii) soils types may vary significantly from one location to another. For cost and practical reasons, it was relevant not to take into account soil carbon in the modelling. Burkinabe stakeholders should focus on tree carbon dynamics rather than on soil carbon.

Table 13: Carbon pools included and excluded from the estimation of carbon stocks

As mentioned above, the land where activities will be implemented are highly degraded areas. The severe droughts (70's and 80's) have dramatically decreased the tree population. Nowadays, there are few, if any trees. This baseline is a result of testimonies of local populations, people from ONG AGED. In addition, remote sensing and trees counting on control plots give a very low number of trees (<10 trees)[21]. The baseline scenario is illustrated with the figure below, showing clogged and bare soils.

[21] INERA (2014 et 2015) : Rapports techniques d'état d'avancement du Protocole d'accord entre l'INERA et le Projet Azawak : Suivi scientifique des sites de récupération de terres dégradées réalisées par le Projet BKF/017 « Azawak Ressources Pastorales » notamment dans les communes de Gorom Gorom, Markoye, Dori et Bani.

Figure 11: Illustration of the baseline scenario

G5 Ecosystem service benefits

A study[22] was carried out to simulate the carbon benefits using CO2fix version 3.2. The CO2FIX simulation model has been used to calculate the carbon sequestration in above-ground and below-ground biomass in time-steps of one year over the crediting period of 30 years. The basic inputs are wood density, stem volume, growth and the allocation to foliage, branches, and roots.

Carbon stocks of living biomass are calculated employing the following variables; growth and turnover, mortality and harvesting (sustainable pruning).

Data collection

In order to produce growth rate data, direct field measurements of trees were done for several reasons:

- There were no available yield tables concerning the trees of the area (and more generally for Burkina Faso tree species)
- An alternative methodology, accepted by the Plan Vivo foundation, was already available. The Estimating-tree-growth-protocol (Berry, 2008[23]) consists of measuring dendometric parameters on trees of all ages for each tree species. Based on this protocol, a collection sheet of biomass data was elaborated.
- Allometric equations were available thanks to the Inventaire Forestier National – *National forestry inventory* - (2015).
- Also, sites of all ages were reported by REACH Italia. These sites are relatively close from each other and were the subject of a study and a publication (cf. CILSS, 2009[24] ; M.

[22] KINOME (2015): « Mise en place d'un système de quantification des stocks de carbone dans le cadre du Projet Plan Vivo : récupération et gestion durable des pâturages dégradés au Sahel Burkinabé »
[23] BERRY (2008) : ECCM Protocol: Estimating tree growth, 15 p. http://www.planvivo.org/tools-and-resources/
[24] CILSS (2009) : Récupération des sols fortement dégradés à des fins sylvo-pastorales : Une évaluation quantitative des

Conedera et al., 2010).

Dendrometric parameters measures on trees of all ages were realized on sites of the REACH Italia NGO in 2003, 2008, 2011. These sites were rehabilitated with the same technique as used in this project, which is the Vallerani system with the Delfino plough. Adult trees (about 30years old) were also measured to finalize a chronosequence. The following steps were applied:

- Measure the trunk based circumference, the trunk at chest height circumference, and the total height of trees of all ages, species by species;
- Deduce the dendrometric profile of each kind of tree, for each age group. For this purpose, we excluded trees exceptionally tall or small, meaning trees out of the standard deviation;
- Apply allometric equations of IFN to each kind of dendrometric profile for each age group.

This approach allows to generate annual productivity data. The rehabilitated sites of REACH Italia in Konsi, Gagara, Salmossi and Gorom-Gorom were chosen to take the measures of height and diameter of known age trees. The number and age classes of trees measured are shown in the Table "Summary table of tree growth data collection" in Annex 8.

Estimating above-ground biomass

Dendometric measurement results are presented in Table 24 "Result of dendrometric measures and extrapolation to others years" in Annex 8. Based on these characteristics, allometric equations were applied in order to calculate the biomass volumes presented in Table 25 "Total volume of aerial part of each tree (stem and branches) for each age group" in Annex 8. The used allometric equations[25] are presented in Table 26 "Used allometric equations" of Annex 8.

Estimating tree growth rates

Above-ground biomass growth rate

From tree volumes previously measured, annual increment per hectare were calculated. In the system, a density of 260 trees/ha after 30 years is targeted. It means that a minimum density of 400 living tree plants/ha is needed at 3 years. We are referring to this age of 3 because the practitioners from REACH Italia and AGED has mentioned during the assessment that the first 3 years are crucial. The maximum mortality rates occur during the years 1, 2 and 3.

	Conservative scenario	
Minimum density targeted at 3 years age in Boussey (tree plants/ha)	400	# survival tree plants on 1 ha
3-5 years	15,0%	340
5-10 years	10,0%	306
10-15 years	6,0%	282
15-20 years	4,0%	270
20-25 years	3,0%	262
25-30 years	0,0%	262
Approx. density at 30 years.	**260**	

Table 14: Mortality rates and tree densities per scenario and per group of age

The species distribution across the rehabilitated sites are influenced by the local specificities (origin and quality of manure used to bring seeds, constancy/uniformity of farmer's practices during sewing, etc.). A reference distribution has been applied in order to estimate the growth rates for each specie based on assumption mentioned in Annex 9. The table below present the composition of the species:

aménagements mécaniques à partir de la charrue Delfino réalisés par l'ONG REACH au Burkina Faso. CILSS, Ouagadougou, 34 p.

[25] IFN2 (2015) Equations allométriques d'estimation des volumes de bois et de la biomasse foliaire des arbres.

Tree species	%	Conservative scenario
Acacia tortilis subsp. raddiana	90.0%	234
A. senegal	1.7%	4
A. nilotica or A. seyal	1.7%	4
Zizyphus mauritiana	5%	13
B. aegyptiaca	1.7%	4
Total	100%	**260**

Table 15: Tree species that compose a total population at mature stage

Based on this tree species distribution the annual increment has been calculated and is presented for each tree species in the tables below:

Species: *Acacia tortilis subsp. raddiana*

Age (yrs)	Aboveground biomass (CAI, m³/ha/yr)
0	0.0000
5	0.1560
10	0.1198
15	0.4205
20	1.1464
25	2.6778
30	0.6705

Species: *Ziziphus mauritania*

Age (yrs)	Aboveground biomass (CAI, m³/ha/yr)
0	0.0000
5	0.0027
10	0.0042
15	0.0397
20	0.1803
25	0.5588
30	0.1370

Species: *Balanites aegyptiaca*

Age (yrs)	Aboveground biomass (CAI, m³/ha/yr)
0	0.0000
5	0.0002
10	0.0013
15	0.0251
20	0.1411
25	0.4627
30	0.1148

Species: *Acacia Senegal*

Age (yrs)	Aboveground biomass (CAI, m³/ha/yr)
0	0.0000
5	0.0009
10	0.0063
15	0,0408
20	0.1532
25	0.4153
30	0.1111

Species: *Acacia nilotica*

Age (yrs)	Aboveground biomass (CAI, m³/ha/yr)
0	0.0000
5	0.0030
10	0.0022

15	0.0071
20	0.0182
25	0.0402
30	0.0099

Table 16 : Current annual increment of above ground biomass (ages 5 to 30 years) for tree species

Below-ground biomass growth rate

As root volumes equations weren't available for Burkina Faso, a ratio aerial biomass / underground biomass was calculated. For this, we first took default values suggested by the IPCC for dry tropical forests of less than 20t MS/ha:

> Tx [tons of dry matter from roots. (tons of dry matter from shoot)-1] = 0.56 (from 0,28 to 0,68)[26] (Source: Mokany et al., 2006.)

As the conditions of the project area are not exactly dry tropical forest but rather steppes, another more adapted source was chosen, also suggested by the IPCC:

> Root Shoot Ratio for Woodland = 0.48[27]

This general data was compared to the average of other data, in particular the work of Poupon[28] on the Ferlo region in Senegal. The conclusion was made that the rate of 0.48 seems relevant and rather conservatory in comparison with its results.

> «Whatever element of relive considered, underground biomass represents on average 40% of the total biomass. In Fété-Olé, the relative weight of roots in the total biomass varies dramatically from one essence to another depending on species characteristics and population structure. Roots represent 2/3 of the biomass for *Boscia senegalensis*, half of the biomass for *Acacia senegal*, *Commiphora africana* and *Guiera senegalensis*, and a third of the biomass for *Balanites aegyptiaca* and *Grewia bicolor* »
> Source: Poupon H., 1980, page 251-252.

	Portion of underground biomass / total biomass	Ratio of underground biomass / aerial biomass
Balanitès	0,5	100%
Acacias	0,3	43%
Average	0,4	66%

Table 17: Underground biomass / total biomass ratio in Fété Olé (Sénégal) (Poupon H., 1980)

Carbon sequestration (tC02e/ha) is based on the number of trees planted. Carbon benefits for the project have been estimated conservatively. Indeed, certifiable tree density of 260 tree plants / ha has been assumed in a conservative manner. This assumption is justified as it is definitely the minimum density in such conditions. Poupon, 1980, in northern Senegal has estimated that 300 trees / ha has survived despite drought condition of year 1972.

The carbon benefits were modeled using CO2FIX version 3.2. The CO2FIX simulation model has been used to calculate the carbon sequestration in aboveground and below-ground biomass in time-steps of one year over the crediting period of 30 years. The basic inputs are

[26] IPCC (2006) Guidelines for National Greenhouse Gas Inventories, Volume 4 Forest land http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_04_Ch4_Forest_Land.pdf (ENG)

[27] IPCC (2006) Table 3a.1.8 : Average belowground to aboveground biomass ratio (root-shoot ratio, r) in natural regeneration by broad category (tonnes dry matter/tonne dry matter).
http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Chp3/Anx_3A_1_Data_Tables.pdf

[28] POUPON H. (1980) : Structure et dynamique de la strate ligneuse d'une steppe sahélienne au nord du Sénégal. Paris : ORSTOM, 1980, (115), 351 p. (Travaux et Documents de l'ORSTOM ; 115). Th. Sc. nat. : Paris Sud. Orsay : 1979/09/26, ISBN 2-7099-0562-0.

wood density, aboveground volume and the allocation to roots. Carbon stocks of living biomass are calculated employing the following variables: growth and mortality.

	Biomass	
year	carbon	dry weight
[yr]	[MgC/ha]	[MgDM/ha]
0	0.00	0.00
1	0.01	0.02
2	0.03	0.07
3	0.07	0.14
4	0.12	0.25
5	0.19	0.38
6	0.25	0.51
7	0.30	0.62
8	0.36	0.73
9	0.40	0.83
10	0.45	0.92
11	0.53	1.09
12	0.65	1.34
13	0.81	1.65
14	1.00	2.04
15	1.22	2.50
16	1.55	3.16
17	1.97	4.03
18	2.50	5.09
19	3.12	6.36
20	3.83	7.82
21	4.79	9.77
22	5.99	12.22
23	7.43	15.17
24	9.14	18.65
25	11.12	22.69
26	12.80	26.11
27	14.18	28.94
28	15.27	31.16
29	16.06	32.77
30	16.55	33.78
tEqCO2/ha	60.68	
tEqCO2/ha/year	2.02	

Table 18: Total carbon benefits of above- and underground biomass

G6 Leakage & Uncertainty

The risks of leakage in the area are firewood collection and livestock grazing. But the fact is that these risks are minimised because after more than a decade of field action, it has been observed that communities do not collect firewood from regenerated lands. It must be said that in the baseline no firewood was collected from the degraded sites, and rehabilitation of these degraded sites will not increase the pressure in adjacent areas. The application of the local land charters will allow the local communities to better manage their natural resources.

To manage uncertainty, a conservative approach has been used in many points:

- Trees growth rates;
- Trees density per hectare;
- Excluding soils carbon pool.

Trees growth rates

During the calculations following dendrometic parameters measurement on samples, trees

data have been excluded that were out of the standard values, i.e.:

- The dispersion of data collected (height, diameter) has been modelled and the standard deviation has been calculated;
- Exceptionally big or small trees have been excluded because of exceeding the standard deviation;
- Finally, conservative mean values of H and DBH have been calculated per age within the new sample.

Trees density per hectare

Trees density during early years after planting varies significantly sites to sites and year to year (eg. 2014 vs 2015, i.e first and second year after sewing). To ensure a reliable density of trees after simulation's duration, we have consulted many literature sources. We have finally retained the most conservative density of 260 trees/ha.

Excluding soils carbon pool

When we provide climatologic patterns of the project area (temperature sum in degree days above zero over the year; precipitation in growing season and Potential evapotranspiration in growing season), CO2fix is able to generate an estimation of carbon stocks in soils during the period. However:

(i) According to the scientists specialized in Sahelian soils, carbon evolution in Burkinabe regenerated soils is too slow to have a significant impact in the carbon assessment.

(ii) Soils types may vary significantly from one location to another.

(iii) To ensure accurate results, it would have been needed to
* realise sampling in ex-ante evaluation
* anticipate a regular follow-up
Both of them are costly and uncertain. For that reasons, we have considered that not to take into account soil carbon in the modelling could be more conservative.

Permanent plots where data has been collected on rehabilitated sites by REACH Italia in 2003, 2008, 2011 (Konsi, Gagara, Salmossi and Gorom-Gorom) will be established in order to collect new dendrometric data (DBH and H) in particular for the older age groups (> 15 years). In addition, project monitoring results will allow to validate the species growth data and trees density. The assumptions taken for the CO2 sequestration model on tree growth rates and tree density per hectare will be reviewed and possibly revised after five years.

Part H: Risk Management

H1 Identification of risk areas

The potential risk factors with the associated risk level, as well as the actions to be taken to mitigate the risks, are presented in the table below.

Risk factor	Risk level	Mitigation strategy	Score
Land ownership / tenure			
Land tenure	Medium	The local land charter based on the new Rural Land Tenure Law formalize the local conventions based on the customs and land uses. Criteria of site selection are: the absence of known land disputes and no presence of mine sites in the neighbourhood of selected sites.	0.1
Disputes caused by conflict of project aims/activities with local communities/organizations	Low	Participatory planning and continued stakeholder consultation over project lifespan. The local land charter foresees procedures to manage land disputes.	0.1
Financial			

Project financial plan	Medium	Initial costs of the restoration of degraded pastures are already underwritten by the program BKF/017. Monitoring costs should be covered through the sales of Plan Vivo certificates. Lux Dev will continue to support the project coordinator after the closure of the BKF/017 project in 2016.	0.15
Technical			
Coordinator capacity	Medium	Already long experience of project coordinator in assisting local communities in the process of restoring degraded pastures	0.15
Management			
Management of activities not carried out effectively	Low	Already long experience of project coordinator in assisting local communities in the process of restoring degraded pastures. Close monitoring of project coordinator to ensure effective management (example reseeding campaigns).	0.1
Poor record keeping	Low	Robust procedures and keen oversight	0.05
Staff with relevant skills and expertise	Medium	Careful selection of project staff and training. Assistance of staff.	0.15
Tree damage from browsing	High	No specific protection of trees and plants is necessary, as direct seeding limits the plant damage after browsing.	0.5
Economic			
Financial failure caused by poor or fluctuating carbon price or by failure to attract buyers	Low	The Lux Dev cooperation lined up as interested buyer. CO2logic, the consultancy partner for the project, could assist the project coordinator to sell the certificates in case of necessity.	0.1
Political			
External pressure to engage in non-sustainable practices	High	Restoration of degraded pastures is vital for these communities as livestock breeding is one of the main activities in the zone. Transhumance is organized through the local land charter. Project coordinator will assist the CVD in the surveillance of the rehabilitated pasture sites according the local land charters.	0.3
Social			
Community disputes over land tenure	Medium	Local land charters foresees procedures to manage land disputes.	0.15
Disputes caused by conflict of project aims or activities with local communities or organisations	Medium	Participatory planning and continued stakeholder consultation over project lifetime	0.15
Fire			
Incidence of forest fire	Low	Not that relevant in project zone	0.05
Physical			
Extreme climatic events in particular droughts	High	Droughts are not unknown in the Sahel, but all used species are native to the Sahel and very drought resistant.	0.75
Pests and diseases	Low	Not that relevant in Sahelian zone	0.05

The risk assessment will be reviewed at least every 5 years and resubmitted to the Plan Vivo Foundation.

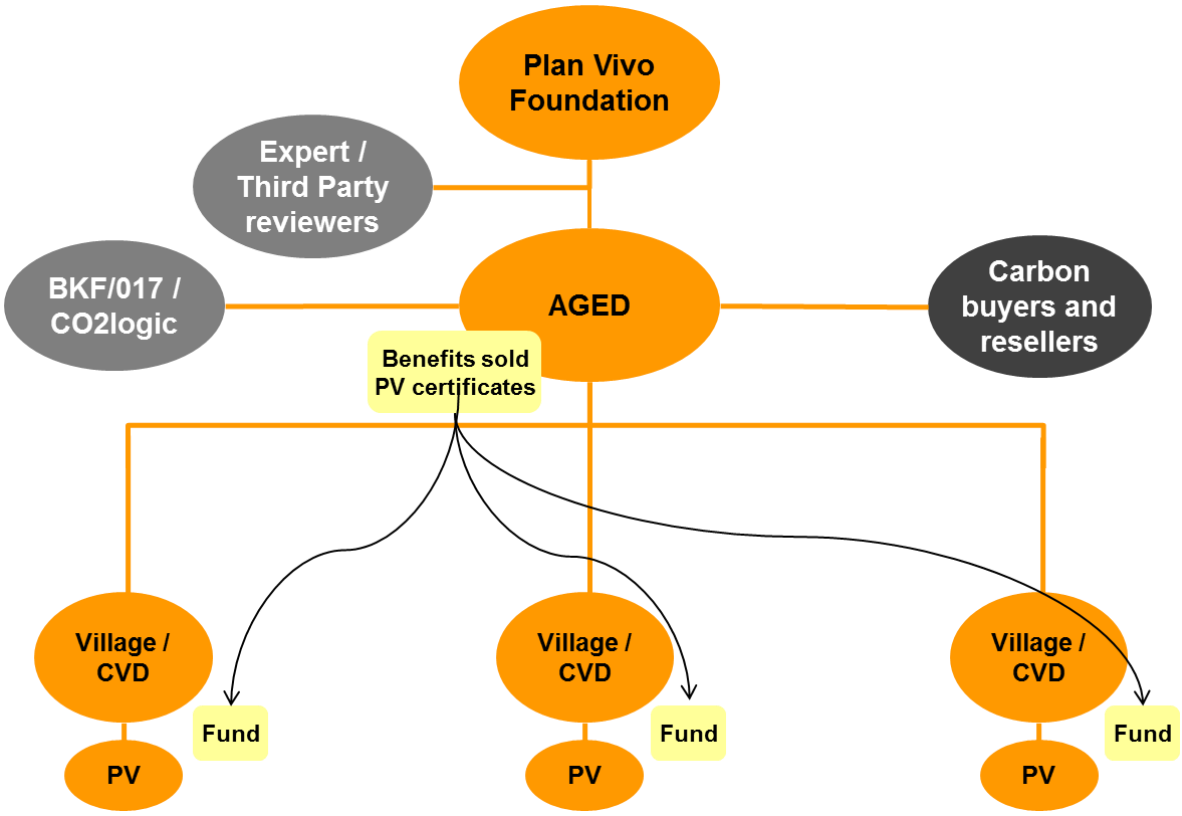
H2 Risk buffer

The risk buffer is a proportion of expected climate services to protect the project from unexpected reductions in carbon stocks or increases in emissions. A risk buffer of 20% has been applied and will be subtracted from all certificate issuances (Annex 11).

Part I: Project Coordination & Management

I1 Project Organisational Structure

The figure below presents the project organisational structure.



AGED

AGED is coordinating the project. AGED is a long-standing local NGO based in the North of Burkina Faso, experienced in community facilitation and forest protection. It is an association by Burkinabe Law, whose existence declaration receipt number is: 2001-02 / MATD / NOGAP / HC / DR 31 MAY 2001; the number of the accreditation agreement at the NGO Monitoring Directorate (DSONG) is 389.

The goal of AGED is to promote the socioeconomic development of the rural population by improving their knowledge and expertise. Its mission is to help the rural communities acquire knowledge, techniques and technologies in natural resource management, in contribution to the establishment of national policies on the fight against poverty and the preservation of national resources. The objectives of AGED are: (i) to help strengthen the capacities of communities; (ii) to contribute to a sustainable management of natural resources; (iii) to contribute to land security among all rural actors; (iv) to support initiatives in improving the performance of economic activities; (v) to support humanitarian and food sovereignty efforts; and (vi) to promote human rights.

AGED will establish an account solely for the management and disbursement of PV funds and separate from their general operational finances. To date, seed funding for establishment of Plan Vivo activities has been provided through the BKF/017 program financed by Lux Dev. This did not take the form of direct payments to participating CVD's, but rather was used to fund rehabilitation of the pasture, elaboration of local land charters and workshops, community meetings and training events, through which PVs were developed and agreed by CVD's. Future funds derived from the sale of PV certificates will be held in this separate account, with funds released to respective CVD's following AGED's review and approval of each periodic monitoring

report. Payments will be made into the existing accounts of the participating CVD's. The CVD's have their own structures and procedures for management and disbursement of funds to members (Part J). Full records will be kept a) by AGED of income and its disbursement to specific CVD's and b) by each CVD through their existing accounting system, to ensure transparency and fairness of disbursements, in accordance with agreed benefit sharing procedures.

AGED carries out the following functions:

- Management of project implementation;
- Community engagement;
- Technical functions, like monitoring and analysing surveys;
- Marketing and selling of Plan Vivo certificates;
- Reporting back to the Plan Vivo Foundation;
- Management of the PES fund and benefit sharing.

Please see Annex 1 for a list of responsible staff.

BKF/017

The project is being developed under supervision of the BKF/017 program "Livestock Improvement Project of the Zebu Azawak and sustainable management of pastoral resources" financed and managed by Lux Dev and the Ministry in charge of animal resources. In addition to rehabilitation and sustainable management of pastures, the program BKF/017 aims at promoting the breeding of a local cattle specie, the zebu Azawak, which is more productive and adaptable to intensive farming. The program started in 2010 and will end in 2016. BKF/017 provided the necessary finance for the implementation of the project activities.

CO2logic

CO2logic is a carbon and environmental consultancy company based in Brussels and among others is providing advisory to local NGO's to valorise their development project in terms of carbon credits mainly in West-Africa. CO2logic is assisting the project coordinator in the development of the Plan Vivo dossier.

CVD/villages

The community groups participating to the project are villages, which are organized through a governance structure that is already in place, i.e. the Village Development Committees (Conseils villageois de Développement CVD). Within a process of decentralization of state services in Burkina Faso, the Village Development Committee has been established in 2007 (Decree N° 2007-032/PRES/PM/MATD) as an official authority to give villages a unique and official structure to organize and develop local initiatives. The CVDs have past experiences in the implementation of local development projects and the management of funds (ex. Local Investment Fund program or FIL – Fonds d'Investissement Local). The CVD's will have different roles in the implementation of the Plan Vivo project: (i) supervisory role on the application of the rules defined in the local land charter and Plan Vivo on the rehabilitated pastures; (ii) providing support to AGED when collecting forest inventory data; (iii) organize benefit-sharing with the implementation of community projects; and (iv) organize reseeding activities in case the identified targets in the PES contracts are not reached.

The BKF/017 program has been set up in accordance with the Rural Development Strategy (RDS) at horizon of 2015, which was adopted in 2003 by the Burkinabe government. The overall objective is to ensure sustained growth of the rural sector to contribute to poverty reduction, enhancing food security and promoting sustainable development. The Rural Development Strategy integrates sectors of agriculture, animal resources and environment. Stakeholders of these sectors have been consulted accordingly. In addition, local authorities have been involved in the design and development phase of the project as they play a key role

in land use planning, integrating the management of pasture land.

I2 Relationships to national organisations

The project complies with all relevant national and international regulations. Government awareness has been built through involvement of different decentralized technical services and local authorities within the design and implementation of the project:

- *Regional/Provincial Directorate of Animal and Fishery Resources*: Several meetings with officials were organized for the pre-selection of degraded pasture sites. Follow-up of the rehabilitated pasture sites are done within the framework of their competences. The Provincial Director of Animal Resources participates in drafting the progress report on the rehabilitation of degraded pastures.
- *Regional/Provincial Directorate of Agriculture*: The officials are involved in the decision making process of to be selected sites in order to avoid potential conflicts between pastoralists and agriculturalists. Officials of the Provincial Directorate of Agriculture are taking part to several meetings concerning the identification, the rehabilitation, the management and follow-up of the sites. The responsible of the Agricultural Technical Support Zone is supervising the compliance to appropriate techniques of rehabilitation of degraded land.
- *Regional Directorate for Environment and Sustainable Development*: The officials of this directorate are also included in the pre-selection process of the sites. In addition, they also give advice on the native woody and herbaceous species for direct seeding. Officials will also provide capacity building towards communities concerning the collection and treatment of seeds, as well as laws and texts related to the management of natural resources and the rights and obligations of smallholders.
- *Regional Directorate of Economy and Planning*: officials of the Gender Cell provide information sessions related to gender on how to involve women and young people in the decision making process and execution of the project activities
- *Local authorities of the municipalities*: local authorities are involved in the development of local land charters. After its elaboration in a participative way, the municipal court will approve or disapprove the local land charter and list the approved once in the register of local land charters.

The project is aligned with the government of Burkina Faso's National Adaptation Programme of Action (NAPA) that considers a drastic decrease and a deterioration of pastures as priority threat for Burkina Faso. NAPA underlines the importance of projects related to the rehabilitation of pastures and securing of pastoral areas. The project is also in line with the Action Plan and Investment Program of the Livestock Sector (PAPISE) which aims to enhance the contribution of breeding to poverty reduction, food security and growth of the national economy.

I3 Legal compliance

At the legislative and regulatory level, various legal texts exist:

- Act no. 003-2011/AN of April 5, 2011: the Forest Code in Burkina Faso, which replaces the previous code (Act no. 006/97/ADP of January 31, 1997, the Forest Code of Burkina Faso);
- Act no. 034-2009/AN of June 16, 2009: rural land tenure in Burkina Faso and its implementing regulations;
- Act no. 005/97/ADP of March 17, 1997: the Environmental Code of Burkina Faso;
- Act no. 034-2002: law on pastoralism designed in order to preserve large areas of rangeland in a zone traditionally devoted to livestock and including rules relating to

transhumance

In particular, the law on rural land (Act no. 034-2009/AN of June 16, 2009) provides tools to formalize land tenure at the local level. The law's main objective is to ensure that all rural stakeholders have equitable access to land and that their investments are secured. It also ensures the effective management of land disputes in order to contribute to poverty reduction, the consolidation of social peace, and the achievement of sustainable development. One of the tools foreseen in the law are local land charters. These are local conventions based on the customs and land uses and are drafted in a participatory way with the communities. These land charters contain rules relating to conservation of shared natural resources, the process of giving and receiving land loans, and managing land disputes. The project coordinator assists the villages/CVD in developing their local land charter, which are presented in annex 6.

The project coordinator complies with all relevant laws relative to labour standard: (i) Respect of employees' freedom of association and their right to collective bargaining and no restrictions of these freedoms and rights; (ii) No involvement and no complicity in any form of forced or compulsory labour; and (iii) No employment and no complicity in any form of child labour.

I4 Project management

The timeline of the project is presented below. The degraded pastures within the three villages of Djigo, Toukabayel and Toukakomo have already been ploughed using the Vallerani system with the Delfino plough and seeded directly by the local communities in 2014 and 2015. In order to have a proper regeneration of the vegetation cover some sites have been reseeded end of 2015 and beginning of 2016. The local land charters have been developed with full participation of the CVD/villages in 2014 and 2015. The Plan Vivo project has been elaborated mainly in 2015. PES contracts will be formalized with the pilot villages as soon as the project has been validated by the Plan Vivo Foundation. After validation the monitoring will start according the monitoring plan described in part K. Scaling up the Plan Vivo project is foreseen for the second half of 2016.

Project activity	2014				2015				2016			
	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4
Application of half-moon technique and seeding	■	■	■	■	■	■	■					
Reseeding activities								■	■			
Development of local land charters	■	■	■	■	■	■						
Development of Plan Vivo project				■	■	■	■	■	■			
Monitoring										■		
Multiplication of other villages											■	■

The project record keeping system will be maintained and continuously updated by AGED. This will entail recording the Plan Vivo submitted by the participating CVD, PES agreement, monitoring and disbursements in accordance with agreed procedures, as specified in Part J (see also Annex 4). Assane BOKOUM of AGED will be responsible for administering the project record keeping system. These records will be kept in Dropbox. An extraction of the project record keeping system will be provided in the annual report.

I5 Project financial management

From the sales of Plan Vivo certificates to companies and private individuals, the local communities receive 60 % as cash. The amount intended for PES is managed through an account in the name of AGED established for this sole purpose, and separate to AGED's general operation finances. The PES disbursement is done in five installments over a period of 10 years

after AGED reviews and approves for each Plan Vivo the monitoring report. Payments will be made into a dedicated account of the participating CVD/village opened at a local "caisse populaire". Cash for expenditure decided by the village community can only be withdrawn from the account with signature from the president of the CVD, the treasurer of the CVD and the project coordinator (see also part J). 40% of the sales revenues is used by AGED for providing advisory services to the involved communities in areas of land-use management, seed collection and treatment and reseeding activities. Plan Vivo Foundation charges an issuance fee of $0.40 per certificate (per tonne).

In case of forward sales of Plan Vivo certificates and in anticipation of forthcoming issuances the Plan Vivo escrow facility will be used to direct payments of the transaction. This will ensure that funds are secured and in place before AGED signs the first PES agreements with the communities.

The project intervention where micro-catchments in half-moon shape are created using the Vallerani system with the Delfino plough, has already been finalized with finance of the BKF/017 program managed by Ministry of Animal Resources and Lux Dev. The budget for this intervention is 21,00 € / 100 ha. Reseeding activities has also been realized through the BKF/017 program and was budgeted on 500 € / 100 ha when using local seeds, and 1500 € when using seeds of CNSF (Centre National de Semences Forestières or National Forest Seed Centre). 40% of the sales revenues of the Plan Vivo project will be used to finance the advisory services to the involved communities and possible reseeding activities. The estimated budget for these services are presented in the table below.

Service	Budget
Follow-up and advisory on land-use management, PES fund management, ...: 4 local animation meetings per community and per year	750 €
Capacity building workshop of 3 days on the collection and treatment of seeds	350 €
Reseeding activities with local seeds per 100 ha	500 €
Yearly monitoring per village	Less 100 €

I6 Marketing

In the first place AGED will search for direct clients through its network within the international development community. As longstanding partner Lux Dev is willing to purchase some PVC to offset its international flights. In addition, Lux Dev is willing to use its network in Luxemburg to market the Plan Vivo certificates of the project. Alain Traore of AGED will be responsible for the business development, whereas Hassane BOKOUM for the account of AGED in Markit registry.

I7 Technical Support

AGED foresees to provide technical support and capacity development to the project participants. As a better quality of seeds will increase the success rate of vegetation regeneration, sessions will be organized on collection and treatment of seeds. Topics that will be demonstrated and discussed are: (i) criteria for selecting seed trees; (ii) seed collection period; (iii) harvesting equipment and methods; (iv) seed preparation equipment and methods (collecting, sorting, drying, etc.); and (v) conservation equipments and methods.

In addition, AGED will provide capacity development sessions to the CVD on the management of funds, conflict handling, planning and on inventory, assessment and monitoring of their rehabilitated sites.

Part J: Benefit sharing

J1 PES agreements

PES agreements have been developed with participating CVD's. These have been derived from a lengthy series of meetings between the AGED and each CVD to (i) explain and discuss the Plan Vivo process; (ii) facilitate CVDs in developing their own Plan Vivo; (iii) develop and agree indicators and monitoring plans; and (iv) agree mechanisms for benefit sharing and disbursement. Agreements are signed and dated by all parties on approval of the Plan Vivos.

Plan Vivos are land management plans which are designed to generate ecosystem services. AGED has facilitated each simple land management plan of the rehabilitated pasture sites with the participants or CVDs to ensure that they meet technical requirements, livelihood needs, and will not endanger food security or displace other land-uses.

AGED has PES agreements contracts with the participants or villages/CVDs, which are contracts providing the basis for the transaction of climate services, and specifying rights and responsibilities of the parties over the contract period. The PES agreement specifies among others, the quantity of climate services transacted based on the technical specifications and the staged, performance-related transactions. If performance targets are not met, the correction action (like reseeding) will be realized. The PES agreements include a paragraph concerning resolving conflicts according community practices and reserving the right to terminate the contract in case of force majeure. The PES agreements were discussed in plenary sessions with maximum participation of the village community in an appropriate format in order to allow making informed decisions about whether or not to enter into a PES Agreement. A draft version of the PES agreement can be found in annex 3.

AGED has the capacity to meet the payment obligations in the PES Agreements entered into with the CVDs by preliminary purchase commitments. As soon as these purchase commitments have been formalized, the PES agreements will be signed by the CVDs and AGED.

J2 Payments & Benefit Sharing

AGED will carry out regular monitoring in close collaboration with the CVDs to determine the performance of the rehabilitation of the pasture sites. The indicators are density of tree plants and specific tree species diversity (defined as minimum of 5 tree plants per specie per hectare). The performance indicators are part of the template PES agreement between AGED and the CVD in Annex 3.

Period	Indicator
1 year	Density (tree plants/ha)
3 years	Density (tree plants/ha) Specific species diversity (min. 5 trees per specie / ha)
5 years	Density (tree plants/ha) Specific species diversity (min. 5 trees per specie / ha)
8 years	Density (tree plants/ha) Specific species diversity (min. 5 trees per specie / ha)
10 years	Density (tree plants/ha) Specific species diversity (min. 5 trees per specie / ha)

Table 19: Overview of performance indicators

Annually, the monitoring results are aggregated and formally submitted to the Plan Vivo Foundation. Payments are made to the CVD's according the payment thresholds defined in the PES agreement:

Period	Full payment PES	50% payment PES	No payment PES
1 year	Density of min. 260 tree plants/ha	Density of min. 180 tree plants/ha	Density of less than 180 tree plants/ha
3 years	Density of min. 260 tree	Density of min. 180 tree	Density of less than 180 tree

	plants/ha AND Specific species diversity of min. 3	plants/ha AND Specific species diversity of min. 2	plants/ha OR Specific species diversity of less than 2
5 years	Density of min. 260 tree plants/ha AND Specific species diversity of min. 3	Density of min. 180 tree plants/ha AND Specific species diversity of min. 2	Density of less than 180 tree plants/ha OR Specific species diversity of less than 2
8 years	Density of min. 260 tree plants/ha AND Specific species diversity of min. 3	Density of min. 180 tree plants/ha AND Specific species diversity of min. 2	Density of less than 180 tree plants/ha OR Specific species diversity of less than 2
10 years	Density of min. 260 tree plants (with min. height of 1.30 m) /ha AND Specific species diversity of min. 3	Density of min. 180 tree plants (with min. height of 1.30 m)/ha AND Specific species diversity of min. 2	Density of less than 180 tree plants (with min. height of 1.30 m)/ha OR Specific species diversity of less than 2

Table 20: Monitoring and payment thresholds

60% of the proceeds of sales income of Plan Vivo certificates are foreseen for the local communities through the CVD. A dedicated account will be opened at a local "caisse populaire". Cash for expenditure can only be withdrawn from the account with signature from the president of the CVD, the treasurer of the CVD and the project coordinator.

The priorities for expenditure on community benefit are determined by the community through consultation process facilitated by AGED. By using the focus group technique opinions of all members of the community are taken into account. The consultation process proceeds as follows:

- Plenary CVD session explaining the objective;
- AGED collect ideas for expenditure from the village community through focus group meetings;
- Plenary CVD session presents the preferred and feasible priorities and ranks the suggested expenditures;
- The ranked priorities are made public, displayed in the village;
- A confirmation meeting of CVD is held to determine final priorities for expenditure.

Focus groups are crucial in the approach, as some groups (like women and youth) are in some villages not allowed to speak publically in presence of men and elderly.

No individual can direct expenditure on his or her own and no prior expectations are established by AGED. The actual community benefits and projects facilitated by the project will be determined by the CVD and will remain their responsibility. Typical candidate projects for expenditure are capacity building sessions on dyeing of cotton, reparation and maintenance of boreholes, provision of school supplies, etc.

Dedicated accounts for the benefits of the project will be publically available and posted on village notice-boards as well as tabled at the annual CVD meeting. According Decree N° 2007-032/PRES/PM/MATD all members of the CVD have the collective responsibility for ensuring good financial governance. Accounts will be prepared for yearly audit by the CVD treasurer with assistance from the CVD president.

Part K: Monitoring

K1 Ecosystem services benefits

The chosen performance indicators to evaluate the state of the project intervention are tree density and specific species diversity. As showed in the technical specifications these indicators are directly linked to the delivery of climate services, i.e. CO2 sequestration. The *Acacia Tortilis* is an invasive pioneer species in rehabilitated pasture sites, but has a lower biomass production than other species seeded by the local communities, like *Balanites Aegyptiaca, Ziziphus Mauritiana, Acacia Nilotica, Acacia Sénégal and Acacia Seyal*. The indicator "specific species diversity (min. 5 trees per specie / ha)" will foster tree species other than the invasive pioneer specie *Acacia Tortilis*, and contribute to the CO2 sequestration.

The indicators density and specific species diversity will be monitored annually by AGED in close collaboration with the local communities. In order to cover the diversity of the rehabilitated site, the number of tree plants according specie and the number of half-moon shaped micro-basins will be counted along two diagonal transects on each site. As the reference number of half-moon shaped micro-basins per hectare is on average 300 per hectare, the tree density can be calculated accordingly. This approach will be more representative than an inventory of monitoring plots with radius of 25 m. At least 1% of the half-moon shaped micro-basins will be inventoried. In addition the number of half-moon shaped micro-basins without tree plants will be counted in order to evaluate the necessity of reseeding activities. The average of the different rehabilitated sites managed by the CVD will be considered as the result of the performance indicators of the corresponding Plan Vivo for a specific monitoring year. The results of the monitoring will be discussed during an annual meeting. The necessary resources for the evaluation of 200 hectares done in one day by one team of animators of AGED with collaboration of the local communities are estimated at 30 €.

Each five years the validity of the assumptions used in the technical specifications are tested with dendrometric measurements (DBH measurements) of identified permanent plots.

K2 Socio-economic impacts

AGED will carry out household and asset surveys in each participating village every five years. In the case when lists of households exist, random sampling will be used. In the absence of household lists the sampling strategy will be based on area sampling: (i) the village will be divided into segments of approximately equal population on a sketch of the village; (ii) segments are selected at random; and (iii) every household in the selected segments is invited to participate in the survey. The minimum sample size should be determined as per guidelines below:

- Project target households < 300: minimum sample size of 30 households;
- Project target households 300 to 1000: minimum sample size 10% of number of households;
- Project target households > 1000: minimum sample size of 100.

Each household visited during the survey will be identified.

The baseline household and asset survey will be conducted for each Plan Vivo or village included in the project before the project interventions.

The table below presents the indicators that will be surveyed and that has been validated in a participatory manner with the local communities:

Area of impact	Household and asset survey item
Livelihood	School-aged girls going to school Indicator: % of girls going to school
Natural resource management	Temporary Migration for the practice of transhumance Indicator: % of households practicing transhumance
	Purchase agro-industrial by-products for livestock during

	lean season Indicator: % of households purchasing agro-industrial by-products
Family economy	Annual Revenue from the sale of livestock Indicator: amount in FCFA
	Annual Revenue from the sale of milk Indicator: % of households selling milk; average annual amount in FCFA
Governance	Conflicts related to the management of the rehabilitated pasture sites Indicator: number of conflicts during last year
	Perception related to access to natural resources of the village Indicator: % of households perceiving that all community members have access to the natural resources of the village
	Perception around tenure security by community members Indicator: % of households perceiving that tenure security is guaranteed for all community

Table 21: Method of measurement of expected socio-economic impacts

AGED will hold group discussions on an annual basis to discuss local perceptions of the socioeconomic impacts of the project and more specific on the natural resource management of the rehabilitated sites (. In regard socio-economic impacts the following parameters will be monitored:

- Number of beneficiaries directly benefiting from the PES payments;
- Total amount of community pay-outs to the Plan Vivo fund of the village;
- Total spent amount of the Plan Vivo fund of the village.

In addition, the number of meetings organized by the CVD will reflect the management dynamics per Plan Vivo. The focus group technique will be used in order to have the view of all members of the community. The group discussions will be used to understand the changes occurring in the community, peoples' interpretations of the reasons behind these changes, and solutions to any negative project impacts.

K3 Environmental and biodiversity impacts

The environmental and biodiversity impacts will be biannually assessed during the household and asset survey together with the local communities. The following indicators will be monitored through information provided by respondents of household and asset surveys:

- Number of tree species present on the rehabilitated pasture sites;
- Number of herbaceous species present on the rehabilitated pasture sites;

K4 Other monitoring

The following indicators will be biannually monitored in order to assess the corresponding impact category:

Area of impact	Indicator
Drivers of degradation	Number of conflicts related to natural resource management
	Monitoring committee in place to overview the respect of the rules defined in the local land

	charters on the land-use of the rehabilitated pasture sites
Governance	Number of meetings chaired by the CVD on the review of the management of the PES funds

Table 22: Other indicators on drivers of degradation and governance

The necessary information to assess these indicators will be provided by the CVD's.

Annexes

Annex 1. List of key people involved with contact information

Name	Organization	Role
Zeza Boureima DRABO	AGED	Coordination
Mamadou KAMBA	AGED	Coordination
Alain TRAORE	AGED	Coordination
Assane BOKOUM	AGED	Coordination
Hama GADIAGA	AGED	Animator / Forester
Ould SIDI	AGED	Animator / Forester
Michel MARICAUX	Lux Dev	Technical advisor BKF/017
Amadou OUEDRAOGO	Lux Dev	Responsible for Natural Resource Management BKF/017
Herman NOPPEN	CO2logic	PDD Development and coordination
Moise NEDAH	CO2logic	Support PDD Development
Yohann FARE	Kinomé	TS Development

Annex 2. Information about funding sources

The funding for the implementation of the activities are financed through the BKF/017 program of Lux Dev and Ministry in charge of Animal Resources. The average budget per item is presented in the table below.

Activity	Budget
Rehabilitation of degraded pastures through the Vallerani system (per hectare)	Tractor works with Delphino plough: 180 €/ha Seeding: 20 €/ha Capacity building activities: 18 €/ha Total: 218 €/ha
Elaboration of local land charters at municipality level with CVD's of all villages of the municipality (per CVD)	Facilitation and capacity building: 137 € / CVD
Reseeding (per hectare)	Reseeding: 15 €/ha

Table 23: Budget per type of activity

Annex 3. Producer/group agreement template

MINISTERE DES RESSOURCES ANIMALES ET HALIEUTIQUES

BKF 017 - PROJET AZAWAK

LUX DEV LUXEMBOURG

RESTAURATION DES PÂTURAGES DÉGRADÉS PAR AGED DANS LE SAHEL BURKINABÉ

CONTRAT PES

entre

AGED et

le Conseil Villageois de Développement de [village]

INTRODUCTION

Le projet Plan Vivo « Restauration des pâturages dégradés par AGED dans le Sahel Burkinabé » a été initié à partir du programme BKF/017 (Projet d'Amélioration de l'Elevage du Zébu Azawak et de Gestion durable des Ressources pastorales) et a entre autres pour objectif de favoriser la reconstitution du couvert végétal des sites dégradés à vocation pastorale pour contribuer à la séquestration du carbone et à l'amélioration des conditions de subsistances des populations rurales par le paiement des services écosystémiques issus des arbres plantés.

Ce contrat décrit les rôles et les responsabilités des parties aux contrats. Il décrit également les termes et conditions régissant la production de services écosystémiques et le paiement pour ces services liés aux activités d'ensemencent et gestion durable des sites récupérés.

Les services écosystémiques générés sont payés en accord avec les normes de la Fondation Plan Vivo.

ARTICLE 1 : PARTIES AU CONTRAT

Ce contrat a été conclue le [date] entre AGED, reconnu comme ONG au Burkina Faso par la convention No. 2003-133 / MATD / SG / DGIFAP / DAOSOC et le Comité Villageois de Développement (CVD) de [village]. L'objectif de cette convention est de définir les termes et conditions pour la vente de services écosystémiques dans le cadre du projet Plan Vivo, « Restauration des pâturages dégradés par AGED dans le Sahel Burkinabé ».

Attendu que AGED accepte d'acheter les services écosystémiques que propose le participant dans le cadre du Plan Vivo aux prix et aux conditions définis ci-après ;

Attendu que le CVD de [village] est le [propriétaire/l'ayant-droit à long terme] du(es) site(s) strictement identifié(s) en annexe A de ce contrat, enregistré sous le numéro Plan Vivo [xxxxx], site(s) qui a été évaluée et approuvée par AGED pour son implémentation dans le projet Plan Vivo.

ARTICLE 2 : ROLE DU CVD DANS LA MISE EN ŒUVRE DU PROJET PLAN VIVO

Le CVD de [village] est maître d'œuvre de son « plan vivo » en annexe D. Le « plan vivo » est un plan d'aménagement et de gestion des terres pour générer des services écosystémiques.

Pour mettre en œuvre son plan vivo, le CVD s'engage à :

- Mettre en œuvre (i) les activités (résumées en Annexe D) et (ii) les actions de gestion énoncées dans leur plan vivo, ainsi que (iii) les mesures correctives qui seraient prescrites pendant le processus de contrôle ;
- Déposer [pourcentage] pour cent de leur bénéfice carbone dans une réserve carboné administré par AGED afin de pouvoir gérer les risques liés à la nature du projet ;
- Ne pas conclure de convention de vente de carbone ou de services écosystémiques en lien avec le même plan vivo et ses activités liés, avec quel qu'autre partie ;
- Informer AGED de toutes circonstances susceptibles de remettre en cause la continuation d'une quelconque activité de gestion dans le cadre du plan vivo ;
- Organiser et bien gérer le partage des bénéfices issues des services écosystémiques générés par les arbres plantés comme : (i) la récompense issue des Paiements pour des Services Ecosystémiques (PSE); (ii) les produits non ligneux tirés des arbres sans les endommager ; et (iii) le bois mort de ramassage.

ARTICLE 3 : ROLE DE AGED

AGED est le coordinateur du projet Plan Vivo et est responsable de la planification et de la mise en œuvre des activités du projet. Il doit :

- Procéder au contrôle des sites aménagés du CVD de [village] pendant la période de suivi et conformément aux objectifs énoncés du Plan Vivo ;
- Assurer un suivi des impacts socio-économiques et environnementales du projet ;
- Assurer le paiement des services écosystémiques en conformité avec le plan de paiement basé sur les résultats du suivi (tableaux 2, 3 et 4). Dans le cas où le CVD de [village] n'a pas obtenu de résultat appréciable, AGED ne doit pas procéder au paiement, mais AGED doit assigner une mesure corrective au CVD de [village] pour l'obtention de meilleurs résultats.

ARTICLE 4: SUIVI DES SITES ET SYSTÈME DE PAIEMENT

La méthode et les activités de suivi des sites sont indiquées en annexe B. Des indicateurs de suivi basés sur la densité et la diversité spécifique seront utilisés.

Le plan de suivi et le système de paiement sont en annexes à ce contrat (annexes B et C). Le suivi est basé sur des indicateurs simples. En cas de réussite, une récompense est donnée et le système de paiement est lié aux taux de réussite. Par contre, en cas de non réussite, la mesure corrective proposée par AGED doit être appliquée par le CVD de [village]. Après l'application de cette mesure, s'il y a une réussite, une récompense sera donnée sur la base du taux de réussite.

ARTICLE 5 : RESOLUTION DE CONFLIT

En cas de difficulté qui naitrait de l'exécution du contrat entre AGED et le CVD de [village], les parties s'engagent à la résoudre à l'aimable et se réservent le droit de mettre fin au présent contrat en cas de force majeure.

ARTICLE 6 : DISPOSITION GENERALES

AGED décline toute responsabilité pour ce qui a trait à l'assurance-vie, l'assurance-maladie, l'assurance-accident, l'assurance-voyage ou protection contre tout autre risque.

ARTICLE 7 : DUREE DU CONTRAT

Le contrat prend effet à partir de la date de sa signature et dure dix (10) ans. En cas d'application de mesure corrective et de retenue de récompense dans la dixième année, il est prévu d'allonger d'une année maximale la durée du contrat.

Les parties ont compris et tombés d'accord sur les termes de ce contrat et leurs annexes.

AGED	**CVD de [village]**
Nom du président :	Nom du président :
Signature :	Signature :
----------	----------
Date :	Date :
----------	----------

ANNEXE A : DETAILS DU CONTRAT

Tableau 1 : Détails du contrat

1	Conseil Villageois de Développement (CVD) du village	
2	Plan Vivo Numéro	
3	Superficie totale des sites récupérés (ha)	
4	Superficie par site récupéré	
5	Date de premier ensemencement (MMM/YYYY)	
6	Durée du contrat	10 ans
7	Bénéfice totale de carbone (tCO2e)	
8	Marge de sécurité du carbone (x%)	
9	Total de séquestration carbone éligible pour paiement (total moins marge de sécurité)	
10	Prix (FCFA/tCO2e)	
11	Total du paiement pour services écosystémiques (PES) Carbone total certifiable (tCO2e) * Prix (FCFA/tCO2e)	
12	Détails du compte	
13	Projet de développement local à financer à partir des PES issus de ce contrat	

ANNEXE B : SUIVI

1. Les sites qui font partis du Plan Vivo du village concerné, sera suivie pour évaluer la densité et la diversité spécifique (min. 5 pieds par espèce / hectare).
2. Le paiement se fera en fonction des résultats du suivi basés sur des indicateurs définis dans les tableaux 2 et 3.

Tableau 2 : Indicateurs de suivi

Période	Indicateur
1 année	Densité (pieds / ha)
3 années	Densité (pieds / ha) Diversité spécifique (min. 4 pieds par espèce / ha)
5 années	Densité (pieds / ha) Diversité spécifique (min. 5 pieds par espèce / ha)
8 années	Densité (pieds / ha) Diversité spécifique (min. 5 pieds par espèce / ha)
10 années	Densité (pieds avec hauteur minimum de 1,30 m / ha) Diversité spécifique (min. 5 pieds par espèce / ha)

Tableau 3 : Suivi et taux de réussite

Période	Paiement 100%	Paiement 50%	Pas de paiement
1 année	Densité de min 260 pieds/ha	Densité de min 180 pieds/ha	Densité de moins de 180 pieds/ha
3 années	Densité de min 260 pieds/ha ET Diversité spécifique de min 3	Densité de min 180 pieds/ha ET Diversité spécifique de min 2	Densité de moins de 180 pieds/ha OU Diversité spécifique de moins de 2
5 années	Densité de min 260 pieds/ha ET Diversité spécifique de min 3	Densité de min 180 pieds/ha ET Diversité spécifique de min 2	Densité de moins de 180 pieds/ha OU Diversité spécifique de moins de 2
8 années	Densité de min 260 pieds/ha ET Diversité spécifique de min 3	Densité de min 180 pieds/ha ET Diversité spécifique de min 2	Densité de moins de 180 pieds/ha OU Diversité spécifique de moins de 2
10 années	Densité de min 260 pieds (avec hauteur minimum de 1,30 m) /ha ET Diversité spécifique de min 3	Densité de min 180 pieds (avec hauteur minimum de 1,30 m) /ha ET Diversité spécifique de min 2	Densité de moins de 180 pieds (avec hauteur minimum de 1,30 m) /ha OU Diversité spécifique de moins de 2

ANNEXE C : CALENDRIER DU PAIEMENT

Année	Montant du paiement	Paiement total (€)	50 % Paiement partiel (€)	Date de suivi et validation du rapport (MMM/YYYY)	Date de paiement (MMM/YYYY)
1 année	10 %				
3 années	20 %				
5 années	20 %				
8 années	30 %				
10 années	20 %				
Total	100%				

ANNEXE D : PLAN D'AMENAGEMENT (PLAN VIVO)

Annex 4. Database template

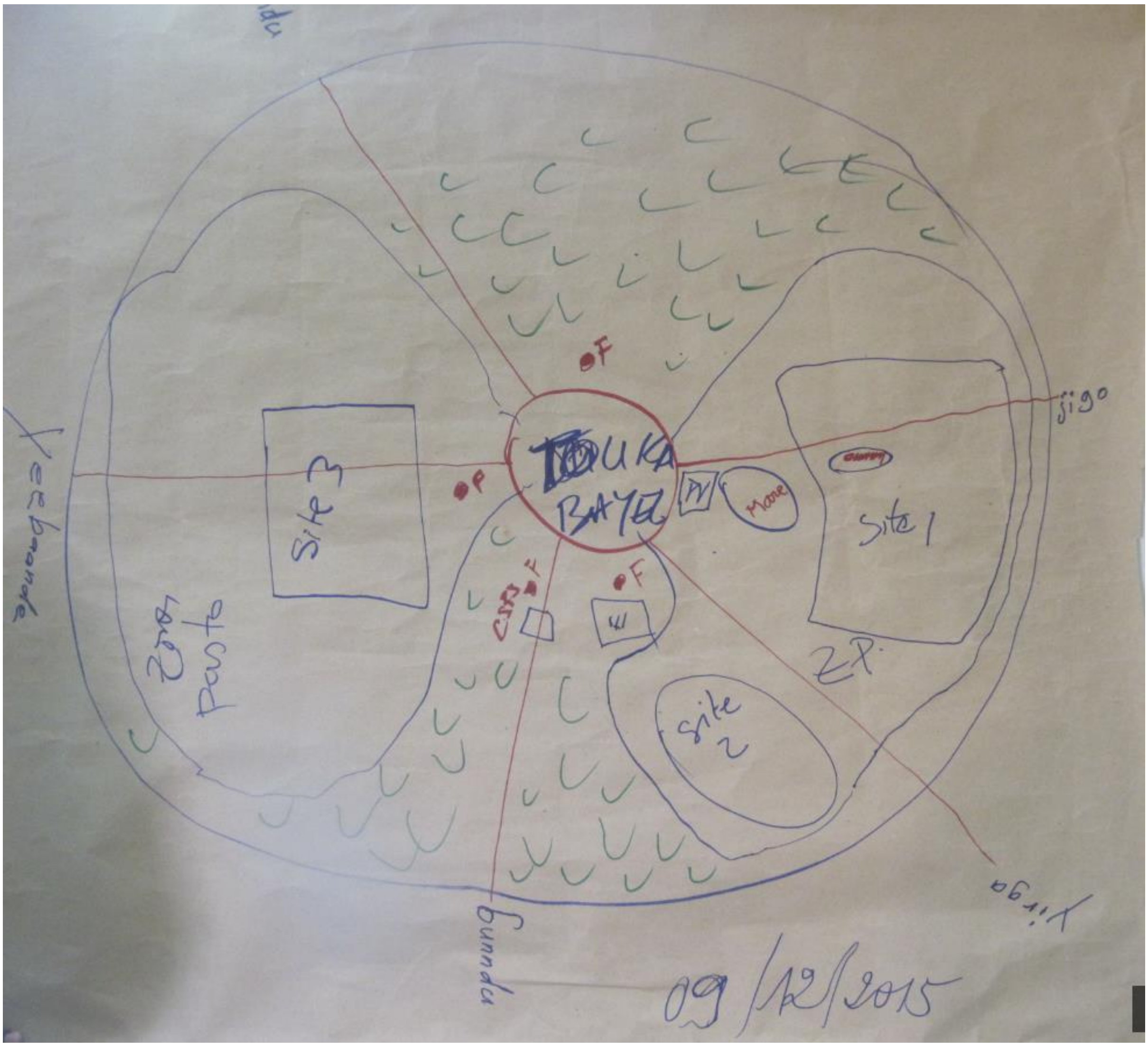
Participants	Per village/CVD participating the following information will be kept: - Plan Vivo ID no - Village - Contact persons of members of CVD: president, secretary and treasurer; - Hectares per site - GPS coordinates of the sites - Plan Vivo: i.e. map specifying the rehabilitated pasture sites with mean tree species and land use rules based on the local land charters. A digital version of the Plan Vivo will be recorded -
PES agreements	Per village/CVD participating the following information will be kept: - Plan Vivo ID no. - Start of payment period - Length of payment period - Planned CO2 sequestration according the technical specifications - Buffer - Price per tCO2e - Total payment of PES agreement (when all performance indicators are met) - Account details
Payments to participants	Per village/CVD participating the following information will be kept: - Plan Vivo ID no - Reporting year - Total payment done
Ecosystem services monitoring results	Per village/CVD participating the following information will be kept: - Plan Vivo ID no - Monitoring year - Payment year - Tree density (trees/ha) - Specific species diversity (species/ha) - Performance target
Socioeconomic, environmental and biodiversity monitoring results	Per village/CVD participating the following information will be kept: - Plan Vivo ID no - Monitoring year - Indicator - Parameter - Result
Sales of Plan Vivo certificates	A record keeping will be kept on the sales of Plan Vivo certificates. Per transaction the following information will be recorded

- Vintage
- Customer
- Date
- No of PVC
- Price per PVC
- Total sales amount
- Price to participants per PVC

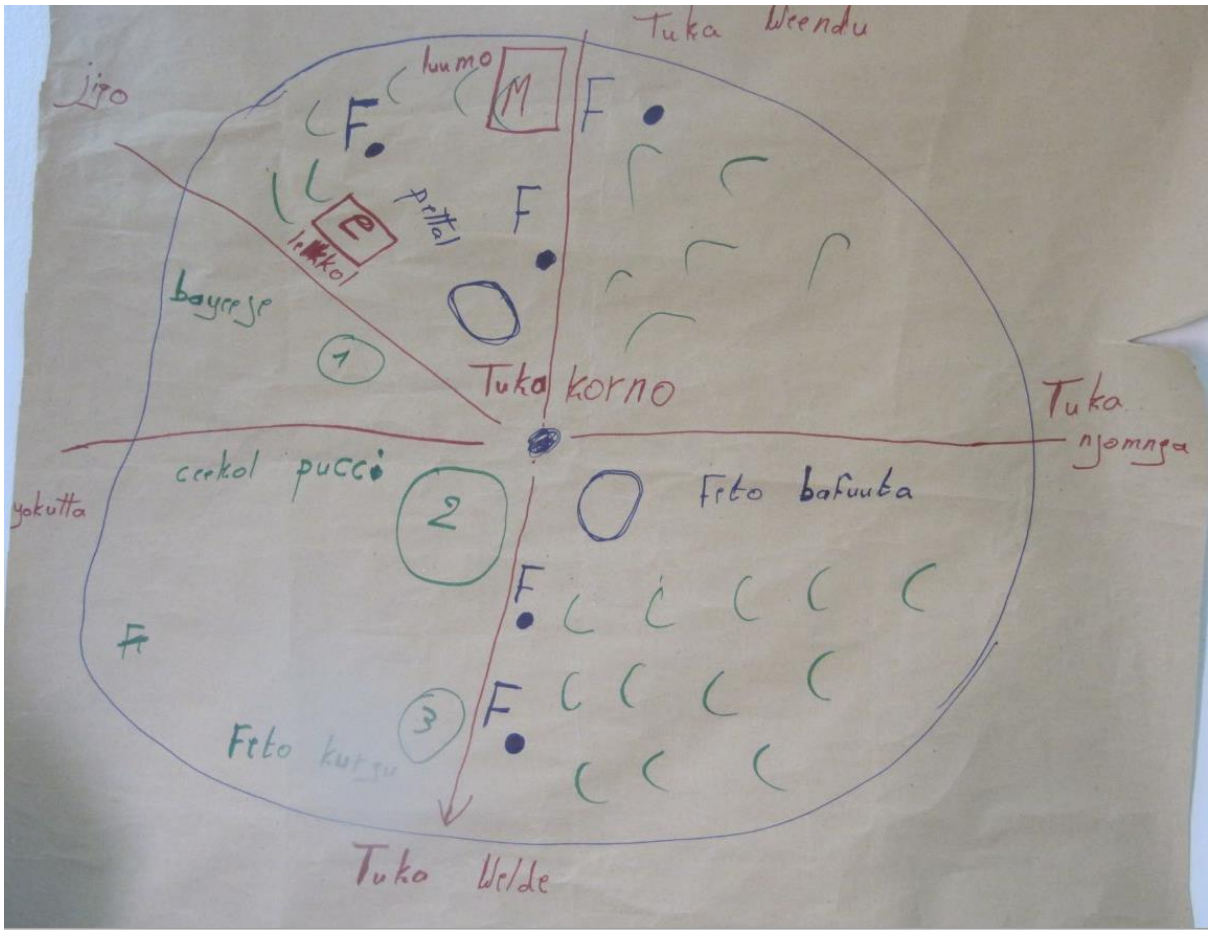
Annex 5. Example forest management plans/*plan vivos*

Plan Vivo – Djigo:

Plan Vivo – Touka Bayel



Plan Vivo – Touka Komo



Annex 6. Permits and legal documentation

See document « Charte Foncier Locale Dori »

Annex 7. Evidence of community participation

See Meeting minutes community meetings

Annex 8. Data for modelling carbon benefits

Species	Age group (years)	Accurate age (years)	Date of soil restoring (for information)	Number of trees measured by age group			Number of treated trees	Total number of trees all ages mixed-up.		
				D_{base} measured	D_{base} and DBH	Height only	# of tree after inclusion of DBH calculated by linear regression	D_{base} Measured on every tree	D_{base} and DBH	# of trees after including DBH values calculated by linear regression
Acacia tortilis subsp. raddiana	0-5 6-10 11-15 16-20 21-25	4 9 14 n/a n/a	2011 2006 2001 n/a n/a	221 248 161 15	11 49 59 27		52 73 92 12	645	146	229
Ziziphus mauritania Estimated value for 0-5 years	0-5 6-10 11-15 21-25	4 8 12 n/a	2011 2007 2003 n/a	0 0 3 0	0 12 27 10		0 12 27 10	3	49	49
Acacia senegal	0-5 6-10 11-15 21-25	3 8 12 n/a	2012 2007 2003 n/a	0 0 0 0	1 13 13 14		1 13 13 14	0	41	41
Balanites aegyptiaca	0-5 6-10 11-15 21-25	3 9 12 n/a	2012 2006 2003 n/a	0 0 2 0	0 16 9 10	12	0 16 9 10	2	35	35
Acacia seyal	0-5 6-10 11-15 21-25	3 9 12 n/a	2012 2006 2003 n/a	0 0 14 28	0 9 19 43	5	5 9 21 43	42	71	78
Faidherbia albida	0-5 6-10 11-15 46-50	4 7 12 n/a	2011 2008 2003 n/a	0 0 0 0	0 0 1 9		0 0 1 9	0	10	10

Table 24: Summary table of tree growth data collection

Year	Age (years)	*Acacia tortilis (id. nilotica)*			*Ziziphus mauritania*			*Acacia senegal*			*Balanites aegyptiaca*			*Acacia seyal*		
		D	DBH	H	D	DBH	H	D	DBH	H	D	DBH	H	D	DBH	H
2012								2,70	1,82	30,00	2,96	2,00	23,64	2,18	1,47	26,00
2011	4	5,18	3,49	195,00	2,79	1,88	144,46	3,11	1,91	68,54	2,53	1,71	46,72	2,84	1,92	82,84
2010	5	5,87	3,60	203,11	3,19	1,96	165,71	3,35	2,05	100,81	2,14	1,32	63,67	4,37	2,69	141,72
2009	6	6,03	3,69	208,18	3,25	1,99	176,30	4,32	2,31	133,10	1,95	1,19	82,00	5,73	3,50	198,13
2008	7	7,44	3,98	220,41	3,84	2,05	187,78	4,41	2,70	165,39	2,50	1,34	101,71	8,16	4,37	252,07
2007	8	6,56	4,02	219,53	4,94	3,03	228,75	5,64	3,47	216,00	2,85	1,75	122,81	8,62	5,28	303,54
2006	9	6,93	4,26	225,81	4,12	2,53	213,45	6,25	3,87	230,02	6,41	3,94	176,25	8,29	5,10	334,00
2005	10	7,36	4,55	232,48	4,76	2,94	227,63	7,45	4,65	262,35	5,44	3,37	169,13	11,69	7,24	399,09
2004	11	7,85	4,90	239,56	5,56	3,47	242,71	8,23	5,56	294,69	7,34	4,58	194,36	13,28	8,29	443,16
2003	12	7,70	5,20	242,91	5,33	3,60	240,00	10,08	6,41	313,75	7,12	4,81	195,56	15,27	10,32	500,00
2002	13	9,05	5,76	254,92	7,66	4,87	275,58	12,09	7,76	359,41	12,28	7,81	248,97	16,56	10,53	523,91
2001	14	9,75	6,26	263,20	8,95	5,75	293,36	13,97	9,06	391,79	15,30	9,83	278,34	18,26	11,73	560,58
2000	15	10,51	6,82	271,88	10,38	6,73	312,04	16,01	10,49	424,17	18,67	12,11	309,09	19,99	12,97	594,79
1999	16	11,35	7,43	280,96	11,97	7,84	331,62	18,21	12,04	456,58	22,38	14,66	341,22	21,76	14,25	626,53
1998	17	12,24	8,09	290,45	13,70	9,06	352,10	20,58	13,72	488,99	26,44	17,48	374,73	23,58	15,59	655,80
1997	18	13,21	8,81	300,33	15,58	10,39	373,49	23,10	15,54	521,41	30,83	20,56	409,63	25,44	16,97	682,60
1996	19	14,24	9,58	310,62	17,60	11,84	395,77	26,00	17,48	553,85	35,55	23,91	445,90	27,35	18,39	706,94
1995	20	15,47	10,40	322,08	19,93	13,40	418,95	28,62	19,55	586,30	40,95	27,53	483,55	29,55	19,87	728,81
1994	21	16,51	11,27	332,39	22,08	15,08	443,03	31,63	21,75	618,76	46,00	31,42	522,58	31,32	21,39	748,21
1993	22	17,74	12,20	343,88	24,54	16,88	468,01	34,79	24,08	651,23	51,72	35,57	562,99	33,38	22,96	765,15
1992	23	19,04	13,18	355,77	27,14	18,79	493,89	38,11	26,54	683,71	57,78	39,99	604,79	35,50	24,57	779,62
1991	24	20,40	14,21	368,06	29,88	20,81	520,67	41,59	29,13	716,21	64,16	44,68	647,96	37,67	26,24	791,62
1990	25	21,84	15,29	380,76	32,85	23,01	550,00	45,44	31,85	750,00	70,98	49,72	694,44	39,79	27,87	750,00
1989	26	22,08	15,47	383,27	33,30	23,34	555,35	46,05	32,30	758,11	72,03	50,49	703,17	40,25	28,21	808,23
1988	27	22,33	15,65	385,78	33,76	23,68	560,69	46,67	32,75	766,21	73,08	51,26	711,89	40,72	28,56	812,83
1987	28	22,58	15,83	388,29	34,21	24,01	566,04	47,29	33,21	774,32	74,14	52,03	720,61	41,18	28,90	814,96
1986	29	22,83	16,01	390,80	34,66	24,34	571,38	47,90	33,66	782,42	75,19	52,80	729,34	41,65	29,25	814,63
1985	30	23,08	16,19	393,31	35,12	24,68	576,73	48,55	34,11	790,53	76,24	53,57	738,06	42,11	29,59	811,83

Table 25: Result of dendrometric measures and extrapolation to others years

- **Underlined :** Values measured on small places respecting Berry methodology as suggested in Berry_2008_Estimating-tree-growth-protocol. Trees that were out of the standard values were excluded. DBH couldn't always be measured (in particular or small tress). In order to obtain these results, had to:
  - Calculate D value dispersion, excluding exceptionally big and small trees, on a tree lot on which the couple (D ; DBH) had been measured.
  - Calculate a regression equation on the left tree lot (explicative variable = D, explicated variable = DBH) We compared linear regression with the polynomial regression and kept the best one.
  - Apply this regression whenever D only was available
  - Exclude tree for which D was out of the standard values
- In grey: Values integrated into the modelling. Figures out of field measures were deduced by linear regression with the age as explicative variable.

Species	LnVT (one entry)	LnVt (two entries)
Acacia tortilis sbsp. raddiana	-2,135+2,372*Ln($D_{1.30}$)	-2,326+2,006*Ln($D_{1.30}$)+0,743*Ln(H)
Acacia senegal	-1,686+2,264*Ln($D_{1.30}$)	-1,897+2,07*Ln($D_{1.30}$)+0,445* Ln(H)
Acacia nilotica	-1,647+2,173*Ln($D_{1.30}$)	-2,097+1,776*Ln($D_{1.30}$)+0,935*Ln(H)
Balanites aegyptiaca	-1,925+2,24*Ln($D_{1.30}$)	-2,293+2,843*Ln($D_{1.30}$)+0,897*Ln(H)
Zizyphus mauritiana	-1,935+2,298*Ln(D1.30)	n/d
Acacia seyal	-2,221+2,441*Ln($D_{1.30}$)	-2,346+2,397*Ln($D_{1.30}$)+0,138*Ln(H)
Faidherbia albida	-2,441+2,2467*Ln($D_{1.30}$)	-2,485+2,168* Ln($D_{1.30}$)+0,471* Ln(H)

Table 26: Allometric equations used (source: INF2, 2015)

	Acacia tortilis (*)						*Ziziphus mauritiana*						*Acacia senegal*						*Balanites aegyptiaca*					
Age (yrs)	5	10	15	20	25	30	5	10	15	20	25	30	5	10	15	20	25	30	5	10	15	20	25	30
Average circumference of stump (cm)	18,43	23,10	33,01	48,58	68,57	72,46	10,01	14,93	32,60	62,59	103,16	110,27	10,50	23,40	50,27	89,88	142,67	152,44	6,73	17,09	58,62	128,57	222,89	239,40
Average diameter of stump (cm)	5,87	7,36	10,51	15,47	21,84	23,08	3,19	4,76	10,38	19,93	32,85	35,12	3,35	7,45	16,01	28,62	45,44	48,55	2,14	5,44	18,67	40,95	70,98	76,24
Average circumference BH 1.3 (cm)	11,32	14,30	21,41	32,67	48,02	50,84	6,15	9,25	21,14	42,08	72,25	77,49	6,42	14,60	32,92	61,39	100,00	107,12	4,13	10,58	38,02	86,45	156,11	168,22
Diameter DBH 1.3 (cm)	**3,60**	**4,55**	**6,82**	**10,40**	**15,29**	**16,19**	**1,96**	**2,94**	**6,73**	**13,40**	**23,01**	**24,68**	**2,05**	**4,65**	**10,49**	**19,55**	**31,85**	**34,11**	**1,32**	**3,37**	**12,11**	**27,53**	**49,72**	**53,57**
Average height (cm)	**203,11**	**232,48**	**271,88**	**322,08**	**380,76**	**393,31**	**165,71**	**227,63**	**312,04**	**418,95**	**550,00**	**576,73**	**100,81**	**262,35**	**424,17**	**586,30**	**750,00**	**790,53**	**63,67**	**122,81**	**248,97**	**409,63**	**604,79**	**720,61**
LN Volume	0,77	1,34	2,27	3,24	4,14	4,28	-0,39	0,55	2,45	4,03	5,27	5,43	-0,41	1,71	3,61	5,04	6,16	6,33	-1,31	0,80	3,66	5,50	6,83	6,99
Volume per tree (dm3)	2,17	3,83	9,66	25,57	62,72	72,0	0,68	1,73	11,56	56,22	194,67	228,6	0,66	5,55	36,98	155,11	475,23	560,9	0,27	2,22	38,91	245,03	920,77	1 088,5
Volume per tree (m3)	**0,002**	**0,004**	**0,010**	**0,026**	**0,063**	**0,072**	**0,001**	**0,002**	**0,012**	**0,056**	**0,195**	**0,229**	**0,001**	**0,006**	**0,037**	**0,155**	**0,475**	**0,561**	**0,000**	**0,002**	**0,039**	**0,245**	**0,921**	**1,088**

Table 27: Total volume of aerial part of each tree (stem and branches) for each age group

(*) *Same values have been applied to A. nilotica, which is a tree species very close to Acacia tortilis.*

Annex 9. Assumptions on species distribution per hectare

1. First years after planting, sites' tree composition may vary significantly (Table below).

2. The question was to determine trees composition pattern 30 years after planting, when trees populations on the stands will be stabilized.

3. For that purpose, we have consulted several documents: monitoring reports 2014 and 2015 of INERA (INERA annually monitors eight stands of a sample)[29], CILSS study of 2009[30].

a) Data analysis from INERA monitoring yearly reports (2014 and 2015):

The eight sites monitored by INERA in 2014 and 2015 give the following results:

Species	Mean values			
	2014		2015	
	#	%	#	%
Acacia raddiana	484	77%	585	66%
Zizyphus mauritiana	89	14%	23	3%
Acacia nilotica	15	2%	6	1%
Calotropis procera	0	0%	1	0%
Balanites aegyptiaca	11	2%	12	1%
Acacia seyal	1	0%	1	0%
Combretum glutinosum	0	0%	0	0%
Faidherbia albida	0	0%	0	0%
Acacia senegal	25	4%	216	25%
Acacia sieberiana	0	0%	0	0%
Acacia laeta	1	0%	0	0%
Maerua crassifolia	2	0%	3	0%
Bauhinia rufescens	3	0%	4	0%
Piliostigma reticulatum	0	0%	0	0%
Prosopis sp	0	0%	0	0%
Leptadenia hastata	0	0%	30	3%
Balanites aegyptiaca	0	0%	0	0%
# trees	630		880	
# species	5		6	

Table 28: Average distribution of species on 8 project sites monitored by INERA

Yet, we can also analyze:

- *Acacia raddiana* is the dominant specie in all plantations.
- Mean values are strongly influenced by the specificities of some sites. There are sites with distributions unusually different from others of:
  - 2014 :
    - 27% of *Maerua crassifolia* et 11% of Acacia senegal in Yakouta
    - 55% of *Acacia nilotica in* Dinalaye
    - 62% of *Balanites aegyptiaca* in Léré.
  - 2015 :
    - 44% of *Acacia senegal* in Darkoye
    - 13% of *Maerua crassifolia* and 38% of *Leptadenia hastata* in Yakouta
    - 69% of *Balanites aegyptiaca* at Dinalaye, 41% in Léré

In this context, we have tried to adjust calculations after excluding following sites: Yakouta, Dinalaye, Léré, Darkoye. New mean values are as following:

Species	Mean values	
	2014	2015

[29] INERA (2014 et 2015) : Rapports techniques d'état d'avancement du Protocole d'accord entre l'INERA et le Projet Azawak : Suivi scientifique des sites de récupération de terres dégradées réalisées par le Projet BKF/017 « Azawak Ressources Pastorales » notamment dans les communes de Gorom Gorom, Markoye, Dori et Bani.

[30] CILSS (2009) : Récupération des sols fortement dégradés à des fins sylvo-pastorales : Une évaluation quantitative des aménagements mécaniques à partir de la charrue Delfino réalisés par l'ONG REACH au Burkina Faso. CILSS, Ouagadougou, 34 p.

	#	%	#	%
Acacia raddiana	836	77%	687	91%
Zizyphus mauritiana	167	15%	25	3%
Acacia nilotica	23	2%	3	0%
Calotropis procera	0	0%	1	0%
Balanites aegyptiaca	8	1%	8	1%
Acacia seyal	0	0%	0	0%
Combretum glutinosum	0	0%	0	0%
Faidherbia albida	0	0%	0	0%
Acacia senegal	45	4%	22	3%
Acacia sieberiana	0	0%	0	0%
Acacia laeta	1	0%	0	0%
Maerua crassifolia	0	0%	1	0%
Bauhinia rufescens	0	0%	2	0%
Piliostigma reticulatum	0	0%	0	0%
Prosopis sp	0	0%	0	0%
Leptadenia hastata	0	0%	6	1%
Total plantes	1081		754	
Nbre d'espèces	5		6	

Table 29: Distribution of species on sample sites monitored by INERA

b) Data analysis from CILSS's survey report (2009).

The CILSS has inventoried sites 8 years after NGO REACH Italia has planted trees. The report mentioned the following mean values:

Species	*A. raddiana*	*A. seyal*	*A. senegal*	*Zizyphus mauritiana*	*B. aegyptiaca*	*L. hastata*	Other*
Distribution	93%	1%	1%	2%	1%	2%	<1%

Source: CILSS (2009)

Table 30: Distribution of species on sites of the NGO REACH mentioned by CILSS survey of 2009

We deduct from these studies (INERA, CILSS) that:

- During early years after planting, the distribution can be influenced by the local specificities (origin and quality of manure used to bring seeds, constancy/uniformity of farmer's practices during sewing, etc.).
- Years going by, few species remain well represented: *Acacia raddiana (mainly)*, *Zizyphus mauritiana (second position) and few Balanites aegyptiaca*, *Acacia senegal*, and very rarely *Acacia seyal* or *Acacia hastata* or *Acacia nilotica*. *A. seyal*, *A. hastata and A. nilotica* have same characteristics as *A. raddiana*.
- In order to have a conservative approach in the estimation of the biomass, the tree species with the lowest yield growth will be the predominant specie, which is the *Acacia raddiana.*
- We finally suggest the following distribution of the 260 trees/ha after 30 years:

Species	Trees density (#/ha)	
Acacia tortilis subsp. raddiana	234	90%
Zizyphus mauritiana	13	5%
B. aegyptiaca	4	1,7%
A. senegal	4	1,7%
Others: *A. nilotica or A. seyal or A. hastata*	4	1,7%
Total	260	100%

Species	Konsi				Beiga				Bossey Etage				Darkoye				Yakouta				Djigo				Dinalaye				Léré				Moyenne essaie			
	2014		2015		2014		2015		2014		2015		2014		2015		2014		2015		2014		2015		2014		2015		2014		2015		2014		2015	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Acacia raddiana	1409	86%	1437	95%	287	94%	458	98%	1536	68%	697	87%	485	84%	1848	49%	33	59%	64	42%	113	87%	155	68%	3	27%	5	8%	9	12%	12	21%	484	77%	585	66%
Zizyphus mauritiana	45	3%	11	1%		0%		0%	607	27%	64	8%	23	4%	67	2%		0%	10	6%	16	12%	23	10%	1	9%	1	2%	16	22%	4	7%	89	14%	23	3%
Acacia nilotica	4	0%	1	0%	12	4%		0%	75	3%	11	1%	21	4%	32	1%	2	4%		0%		0%		0%	6	55%	3	5%	2	3%	4	7%	15	2%	6	1%
Calotropis procera		0%	2	0%		0%		0%	1	0%		0%	1	0%	2	0%		0%	1	1%		0%		0%		0%		0%		0%		0%	0	0%	1	0%
Balanites aegyptiaca	8	0%	22	1%	4	1%	5	1%	19	1%	0	0%	10	2%	0	0%	0	0%	0	0%	0	0%	4	2%	0	0%	43	69%	46	62%	23	41%	11	2%	12	1%
Acacia seyal		0%		0%		0%		0%		0%		0%	3	1%		0%		0%		0%		0%		0%	1	9%		0%	1	1%	10	18%	1	0%	1	0%
Combretum glutinosum		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%	0	0%	0	0%
Faidherbia albida		0%		0%	1	0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%	0	0%	0	0%
Acacia senegal	170	10%	41	3%	1	0%		0%	10	0%	5	1%	12	2%	1644	44%	6	11%		0%		0%	41	18%		0%		0%		0%		0%	25	4%	216	25%
Acacia sieberiana		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%	1	1%		0%		0%		0%		0%		0%	0	0%	0	0%
Acacia laeta	4	0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%		0%	1	0%	0	0%
Maerua crassifolia		0%	5	0%		0%		0%		0%		0%		0%		0%	15	27%	20	13%		0%		0%		0%		0%		0%		0%	2	0%	3	0%
Bauhinia rufescens		0%		0%		0%		0%		0%	8	1%	21	4%	22	1%		0%		0%		0%		0%		0%		0%		0%		0%	3	0%	4	0%
Piliostigma reticulatum		0%		0%		0%		0%		0%		0%	1	0%	1	0%		0%		0%		0%		0%		0%		0%		0%		0%	0	0%	0	0%
Prosopis sp		0%		0%		0%		0%		0%		0%	1	0%		0%		0%		0%		0%		0%		0%		0%		0%		0%	0	0%	0	0%
Leptadenia hastata		0%		0%		0%	3	1%		0%	15	2%		0%	141	4%		0%	59	38%		0%	6	3%		0%	10	16%		0%	3	5%	0	0%	30	3%
Total # trees	1640		1519		305		466		2248		800		578		3757		56		154		130		229		11		62		74		56		630		880	
# species	6		7		5		3		6		7		10		9		5		6		4		5		5		5		5		6		6		6	

Source: INERA annual monitoring reports (2014 and 2015).

Table 31: Trees density on some samples monitored in 2014 and 2015.

Espèces	Konsi				Beiga				Bossey Etage				Djigo				Moyenne essai			
	2014		2015		2014		2015		2014		2015		2014		2015		2014		2015	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Acacia raddiana	1409	86%	1437	95%	287	94%	458	98%	1536	68%	697	87%	113	87%	155	68%	836	77%	687	91%
Zizyphus mauritiana	45	3%	11	1%		0%		0%	607	27%	64	8%	16	12%	23	10%	167	15%	25	3%
Acacia nilotica	4	0%	1	0%	12	4%		0%	75	3%	11	1%		0%		0%	23	2%	3	0%
Calotropis procera		0%	2	0%		0%		0%	1	0%		0%		0%		0%	0	0%	1	0%
Balanites aegyptiaca	8	0%	22	1%	4	1%	5	1%	19	1%	0	0%	0	0%	4	2%	8	1%	8	1%
Acacia seyal		0%		0%		0%		0%		0%		0%		0%		0%	0	0%	0	0%
Combretum glutinosum		0%		0%		0%		0%		0%		0%		0%		0%	0	0%	0	0%
Faidherbia albida		0%		0%	1	0%		0%		0%		0%		0%		0%	0	0%	0	0%
Acacia senegal	170	10%	41	3%	1	0%		0%	10	0%	5	1%		0%	41	18%	45	4%	22	3%
Acacia sieberiana		0%		0%		0%		0%		0%		0%	1	1%		0%	0	0%	0	0%
Acacia laeta	4	0%		0%		0%		0%		0%		0%		0%		0%	1	0%	0	0%
Maerua crassifolia		0%	5	0%		0%		0%		0%		0%		0%		0%	0	0%	1	0%
Bauhinia rufescens		0%		0%		0%		0%		0%	8	1%		0%		0%	0	0%	2	0%
Piliostigma reticulatum		0%		0%		0%		0%		0%		0%		0%		0%	0	0%	0	0%
Prosopis sp		0%		0%		0%		0%		0%		0%		0%		0%	0	0%	0	0%
Leptadenia hastata		0%		0%		0%	3	1%		0%	15	2%		0%	6	3%	0	0%	6	1%
Total # trees	1640		1519		305		466		2248		800		130		229		1081		754	
# species	6		7		5		3		6		7		4		5		5		6	

Source: INERA annual monitoring reports with additional calculations from authors.

Table 32: Trees density adjusted after by excluding unusual results.

Annex 10. Calculation of annual increment for above-ground biomass and below ground biomass (260 trees/ha)

With CO2fix, the driving factor of each cohort in the biomass module is the stem-wood production in volume per ha. Multiplication with the stem-wood density and the carbon content yields carbon flux into the stem-wood compartment. Fluxes into the other biomass compartments are determined by their growth, relative to the stem-wood production, and their respective carbon contents ».

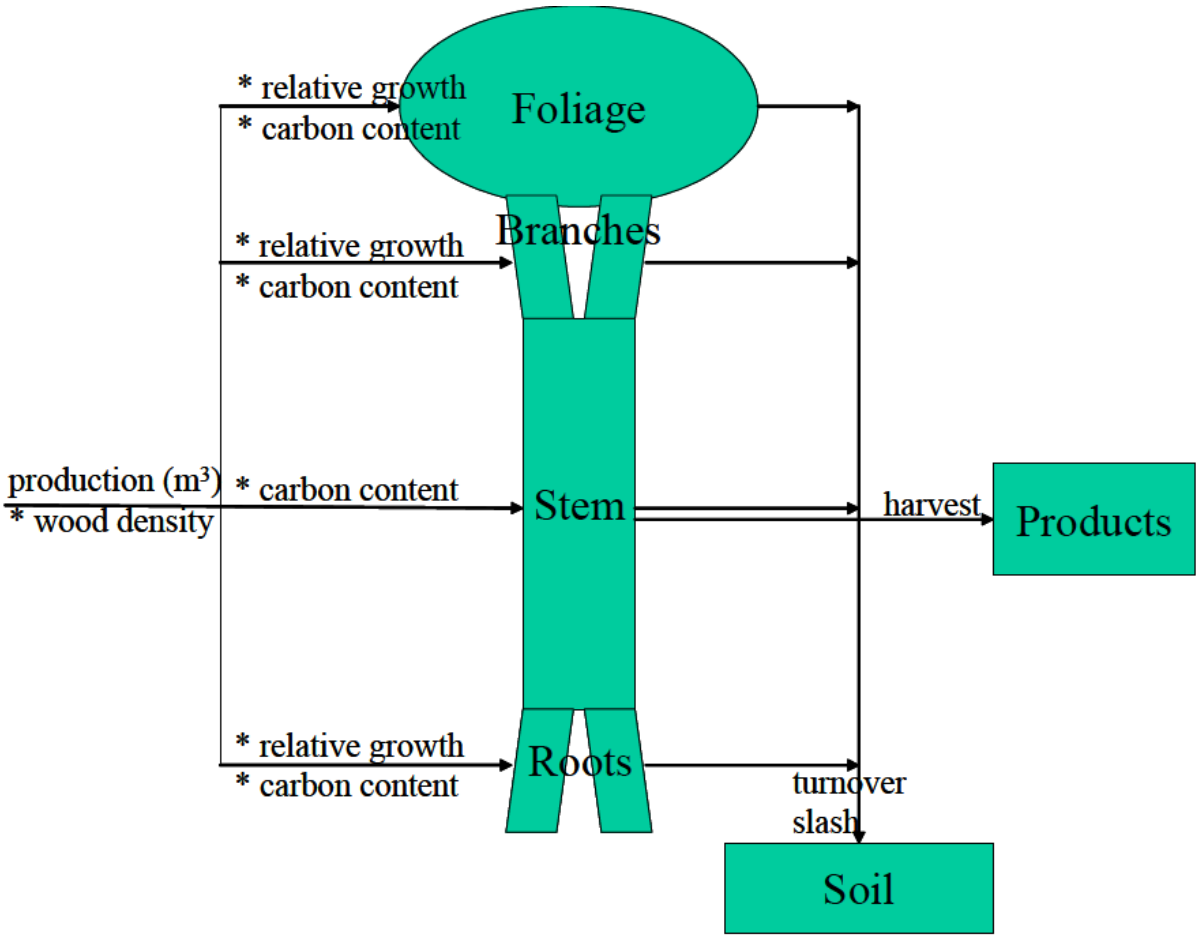
$B_i = F_i * B_s$, or $F_i = B_i / B_s$

Où

F_i = relative biomass allocation coefficient (F_f for foliage, F_b for branches, F_r for roots)

B_i = growth of biomass (B_f for foliage, B_b for branches, B_r for roots)

B_s = growth of stem biomass



No published tree growth data were available for any of the tree species identified for tree planting activities in Northern Burkina Faso. Therefore, to determine how these trees are likely to grow under the conditions found within the project area, field measurements of trees of a known age were made to help determine annual (stem) volume increments (m3/yr). Growth data were collected from the project areas of NGO REACH Italia because there were stands of the selected species with known age. These areas (Konsi, Gagara, Salmossi et Gorom-Gorom) have similar climatic and soil characteristics than other sites used within the project.

Reference distribution of tree species:

Tree species	%	Conservative scenario
Acacia tortilis subsp. raddiana	90.0%	234
A. senegal	1.7%	4
A. nilotica	1.7%	4
Zizyphus mauritiana	5%	13
B. aegyptiaca	1.7%	4
Total	100%	260

1. Annual increment calculation for *Acacia tortilis subsp. Raddiana* :

Above ground biomass (excl leaves)								*Below ground biomass*						*Total (excl leaves)*					
Age (yrs) *Timestep (years) =5 (1)*	Density just after planting	5 yr	10 yr	15 yr	20 yr	25 yr	30 yr	5 yr	10 yr	15 yr	20 yr	25 yr	30 yr	5 yr	10 yr	15 yr	20 yr	25 yr	30 yr
(2) Tree density (# trees/ha)	2000	401	340	306	288	277	268												
Mortality rates	80%	15%	10%	6,0%	4,0%	3,0%	0%												
Volume per tree (dm3)		2,17	3,83	9,66	25,57	62,72	72,03												
(3) Volume per tree (m3)		0,002	0,004	0,010	0,026	0,063	0,072												
(4) Volume per hectare (m3)		0,87	1,30	2,96	7,36	17,34	19,30												
Cohort CAI incl annual mortality (m3/ha/an) *(5) = [(4)N+1-(4)N]÷(1)*		0,17	0,09	0,33	0,88	2,00	0,39												
Wood density (t/m3)		0,64	0,64	0,64	0,64	0,64	0,64	0,64	0,64	0,64	0,64	0,64	0,64						
(6) Biomass per tree (kg/tree)		1,39	2,45	6,18	16,36	40,14	46,10	0,67	1,18	2,97	7,85	19,27	22,13	2,05	3,63	9,15	24,22	59,41	68,22
Biomass per hectare (t DM/ha)		0,56	0,83	1,89	4,71	11,10	12,35	0,27	0,40	0,91	2,26	5,33	5,93	0,82	1,23	2,80	6,98	16,43	18,28
Calculation of biomass growth rate																			
Annual increment of volume with fix density *(7) = (4)*(2)÷(1)*		0,173	0,133	0,467	1,274	2,976	0,745												
Annual increment per tree *(8)=(6)÷(1)*		0,28	0,21	0,75	2,04	4,76	1,19	0,13	0,10	0,36	0,98	2,28	0,57						
Bi : *Annual increment of biomass with fix density* *(9)=(8)*(2) ÷1000*		0,11	0,09	0,30	0,82	1,90	0,48	0,05	0,04	0,14	0,39	0,91	0,23						
Relative growth (Fi = B_{stem}/B_i)								48%	48%	48%	48%	48%	48%						

2. Annual increment calculation for *Ziziphus mauritiana*

Above ground biomass (excl leaves)								*Below ground biomass*						*Total (excl leaves)*					
Age (yrs) *Timestep (years) =5 (1)*	Density just after planting	5 yr	10 yr	15 yr	20 yr	25 yr	30 yr	5 yr	10 yr	15 yr	20 yr	25 yr	30 yr	5 yr	10 yr	15 yr	20 yr	25 yr	30 yr
(2) Tree density (# trees/ha)	607	121	103	92	87	83	81												
Mortality rates	80%	15%	10%	6,0%	4,0%	3,0%	0%												
Volume per tree (dm3)		0,68	1,73	11,56	56,22	194,67	228,62												
(3) Volume per tree (m3)		0,001	0,002	0,012	0,056	0,195	0,229												
(4) Volume per hectare (m3)		0,02	0,03	0,20	0,91	3,01	3,43												
Cohort CAI incl annual mortality (m3/ha/an) *(5) = $[(4)_{N+1}-(4)_N]\div(1)$*		0,003	0,004	0,03	0,14	0,42	0,08												
Wood density (t/m3)		0,64	0,64	0,64	0,64	0,64	0,64	0,64	0,64	0,64	0,64	0,64	0,64						
(6) Biomass per tree (kg/tree)		0,43	1,11	7,40	35,98	124,59	146,32	0,21	0,53	3,55	17,27	59,80	70,23	0,64	1,64	10,95	53,25	184,39	216,55
Biomass per hectare (t DM/ha)		0,01	0,02	0,13	0,58	1,93	2,19	0,00	0,01	0,06	0,28	0,93	1,05	0,01	0,03	0,19	0,86	2,86	3,25
Calculation of biomass growth rate																			
Annual increment of volume with fix density *(7) = (4)*(2)÷(1)*		0,016	0,025	0,238	1,080	3,347	0,821												
Annual increment per tree *(8)=(6)÷(1)*		0,09	0,13	1,26	5,72	17,72	4,35	0,04	0,06	0,60	2,74	8,51	2,09						
Bi : Annual increment of biomass with fix density *(9)=(8)*(2) ÷1000*		0,0019	0,0030	0,0282	0,1282	0,3975	0,0975	0,0009	0,0014	0,0135	0,0615	0,1908	0,0468						
Relative growth (Fi = B_{stem}/B_i)								48%	48%	48%	48%	48%	48%						

3. Annual increment calculation for *Acacia senegal*

Above ground biomass (excl leaves)								*Below ground biomass*						*Total (excl leaves)*					
Age (yrs) *Timestep (years) = 5 (1)*	Density just after planting	5 yr	10 yr	15 yr	20 yr	25 yr	30 yr	5 yr	10 yr	15 yr	20 yr	25 yr	30 yr	5 yr	10 yr	15 yr	20 yr	25 yr	30 yr
(2) Tree density (# trees/ha)	10	2	2	2	1	1	1												
Mortality rates	80%	15%	10%	6,0%	4,0%	3,0%	0%												
Volume per tree (dm3)		0,66	5,55	36,98	155,11	475,23	560,9												
(3) Volume per tree (m3)		0,001	0,006	0,037	0,155	0,475	0,561												
(4) Volume per hectare (m3)		0,00	0,01	0,06	0,22	0,65	0,56												
Cohort CAI incl annual mortality (m3/ha/an) *(5) = $[(4)_{N+1}-(4)_N]\div(1)$*		0,00	0,00	0,01	0,03	0,09	-0,02												
Wood density (t/m3)		0,57	0,57	0,57	0,57	0,57	0,57	0,64	0,64	0,64	0,64	0,64	0,64						
(6) Biomass per tree (kg/tree)		0,38	3,16	21,08	88,41	270,88	319,70	0,18	1,52	10,12	42,44	130,02	153,46	0,56	4,68	31,20	130,85	400,90	473,16
Biomass per hectare (t DM/ha)		0,00	0,01	0,03	0,13	0,37	0,32	0,00	0,00	0,02	0,06	0,18	0,15	0,00	0,01	0,05	0,19	0,55	0,47
Calculation of biomass growth rate																			
Annual increment of volume with fix density *(7) = (4)*(2)÷(1)*		0,000	0,002	0,013	0,047	0,127	0,034												
Annual increment per tree *(8)=(6)÷(1)*		0,08	0,56	3,58	13,47	36,49	9,76	0,04	0,27	1,72	6,46	17,52	4,69						
Bi : Annual increment of biomass with fix density *(9)=(8)*(2) ÷1000*		0,00	0,00	0,01	0,03	0,07	0,02	0,00	0,00	0,00	0,01	0,03	0,01						
Relative growth (Fi = B_{stem}/B_i)								48%	48%	48%	48%	48%	48%						

4. Annual increment calculation for *Balanites aegyptiaca*

Above ground biomass (excl leaves)								*Below ground biomass*						*Total (excl leaves)*					
Age (yrs) *Timestep (years) = 5 (1)*	Density just after planting	5 yr	10 yr	15 yr	20 yr	25 yr	30 yr	5 yr	10 yr	15 yr	20 yr	25 yr	30 yr	5 yr	10 yr	15 yr	20 yr	25 yr	30 yr
(2) Tree density (# trees/ha)	19	4	3	3	3	3	3												
Mortality rates	80%	15%	10%	6,0%	4,0%	3,0%	0%												
Volume per tree (dm3)		0,27	2,22	38,91	245,03	920,77	1 088,5												
(3) Volume per tree (m3)		0,000	0,002	0,039	0,245	0,921	1,088												
(4) Volume per hectare (m3)		0,00	0,01	0,11	0,67	2,40	3,27												
Cohort CAI incl annual mortality (m3/ha/an) *(5) = $[(4)_{N+1}-(4)_N]\div(1)$*		0,00	0,00	0,02	0,11	0,35	0,17												
Wood density (t/m3)		0,78	0,78	0,78	0,78	0,78	0,78	0,64	0,64	0,64	0,64	0,64	0,64						
(6) Biomass per tree (kg/tree)		0,21	1,73	30,35	191,12	718,20	849,01	0,10	0,83	14,57	91,74	344,74	407,52	0,31	2,56	44,92	282,86	1062,94	1256,53
Biomass per hectare (t DM/ha)		0,00	0,01	0,09	0,52	1,88	2,55	0,00	0,00	0,04	0,25	0,90	1,22	0,00	0,01	0,13	0,77	2,78	3,77
Calculation of biomass growth rate																			
Annual increment of volume with fix density *(7) = (4)*(2)÷(1)*		0,000	0,001	0,028	0,156	0,511	0,127												
Annual increment per tree *(8)=(6)÷(1)*		0,04	0,30	5,72	32,15	105,42	26,16	0,02	0,15	2,75	15,43	50,60	12,56						
Bi : Annual increment of biomass with fix density *(9)=(8)*(2) ÷1000*		0,00	0,00	0,02	0,12	0,40	0,10	0,00	0,00	0,01	0,06	0,19	0,05						
Relative growth (Fi = B_{stem}/B_i)								48%	48%	48%	48%	48%	48%						

5. Annual increment calculation for *Acacia nilotica*

Above ground biomass (excl leaves)								*Below ground biomass*						*Total (excl leaves)*					
Age (yrs) *Timestep (years) = 5* *(1)*	Density just after planting	5 yr	10 yr	15 yr	20 yr	25 yr	30 yr	5 yr	10 yr	15 yr	20 yr	25 yr	30 yr	5 yr	10 yr	15 yr	20 yr	25 yr	30 yr
(2) Tree density (# trees/ha)	75	15	13	11	11	10	10												
Mortality rates	80%	15%	10%	6,0%	4,0%	3,0%	0%												
Volume per tree (dm3)		2,32	3,99	9,47	23,48	54,44	62,1												
(3) Volume per tree (m3)		0,002	0,004	0,009	0,023	0,054	0,062												
(4) Volume per hectare (m3)		0,03	0,05	0,11	0,25	0,56	0,62												
Cohort CAI incl annual mortality (m3/ha/an) *(5) = $[(4)_{N+1}-(4)_N]\div(1)$*		0,01	0,00	0,01	0,03	0,06	0,01												
Wood density (t/m3)		0,64	0,64	0,64	0,64	0,64	0,64	0,64	0,64	0,64	0,64	0,64	0,64						
(6) Biomass per tree (kg/tree)		1,49	2,56	6,06	15,03	34,84	39,74	0,71	1,23	2,91	7,21	16,72	19,07	2,20	3,78	8,97	22,24	51,57	58,81
Biomass per hectare (t DM/ha)		0,02	0,03	0,07	0,16	0,36	0,40	0,01	0,02	0,03	0,08	0,17	0,19	0,03	0,05	0,10	0,24	0,53	0,59
Calculation of biomass growth rate																			
Annual increment of volume with fix density *(7) = (4)*(2)÷(1)*		0,007	0,005	0,016	0,042	0,092	0,023												
Annual increment per tree *(8)=(6)÷(1)*		0,30	0,21	0,70	1,79	3,96	0,98	0,14	0,10	0,34	0,86	1,90	0,47						
Bi : Annual increment of biomass with fix density *(9)=(8)*(2) ÷1000*		0,00	0,00	0,01	0,03	0,06	0,01	0,00	0,00	0,01	0,01	0,03	0,01						
Relative growth (Fi = B_{stem}/B_i)								48%	48%	48%	48%	48%	48%						

Annex 11. Risk buffer calculation

Managing the risks of non-sustainability

Version 2, 30/10/2012

Bioclimate

User inputs

	Risk type	Influence of coordinating group	Situation at project outset	Action to manage risk	Time-scale	Will a problem happen? (Probability)		Severity of problem (Significance)		Score
A	Land ownership / tenure									**0,18333**
A.1	Land tenure	Partial	Communally owned land	Local land charter formalize the local conventions based on customs and land uses.	Short	Unlikely	0,05	High	3	0,15
A.3	Disputes caused by conflict of project aims/activities with local communities/organizations	Partial	Not the case	Participatory planning and continued stakeholder consultation over project lifespan.	Short	Unlikely	0,05	Medium	2	0,1
A.4	External pressure to engage in non-sustainable practices	Partial	In the baseline scenario the sites don't have high production and thus not exposed to external pressure	Restoration of degraded pastures is vital for these communities as livestock breeding is one of the main activities in the zone. Transhumance is organized through the local land charter. Project coordinator will assist the CVD in the surveillance of the rehabilitated pasture sites according the local land charters.	Short	Likely	0,1	High	3	0,3
B	Financial									**0,15**
B.1	Project financial plan	Complete	Project interventions have already been financed by the BKF/017.	The monitoring cost for the project coordinator is limited. After closure of BKF/017 end 2016. Lux Dev will continue to support the project coordinator as from 2017	Short	Unlikely	0,05	High	3	0,15
C	Technical									**0,15**
C.1	Coordinator capacity	Complete	Experience in assisting communities	Already long experience of project coordinator in assisting local communities in the process of	Short	Unlikely	0,05	High	3	0,15

D	Management									**0,2**
D.1	Ineffective management	Complete		Project managers and staff adequately trained	Short	Unlikely	0,05	Medium	2	0,1
D.2	Poor record keeping	Complete		Robust procedures and keen oversight. Limited number of Plan Vivos to record.	Short	Unlikely	0,05	Low	1	0,05
D.3	Staff with relevant skills and expertise	Complete		Careful selection of project staff and training	Short	Unlikely	0,05	High	3	0,15
D.4	Tree damage from browsing	Partial		No specific protection of trees and plants is necessary, as direct seeding limits the plant damage after browsing	Short	Very likely	0,25	Medium	2	0,5
E	Economic									**0,1**
E.1	Financial failure caused by poor or fluctuating carbon price or by failure to attract buyers	Partial		The Lux Dev cooperation lined up as interested buyer. CO2logic, the consultancy partner for the project, could assist the project coordinator to sell the certificates in case of necessity.	Short	Unlikely	0,05	Medium	2	0,1
F	Political									**0,3**
F.1	External pressure to engage in non-sustainable livelihood activities	None		Implementation of project activities to improve livelihoods	Short	Likely	0,1	High	3	0,3
G	Social									**0,15**
G.1	Community disputes over land tenure	Partial		Local land charters foresees procedures to manage land disputes.	Short	Unlikely	0,05	High	3	0,15
G.2	Disputes caused by conflict of project aims or activities with local communities or organisations	Partial		Participatory planning and continued stakeholder consultation over project lifetime	Short	Unlikely	0,05	High	3	0,15
H	Fire									**0,05**
H.1	Incidence of forest fire	Partial		Not that relevant in project zone	Short	Unlikely	0,05	Low	1	0,05
I	Physical									**0,4**
I.1	Drought	None	Droughts are not unknown in the Sahel	All used species are native to the Sahel and very drought resistant	Short	Very likely	0,25	High	3	0,75
I.6	Pest and diseases		Infrequent (<1 in 10 years)	Replanting of trees as required	Short	Unlikely	0,05	Low	1	0,05
	Overall Score (average of risk types)									**0,18704**
	Suggested risk buffer (tCO2e):									**20%**

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