




PROMOTION FOR LOW CARBON RURAL DEVELOPMENT THROUGH EFFICIENT UTILIZATION OF LOCAL RESOURCES

POR THE REALIZATION OF SUSTAINABLE DEVELOPMENT

Japan International Research Center for Agricultural Sciences (JIRCAS)

Ministry of Environment, Green Economy,
and climate Change (MEEVCC), Burkina Faso

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Foreword

The Ministry of Environment in collaboration with the Japan International Research Centre for Agricultural Sciences (JIRCAS) committed in 2013 for the realization of a "Study on the development of low-carbon methodologies for rural development through the efficient use of local resources." The purpose of this study was to develop methodologies and techniques using local natural resources to effectively respond to climate change and ensure sustainable rural development. To this end, in 2014 a scientific collaboration was signed with JIRCAS for the execution of this study.

For three years, the study proceeded with target actors in the area of intervention by the development of tests, collection and analysis of data, and then a verification of proven methodologies to fight against climate change using effective natural local resources. These activities were carried out with the technical support from the ministry of environment and actors from other involved agencies. The results obtained were then validated by a Scientific and Technical Committee (CST). The CST has significantly contributed to improving the research methodologies on one hand and the quality of the content of this document.

The document summarizes the results achieved by the study in the target area and should be an effective vulgarization tool of carbon emission reduction for the creation of carbon sinks and the use of renewable energy.

Its usefulness is recognized by the Government of Burkina Faso to serve the actors and communities involved in activities against climate change and sustainable development of regional and local authorities.

We then recommend it to the public as a source of additional information to practices for the protection of the environment and sustainable development, while contributing to the development of local natural resources.

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Contents

Abbreviations

Acronym	Offiical designation	English name
AF	Agroforestry	Agroforestry
AP	Action Plan	Action Plan
APFNL	Agence de Promotion des Produits Forestiers Non Ligneux	Agency of Promotion of the non-wood forest Product
CDM	Clean Development Mechanism	Clean Development Mechanism
CNSF	Centre National de Semences Foretière	National center of seed forest
CNRST	Centre National de la Recherche Scientifique et Technologique	National center of the Scientific and Technological Research
C/P	Counterpart	Counterpart
CVD	Comité Villagois de Développement	Village development Committee
CVP	Cost-Volume-Profit Analysis	Cost-Volume-Profit Analysis
DC	Direct Current	Direct Current
DERED	Direction des Energies Renouvelables et de l'Energie Domestique	Direction of the Renewable Energies and the Domestic energy
DIFOR	Direction des Forêts	Direction of the Forests
DGPV	Direction Générale de la Production Végétale	General direction of the Plant Production
FA	Foyer Amélioré	Improved oven
FAFASO	Foyer Amélioré de Burkina FASO	Improved oven of Burkina Faso
FCFA	Frnac Colonies Française d'Afrique	Frnac Colonies French of Africa
FAO	Food and Agriculture Organization of the United Nations	Food and Agriculture Organization of the United Nations
GHG	Greenhouse Gas	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit	German Corporation for International Cooperation
GL	Ground Level	Ground Level
INERA	Institut de l'Environnement et de Recherches Agricoles	Institute of the environment and Agricultural Research

Acronym	Offiical designation	English name
IPCC	Intergovernmental Panel on Climate Change	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return	Internal Rate of Return
IRSAT	Institut de Recherche en Sciences Appliquées et Technologies	Institute of Research in Applied Sciences and Technologies
JICA	Japan International Cooperation Agency	Japan International Cooperation Agency
JIRCAS	Japan International Research Center for Agricultural Sciences	Japan International Research Center for Agricultural Sciences
JRA	Joint Research Agreement	Joint Research Agreement
MAAH	Ministère de l'Agriculture et des Aménagemens Hydrauliques	Ministry of Agriculture and Water Facilities（from Jan 2016）
MARHASA	Ministère de l'Agriculture, de Ressources hydrauliques, de l'Assainissement et de la Sécurité Alimentaire	Ministry of agriculture, hydraulic Resources, purification and Security Alimentair（from Jan 2015）
MASA	Ministère de l'Agriculture et de la Sécurité Alimentaire	Ministry of agriculture and Food Security（until Jan2015）
MEDD	Ministère de l'Environnement et Développement Durable	Ministry of environment and sustainable Development（until Jan 2015）
MEEVCC	Ministère de l'Environnement, de l'Economie Verte et du Changement Climatique	Ministry of Environment, Green Economy, and climate Change（from Jan 2016）
MERH	Ministère de l'Environnement et des Ressources Halieutiques	Ministry of environment and fishery Resources
MG	Market Gardening	Market Gardening
MME	Ministère des Mines et de l'Energie	Ministry of Mines and energy
MRSI	Ministère de la Recherche Scientifique et de l'Innovation	Ministry of the Scientific Research and the innovation
NAP	National Adaptation Plan	National Adaptation Plan
NAPA	National Adaptation Program of Action to Climate Change	National Adaptation Program of Action to Climate Change
NEDO	New Energy and Industrial Technology Development Organization	New Energy and Industrial Technology Development Organization

Acronym	Offiical designation	English name
NGO	Non Governmental Organization	Non Governmental Organization
NTFPs	Non-Timber Forest Products	Non-Timber Forest Products
PRA	Participatry Rural Appraisal	Participatry Rural Appraisal
SP/CONEDD	Secrétariat Permanent du Conseil National pour l'Environnement et le Développement Durable	Permanent secretariat of the Council National for environment and sustanable Development
SCADD	Stratégie de Croissance Accélérée et de Développement Durable	Strategy of Accelerated Growth and sustanable Development
STC	Scientific Technical Committee	Scientific Technical Committee
UBTEC	Union des Baoré Tradition d'Epargne et de Crédit	Union of the Baoré Tradition of saving and Credit
UNDP	United Nations Development programme	United Nations Development programme
UNFCCC	United Nations Framework Convention on Climate Change	United Nations Framework Convention on Climate Change

1 Introduction

1.1 Background and Objectives

In its 5th Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) of the United Nations found again global warming on the basis of his observations of temperature, the temperature of sea water and sea level, saying that "warming of the climate system leaves no room for doubt." The IPCC also said it was very likely that this warming is due to human causes, and that in one of its scenarios, there would be a global warming average of about 0.3 to 4.8˚ C, as well as a rise in sea level of about 0.26 to 0.82 m by the end of the century, and noted that the drastic and continuous reduction of greenhouse gas emissions (GHG) would be necessary to control climate change. In particular, GHG linked to agriculture and forestry, including farming, and other land uses are considered to account for about 1/4 of net manmade GHG emissions in global warming, and actions reducing emissions in the agricultural and forestry sector are considered essential.

Furthermore, the very limited natural resources such as water, oil and natural gas constituting the energy sources are in a critical situation, and drying is feared, it is required to promote the efficient use of natural resources and renewable energy.

Agriculture is the main activity in Burkina Faso, 33% of gross national product and the population working in this sector accounts for over 80% of the workforce. In a context of significant population growth (2.8%), the poverty rate reached 44.5%[1] according to the international poverty line, and the human development index, indicating the degree of life humanized ranks the country 181th out of 187 countries[2]. In many West African developing countries, where Burkina Faso is, and other regions, suffer from fundamental problems such as poverty reduction, assurance of water resources, resources and energy, improvement of medical care, etc. that need to tackle for sustainable development. In Burkina Faso, a National Adaptation Programme of Action (NAPA) (currently under changing to a National Adaptation Plan (NAP)) to climate change is established to deal with these problems.

[1] Development Indicators in the world, WB (2015)
[2] Report on Human Development, UNDP (2014)

On the other hand, not having the capacity to respond to climate change (adaptation and mitigation measures), taking mitigation measures can obstruct the development. Therefore, the adoption of a co-benefit type approach for achieving the benefits while addressing climate change and responding to high-priority development needs of developing countries is essential.

Considering this situation, the project subject of this document's objective is to achieve the effective and efficient agricultural and rural development while contributing to measures of mitigation and adaptation to climate change; that, through the development of methodologies and techniques related to measures against climate change, efficient use of local natural resources to provide benefits involving measures against climate change through sustainable development actions based on Burkina Faso's needs.

1.2 Orientation

The many conventional development projects so far undertaken by many international organizations and donors have sought out the benefits of development while seeking sustainable development have led to the accumulation of many methodologies and techniques. The participatory approach promoting the awareness of stakeholders and motivating residents constitutes a representative example.

In the project subject of this Document, based on the usual tools of development projects of the past, that is to say by posing as major premises responding to people's needs and building consensus with them regarded as essential elements in the implementation of a development project, the profits will be sought not only by following the same course, but also taking account of the fight against climate change.

Improving living conditions, income growth and the conservation of natural resources also considered beneficial in the fight against climate change and the

efficient use of resources may be cited as the expected development profits of the project subject of this Document. The benefits of the fight against climate change are to develop the methodologies for reducing GHG and simple quantification of GHG reduction.

As for the method of calculating the effect of fight against climate change, the methodology of Clean Development Mechanism (CDM) currently applied in the international framework for the fight against climate change was adopted for efficient calculation. The CDM is a mechanism for a developing country which has invested in a project to fight against climate change to achieve GHG emission reductions (or quantity absorbed). The reduction of GHG emissions ensured by the implementation of this CDM is calculated using the quantitative formula defined by the United Nations Framework Convention on Climate Change (UNFCCC). Thus, using the formula defined in the CDM methodology, reducing achievable GHG emissions by the project against climate change, equal to the benefits of climate change prevention measures, can be searched, which allows benefits quantification related to climate change. This allows to quantify from the climate change point of view the effectiveness of the co-benefit type of project as a measure against climate change meeting the development needs of developing countries, and thus to propose a methodology that indicates easily the effectiveness of the project.

1.3 Outline of actions

In the "Feasibility study for agricultural and rural development through the effective use of local resources" (hereinafter "the study") funded by the Ministry of Agriculture, Forestry and Fisheries of Japan, actions, based on the above guidance, have been undertaken focusing on three main activities, namely: (a) improved cook stove, (b) tree planting and agroforestry and (c) solar photovoltaic energy, after identifying the needs of people and building consensus with them.

In the activity "improved cook stove", the methodology of quantitative calculation, the dissemination methodology as well as the example of their practice were presented through experimental verification to accelerate its introduction, in order to develop a methodology for calculating the quantitative impact of calculating the effective reduction of CO_2 emissions and to propose a methodology to disseminate improved cook stoves in rural areas.

In the activity "Tree planting and agroforestry" aiming the organization of knowledge and lessons accumulated so far for the establishment of tree planting techniques and agroforestry practiced in agricultural land using indigenous fruit trees, the criteria for selection of varieties of fruit trees for example trees adapted to local conditions were presented, as well as theoretical and practical training necessary for the introduction of indigenous fruit trees by farmers were proposed and implemented, and the evaluation of the profitability in case of use of indigenous fruit trees was also performed.

In the activity "production of photovoltaic solar energy," to evaluate the economic relevance of irrigated agriculture on a small scale with the introduction of solar photovoltaic system, and quantitative assessment of the reduction of CO_2 emissions, was conducted. Experimental verification of market gardening for sale on markets using the photovoltaic solar system for irrigated small scale agriculture that generates income during the dry season and profitability-reducing CO_2 emissions has also been verified.

1.4 Composition and Document Content

This Document presents the knowledge and methodologies against climate change using effectively local natural resources, acquired through the planning and implementation of the three aforementioned activities and gives concrete examples

as references and examples of calculations and calculation tests practiced in this study. Here are below the composition of the contents of this document.

Chapter 1 Development needs of Burkina Faso
Chapter 2 With a view to achieving the co-benefit approach
Chapter 3 Planning
Chapter 4 Implementation- Improved Cook stove
Chapter 5 Implementation - Tree planting and agroforestry
Chapter 6 Implementation - Production of photovoltaic solar energy

1.5 Use the Document

This Document is used for the formulation and implementation of projects against climate change in order to address the problems of rural areas of Burkina Faso, or as a manual for the implementation of a project similar in translating - a project under the NAPA or NAP.

People in charge of project execution formulation, such as personal state (central or regional state services), donor staff, international NGOs and national NGOs, particularly those in charge of the realization - implementation of NAPA or NAP projects, are considered as users of this Document.

Chapter 1 National Context and objective of NAP in Burkina Faso

Burkina Faso, like many other developing countries and some developed countries, has ratified the United Nations Framework Convention on Climate Change (UNFCCC). The implication of this ratification for the International Community was the commitment to prepare to better define the extent of climate change through national communications, policies and measures to mitigate greenhouse gas, adaptation to climate change programs and systematic observation of the phenomenon.

After the ratification of the Kyoto Protocol in March 2005, Burkina Faso has committed in the process of developing its National Action Programme of Adaptation to Climate Change (NAPA), which was adopted in November 2007 with as key areas of intervention: agriculture, water resources, animal resources and forestry/biodiversity.

Twelve (12) priority projects were identified in highly vulnerable areas and developed for their urgent implementation on the ground. Several major gains have been reaped with perfect adherence of the population. These experiences were the basis for the development of national adaptation plan to climate change (PNA) desired by the international community for implementation of actions in the long term.

Burkina Faso has adopted a new programming framework called the NAP. This new vision will have the advantage of achieving greater integration of climate change into development policies and strategies in the long term. Indeed, the NAP has the following objectives:

- To reduce the Vulnerable to the impacts of climate change through the development of capacity adaptation and resilience;
- To facilitate the integration of adaptation to climate change, in a coherent way, in policies, new or existing programs or activities, specific processes of development and strategies planning within relevant sectors and different levels.

Vision and objectives of the NAP

The vision of the NAP of Burkina Faso is entitled as follows:

"Burkina Faso manages more effectively its economic and social development through the implementation of planning mechanisms and measures taking into account the resilience and adaptation to climate change by 2050 ".

From this vision, long-term adaptation objectives are:

- To protect pillars of accelerated growth ;
- To ensure sustainable food security and nutrition;
- To preserve water resources and improve access to sanitation;
- To protect people and property against extreme climate events and natural disasters;
- To protect and improve the functioning of natural ecosystems;
- To protect and improve populations' health

Identified sectors in the NAP and adaptation actions

Burkina Faso's NAP has identified the following vulnerable sectors and areas in its formulation following vulnerability analysis and projections made by the Laboratory for Analysis of Mathematical Equations at the University of Ouagadougou. They are:

- Agriculture
- Livestock production
- Environment and natural resources
- Health
- Energy
- Housing and infrastructure
- Cross-cutting issues

As part of this project, the agriculture sector, environment and natural resources and energy are the subject of collaborative research. The main adaptation actions in these areas are presented as follows:

Agriculture

- Cultivation of early varieties and resistant to drought
- Implementation of water and soil conservation techniques (stone barriers, dikes, filtering bunds, terraces, crescents, agroforestry, sand dune fixation, etc.)
- Promoting sustainable land management (GDT)
- Improvement of access to climate information
- Establishment of agricultural insurance.

Energy Sector,

- Diversification of sources of energy (solar, wind power e, biogas)
- Implementation of development plan and water management in the Sudan region where the climate forecast announces a slight increase of rainfall.
- Promoting technologies of economics of energy in industry and building

- Promotion of the use of improved cook-stoves to reduce substantially the consumption of wood and charcoal

Environmental and natural resources sector

- Implementation of forestry and agroforestry good practices (firewood selective cutting, assisted natural regeneration, controlled land clearance, etc.)
- Community and Participative forestry and Wildlife resources Management
- Increased and sustainable exploitation of non-timber forest products (NTFPs)

Chapter 2 To achieve the co-benefit approach

2.1 What is the co-benefit approach?

The co-benefits (combined benefits) are the profits generated in various areas as a result of a policy, a strategy or action plan.[1]

This co-benefits approach project aims simultaneously at producing two different profits from a policy, strategy or single activity, considering the one hand, the developing country's development needs and also the needs in the fight against global warming as application areas. Here, the co-benefits approach is an approach to fight against climate change taken while considering the development needs and benefit of the project meets the development needs is called "development benefit" and the project benefit responding to climate change "Climate benefit". Figure 2.1.1 shows an image of the co-benefit approach.

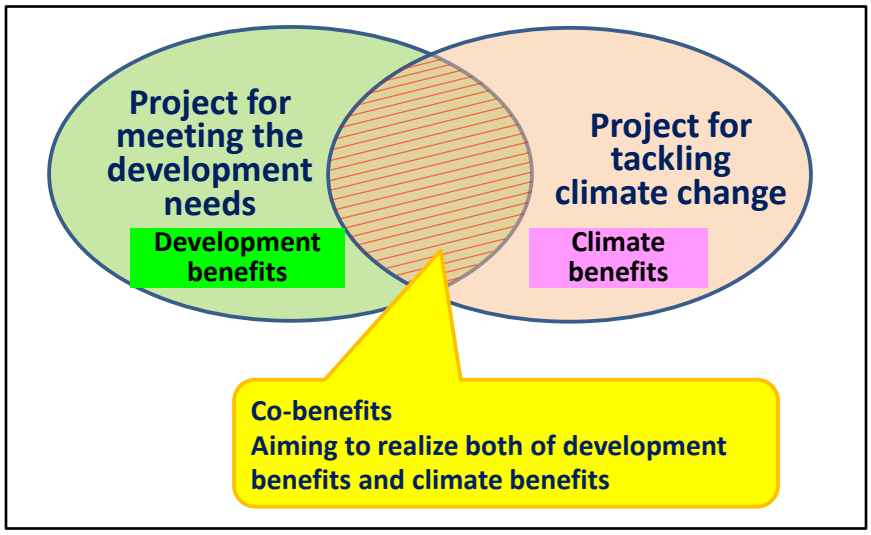


Figure 2.1.1 Image of the co-benefits approach

The IPCC also mentions in its 5th Assessment Report of the importance of the concept of co-benefits, and since its 4th Report, it strengthens the degree of attention to established policies by integrating several objectives for the expansion of common benefits (co-benefits) and reducing the negative side effects.[2]

[1] Environmental Protection Agency (USA) (2007) Co-benefits of climate change mitigation: coordinator in Asia
[2] IPCC (2014) Report 5, Working Group 3 report for policymakers (SPM)

2.2 For the realization of the benefits approach in Burkina Faso

As mentioned in Chapter 1, there are in Burkina Faso development goals and the NAPA (see Table 2.2.1 for list of projects mentioned in the NAPA). The NAPA tends to move to a NAP, and in February 2015 a workshop was held bringing together government officials, citizen groups and technical and financial community, and PNA provisional version was shared there.

Table 2.2.1 List of projects listed in the NAPA

	Recommended Actions
1	Strengthening of conservation related to food security and early warning system (information system, tracking of agriculture and livestock farming activities, seasonal information, storage for food preservation)
2	Promotion of farming for food production and supplementary irrigation
3	Development and management of the pond of Oursi
4	Grass production for forage and system of its storage (hay, crop residues, stem, etc.)
5	Rational management and increase value planning of Non Timber Forest Products (NTFPs)
6	Prevention against sedimentation of pond, river, and reservoir
7	Efficiency of water use of irrigated agriculture
8	Conservation of pastoral areas where are strategically important and suitable place
9	Dissemination of soil and water conservation technique (Zai, land conservation such as contour ridge)
10	Conservation of wildlife and management of its habitat
11	Construction work for water resources development and setting up conservation measures against river pollution and conservation area
12	Promotion of improved cook stoves, renewable energy, alternative energy equipment (solar cooker, water heater, solar, etc)

According to the NAP project, in the Strategy for Accelerated Growth and Sustainable Development (SCADD) based on the vision for 2025 of Burkina Faso, each of the fields of agriculture, livestock, forestry, energy and infrastructure is positioned as the main pillar of accelerated growth. Moreover, each of these pillars

under the influence of the risks of the natural environment, the nature of climate change and the scale of its impact were analyzed in relation to socioeconomic development. Thus, the areas of development most threatened by climate change were defined as follows:

- The pillars of accelerated growth: agriculture, forestry, energy and infrastructure
- Food and nutrition security
- Water resources
- The Security of physical health and property of populations
- Natural ecosystems
- Health

In order to remedy these areas threatened by climate change, the UNFCCC has supported the development of the NAP draft as part of its assistance to the least developed countries.

The short, medium and long term objectives, and measures to be taken, are listed in the draft of NAP; the long-term objectives are the following.

- To protect pillars of accelerated growth
- To ensure sustainable food and nutrition security
- To preserve water resources and improve access to sanitation
- To protect people and property against extreme weather events and natural disasters
- To protect and improve the functioning of natural ecosystems
- Protecting and improving the health of populations

In the draft of NAP, the various measures are recommended for each of the long-term goals mentioned above. Table 2.2.2 presents the main long-term goals and recommended actions. These measures being measures in response to climate change based on the national development strategy much correspond to the approach taken in this project. The implementation of these measures will be therefore an action for achieving co-benefits approach adopted in this project.

Table 2.2.2 Measures mentioned in the draft PNA

Short, medium and long term adaptation objectives,		Recommended adaptation measures	Short/medium long term
Protection of the pillars of economic growth	Agriculture	- Cultivation of early maturing and dryness resistant varieties - Implementation of water and soil conservation techniques (stone lines, dikes, filtering dikes, terraces, half-moon, agroforestry, sand dune fixation, etc.) - Promotion of sustainable land management - Improved access to climate information - Strengthening of weather data use capabilities in planning the agricultural sector activities - Implementation of water-saving irrigation techniques - Adaptation of irrigation systems to the phenomenon of evapotranspiration of water from developed areas - Establishment of agricultural insurance - Support for surveillance and fight against Locust	Short term Short term medium term medium term medium term Short term medium term long term Short term
	Forestry	- Implementation of good forestry and agroforestry practice (selective cutting firewood, assisted natural regeneration, controlled clearing etc.) - Community Management and Participatory forest resources, fish and wildlife - Increased exploitation and sustainable exploitation of non-timber forest products (NTFPs) - Agroforestry practice for sustainable management of natural resources - Realization of cities sustainable supply patterns of fuelwood and charcoal	Short term long term long term long term long term
	Energy	- Development of Energy Efficiency - Investment in hydroelectric production micro power plants - Diversification of energy sources (solar, wind, biogas) - Implementation of land use planning and management in the Sudan region where climate forecasts predict a slight increase in rainfall - Strengthening of hydro-electric works - Promotion of energy-saving techniques in industry and construction - Promoting the use of improved cook stoves to substantially reduce the consumption of wood and charcoal - Promotion of alternative energy sources such as butane and biogas - Promoting the use of biomass (crop residues) in	long term long term medium term long term long term long term Short term medium term long term

		the form of briquettes - Information and sensitization of stakeholders/ consumers on energy savings, choice of thermal equipment (engines, refrigeration machines) - Reduced cooling requirements in new buildings through bioclimatic design techniques - Development and dissemination of new air conditioning technologies (solar cooling, evaporative air conditioner)	Short term long term long term
	Preserve water resources and improve access to sanitation	- Monitoring of dams (dikes and dams, water flow, functionality of valves, etc.) - Realization of dams: construction of modern wells, high flow boreholes, dams, ponds amenities, stream diversion - Fight against silting of water plans - Reduction of water consumption for domestic use (watering, pool) during shortages - More efficient use of water resources - Development of integrated water resources management (IWRM) - Reduction of women's access to safe drinking water hardship in times of drought through appropriate technology - Realization of sanitation infrastructure in urban and rural areas - Strengthening of knowledge on Water Resources in a context of climate change	Short term long term long term Short term Short term Short term Short term medium term long term

Chapter 3 Planning

3.1 Selection of the target area

3.1.1 Definition of the Project implementation area

In the CDM methodology, it is required to first determine the benefited area of the project. In ordinary rural development projects also, the determination of the target area is required depending on the scope of the project. Therefore, in this Rural Development Project of low carbon emission through the effective use of local resources (hereinafter referred to as "Low Carbon Emission Project") which is the subject of this document as it is necessary to define the areas and target villages taking into account its size and the number of personnel practicing the Low Carbon Emission Project.

The Low Carbon Emission Project has as prerequisites the participation of residents of each village and appropriate assistance for this achievement and monitoring after project implementation, a more careful attention than in regular development projects should be given on the human resources level involved the Project. In fact, it will be essential to study well at this early stage of project planning to set the number of target areas and villages of the Project.

The process of this work will be as follows: (1) Selection of candidate areas (at provincial level) → (2) Selection of target areas (at provincial level) → (3) selection of candidate villages → (4) Selection of target village(s).

People involved in this work will be the technicians of the target areas in project planning matters (hereinafter "planner"), and the heads of provincial offices of the Ministry of Agriculture, Water Resources, Sanitation and Food Security (MARHASA) and the Ministry of Environment and Fishery Resources (MERH) (hereinafter, the "office managers"). In addition, each ministry was restructured and changed the name on January 2016. In the document is applied the former name of the time of the study.

3.1.2 Selection of target areas (at provincial level)

Here is explained the selection method presupposes the selection of one province.

After collecting and classifying information on the selection criteria, the planner holds consultations with government departments in charge of the Low Carbon Emission Project about it, and selects 3 or 4 candidate areas.

Then, the same planner conducts a survey through interviews with the responsible offices of the different candidate provinces and established a classification sheet of the different selection criteria. The most suitable province is selected on the basis of this sheet.

Case of this study

Tables 3.1.1 and 3.1.2 provide an example of the selection criteria actually established for this study and the grading sheet comparing different provinces. At the project implementation, selection will normally be conducted in accordance with this example, but the revision of its contents will be to some extent permitted according to the situation of areas, etc.

Table 3.1.1 Criteria for the selection of the target area

Selection criteria	Description
Public security	The areas where the actions of obstructions to the project are predictable because of political and security instability or the areas where the implementation of the project in long-term is considered difficult will be excluded.
Natural conditions	Areas with average annual rainfall above 600 mm where you can expect the effects of tree planting and AF
	Areas where vegetation is declining
	Areas where land degradation is advanced
Reserved areas	Not be considered protected area as national forest reserve which are limited tree planting activities and AF
National	Area without national grid or implementation plan of the network for the

grid	use of solar energy
Accessibility	From the perspective of project management, accessible area within a radius of 1 to 1.5 hours away from the project base.

Discussions have been held with JIRCAS and the Permanent Secretariat of the National Council for Environment and Sustainable Development (SP/CONEDD) of MERH, the ministry of this study, on the basis of these criteria, which led the selection of four candidate areas: (1) Kourwéogo province of the Central Plateau region, (2) Oubritenga province of the same region, (3) Ganzourgou province of the same region and (4) Bazèga province the South-Central region.

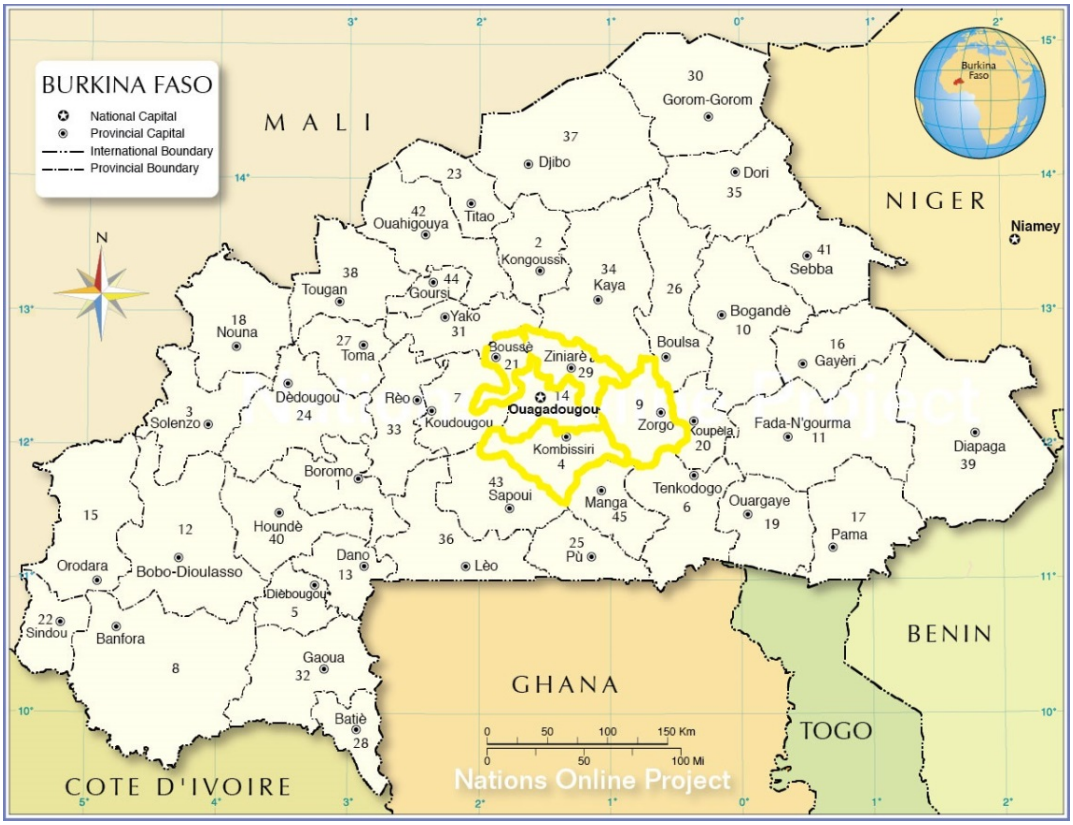


Figure 3.1.1 Results of selection of candidate areas for the study

Source: http://www.nationsonline.org/oneworld/map/burkina_faso_map.htm (05/19/2015)

Then, a visit was made to the regional offices of the 4 aforementioned MERH provinces and an interview survey was done on the elements required to assess the need for and feasibility study. Table 3.1.2 gives the results.

Following the analysis of these results made taking into account the selection criteria, it turned out that improved cook stove project (FA) similar to the project was already implemented in the province of Bazèga (4) and problems in terms of natural conditions were important. Bazèga (4) province was therefore excluded and other provinces (1), (2) and (3) were selected. Then the province of Ganzourgou (3) was eliminated from the standpoint of access because located more than 1.5 hours away, and the province of Oubritenga (2) was also eliminated because a similar Japanese research study project has already been implemented there, and the province of Kourwéogo (1) has been selected. It was found that the provinces (1) to (4) all met all criteria except the access time. Moreover, a project of improved stoves similar in this project is carried out in the province (1), and in principle areas with similar project should be excluded, but given that improved stove projects are carried out in all of these 4 provinces, and the FA project areas are only part of each province, the implementation of low-carbon project in the province of Kourwéogo (1) was decided as long as the absence of duplication projects is confirmed at the stage of selecting target villages.

Table 3.1.2 Results of interview surveys in candidate areas

	Province Kourwéogo	Oubritenga Province	Province Ganzourgou	Province Bazèga
People met	Director of the Provincial Office	Acting Director of the Provincial Office	Acting Director of the Provincial Office	Director of the regional office and director of the provincial office
Region	Plateau-Central Region	Plateau-Central Region	Plateau-Central Region	South Central Region
Capital of the region	Ziniaré	Ziniaré	Ziniaré	Manga
Capital of	Boussé	Ziniaré	Zorgho	Kombissiri

the province				
Number of cities	5	7	8	7
Provincial Office Staff	9 in total 7 foresters, 2 officers from the Environment Directorate	15 in total 13 forest officers, 1 secretary, 1 Keeper	11 in total 10 forest officers, 1 environmental agent 1 in each city, and 2 forest officers assigned to forest reserves	19 in total 17 forest officers, 1 officer from the direction of the environment, 1 secretary 2-3 foresters affected city
Main problems	1. Excessive cutting 2. Reduction of agricultural land by influx of residents from other provinces 3. Lack of water	1. Excessive cutting 2. Soil degradation (continuous culture, low rainfall) 3. Difficulty acquisition of agricultural land due to the increase in population	1. Decrease of vegetation 2. Excessive cutting 3. Difficulty acquisition of agricultural land due to population growth 4. Pollution of water (due to the use of chemicals for the extraction of gold)	1. Excessive felling 2. Decrease vegetation 3. Land Degradation 4. Water/Soil Pollution
Similar projects (rural development, environment)	- Improved stove by NGOs - Bio-digester of the Ministry of Animal Resources	- Improved stove by NGOs - Improved stove by group support to women	- Prevention of soil erosion by NGOs - Improved stove Project by NGOs	Integrated small scale rural development by NGOs (improved stove, tree planting, seed production, green manure crops, capacity building)
National grid, electrification	No electricity in the villages	No electricity in the villages Partial electrification of urban areas	No electricity in the villages Partial electrification of urban areas	No electricity in the villages Partial electrification of urban areas
Main ethnics and inter-ethnic	Mossi ethnic group, no particular	Mossi ethnic group, no particular	Mossi ethnic group, no particular	Mossi ethnic group, no particular conflicts

conflicts	conflicts	conflicts	conflicts	
Access *	75 min.	50 min.	115 min.	50 min.

* Access: The base is in Ouagadougou, time required from Ouagadougou to the provincial office

3.2 Selection of candidates villages and target villages

3.2.1 Selection of candidates villages

Here is explained the selection method presupposes the selection of a target village.

At this stage, activities are carried out jointly by the planner and the head of the provincial office. The planner tells the head of the provincial office candidate villages of the selection criteria of Table 3.2.1 and asks him to select five candidate villages in his province. The provincial head offers the planner 5 candidate villages meeting the selection criteria. By checking the selection elements of Table 3.2.1, the two select among these five villages, three candidate villages which better meet the selection criteria.

Case of this study

In the case of the province of Kourwéogo, during discussions with the director of the provincial office of MERH Boussé located, the 5 villages of Y, K, Gu, Go and Ga have been proposed. Table 3.2.2 gives the results of their judgment.

Table 3.2.1 Criteria for selecting candidate villages

Selection criteria	Description		Judgment
1. Social conditions	1-1	No quarrels in the village or with neighboring villages	Yes/No
	1-2	Existence of a key person in the village	Yes/No
	1-3	No "Food for work" or "Cash for work" project	Yes/No
2. Conditions relating to the production of	2-1	No connection to the national grid or connection plan	Yes/No
	2-2	Village of about 1,000 people (for effective monitoring)	Number of inhabitants

photovoltaic solar energy	2-3	Water sources are available or easily obtainable	Easy to get water or not
3. Conditions for Improved Stove	3-1	No ongoing Improved stove project	Yes/No
	3-2	The improved stove is not disseminated	Popular or not
	3-3	Inadequate firewood	Degree of insufficiency
4. Conditions relating to agroforestry	4-1	Agroforestry Experience	Yes/No
	4-2	Vegetation decreasing	Degree of reduction
	4-3	Advanced Soil Erosion	Degree of progress
	4-4	Existence of fallow land or old fields	Yes/No
5. Access	5-1	Less than 30 mn from Provincial Office	Required time

Table 3.2.2 Sample output judgment on the basis of selection criteria

Differences between the villages	Judgment against the conditions selection		Remarks
Common to the 5 villages	1-1	No quarrels in the village or neighboring villages	
	1-2	Existence of a key person in the village	
	1-3	No "Food for work" or "Cash for work" project	
	2-1	No connection to the national grid or connection plan	
	2-3	Water sources are available or easy to obtain	
	3-2	The improved stove is not disseminated	
	3-3	Inadequate firewood	
	4-1	Agroforestry Experience	
	4-4	Existence of fallow land or old fields	
Different only in the village Y	3-1	Improved stove project ongoing	No ongoing project in the other 4 villages
Different only in the village Go	4-2	Vegetation "decrease"	In the remaining 4 villages, there was "significant decrease in vegetation"
Different only in the village Go	4-3	Soil erosion "advanced"	In the remaining 4 villages, there was soil erosion "very

			advanced"

The study of the first three villages considered candidates based on the selection criteria using the Table 3.2.2 led to select the village K, the village of Gu and the village of Ga of the City of Boussé as candidate villages, given the fact that an improved stove project by an NGO is ongoing in the village of Y and the decrease of the vegetation and the progression of soil erosion are less advanced in the village of Go than in the others.

3.2.2 Selection of target villages

In collaboration with the provincial official, the planner performs an interview survey with key persons of candidate villages which serves as a basic document for the selection, to capture the will of participation in this study of the village, its capacity of the project implementation (organizations in the village and literacy level) and situation of the village (particularly requirements concerning activities in the village).

Key people, namely, the village chief, city council members, representatives from farm groups, representatives of groups of animals breeding, representatives of women's groups, youth groups representatives, representatives of religious groups, representatives of school group, representatives of health center management groups, etc. are the number of 30 to 40.

In this study, after explaining the outline of the study (objectives, etc.), the interview survey takes place by means of a questionnaire prepared. The interview lasts 1h30 to 2h. The topics of the survey are as follows.

- Constraints of the village (the 3-5 main)
- Types of organizations and content of activities
- Respondent willingness to collaborate in the Low Carbon Emission Project

- Water Resources (access to water resources, number of water resources (facilities))
- Landowners
- Literacy level (number of people who can write in Moore language, number of people who can read and write in French)
- Energy (electrification situation, fuel lamps)
- Improved Stove (use situation, fuel, etc.)
- Tree planting and agroforestry (AF) (existence whether or not, technical activities of seeding and plant growth)

In case of selecting a large number of villages, it is possible to simplify the survey by extracting the essential sections. Upon selection, the use of basic notation for the sections of the survey above has the advantage of ease of comparison, but the planner in charge of the investigation may give a global judgment.

Case of this study

Table 3.2.3 gives the result of the survey conducted in the 3 candidate villages; since it was comparing the three villages, scoring was not used, and only the selection according to the superiority was made after studying the different elements. The selection of detail is given below.

After analyzing the results of this survey, the village of Ga was excluded because of inaccessibility during the rainy season. And in comparison to the villages of K and Gu, there was no major difference in the present situation of three areas of activity, but the problems of "decline of vegetation and difficulties in obtaining firewood "and problems "in market gardening activities related to water resources" were found in the village of Gu and his vis-a-vis potential of the activities of this study was considered high because many associations, e.g. Tree Planting Association are active, which led to the selection of the village of Gu as a target village.

Table 3.2.3 Selection of the target area; Gu village Case

Name of the village	K Village	Gu Village	Ga Village
Accessibility	Access time 30 min., Distance 27 km Road branching off a main road (tarmac) in relatively good condition	Access time 20 min., Distance 9 km Accessible even under the rain during the rainy season	Access time 50 min., Distance 16 km Narrow road, many puddles in November even impossible access during the rainy season
Population, ethnic groups (registered population)	996 inhabitants., 6 districts, Mossi 100%	1061 inahabit., 6 districts, almost Mossi, some Fulani	1712 inhab., 7 districts, almost Mossi, some Fulani
Problems in the village	(1) Lack of materials and fertilizer for farming, and insufficient food (2) Too small health center cannot accommodate all the patients, lack of medicines (3) Lack of water during the dry season (4) No work for women during the dry season (5) Stagnation of adult literacy activities, there are rooms but no teachers	(1) Medical problems (many people with malaria, health infrastructure and inadequate health facilities) (2) No work during the dry season, market gardening is not possible during the dry season because there is no dam or water tank (3) The soil is dry because the vegetation has decreased, control of collecting firewood (4) No accommodation for teachers	(1) Lack of water (2) Poor access road to the urban area (3) No health center in the village. Poor condition of access roads to other villages' health center (4) Insufficient Knowledge and funds to increase agricultural productivity
Organizations	Existence of women's groups engaged in agriculture, agricultural groups	Many farm groups, youth groups, associations of water users, tree planting associations etc. in activity	Farm groups, breeding groups, associations of water users, etc. active
Collaboration with the study activities	Granted	Granted	Granted
Water resources	Easy access to water sources 9 boreholes, 5 wells (3 Broken)	Easy access to water sources 9 boreholes, 1 well	Easy access to water sources

			10 boreholes (1 broken), 4 wells
Land Ownership	Village chief is owner	Right of ownership to the state, authorization of the village chief required for the acquisition of new land	Village chief
Literacy	4 inhabitants in Moore, 10 inhabitants in French	1 inhabitant in Moore, 6 inhabitants in French	Many in Moore, none in French
Energies	No electricity, electrification no plan , unused oil lamp Dry cell lamp used	No electricity, electrification no plan , unused oil lamp Dry cell lamp used	No electricity, electrification no plan , unused oil lamp Dry cell lamp used
Improved stove	Traditional stove (3 stones stove) used Fuel: firewood, residues from millets	Traditional stove (3 stones stove) used Fuel: firewood, residues from millets	Traditional stove (3 stones stove) used Fuel: firewood, residues from millets
Tree planting / AF	Experienced groups and individuals Insufficient training on planting techniques and cultivation of plants	Experienced groups and individuals Several individuals with experience in seeding techniques and cultivation of seedlings, conducted project in the past	Experienced groups and individuals 2 farms with personal nurseries

3.3 Recognition of the current situation of the target village

Before the beginning of the Low Carbon Emission Project, activities must be defined in terms of different activities and talk with the inhabitants. At that time, the planner must understand the basic information on the situation in the village, and prepare a draft of each plan on this basis. The study conducted in this direction is called "the real situation of the reconnaissance survey of the target village."

The content of this study is divided into general elements and specific elements required to develop an action plan for each area, they must be classified according to the objectives in each area.

What to consider at this point is to try to simplify the study minimizing the necessary information collected. However, further study will be made every time we encounter new information for the advancement of Low Carbon Emission Project.

Please refer to the results of "the real situation of reconnaissance survey of the target village" conducted in the village of Gu in the Annexes.

3.4 Development of action plan

3.4.1 Process of Development

As desirable as the results of Low Carbon Emission Project activities are used sustainably and independently by the population, it was decided to define the activities to be performed in the target village through to preparation of the action plan using the Farmer Participatory methods. The development of an action plan proposed by the people who are the main actors, aimed at promoting their awareness of their own responsibility and to motivate participation in the action plan or the activities of the Low Carbon Emission Project itself.
The procedure for preparation of the action plan is as follows.

(1) Identification of problems
(2) Analysis of means and methods to solve the problems identified
(3) Development of a proposed action plan and activities screening
(4) Development of the action plan
Here, points (1) to (3) are made in a workshop bringing together the inhabitants, and the point (4) separately executed at the launch of each activity.

3.4.2 Identification of problems and study of problems counter-measures

The method for the identification of problems and the study of means and plans to solve these problems is as follows.

(1) Preparations

Photo 3.4.1 an inhabitant express themselves (Scene of the workshop)

- Facilitators assignment (people who attended PRA training are desirable)
- Meeting of representatives of the village (village chief, members of the Village Development Committee (CVD), women groups' leaders, etc.). (Gathering of participants from diverse backgrounds provides the most expanded opinion, but to summarize the opinion becomes more difficult if they are too many.)
- Preparation of sheet of papers and a table to display and gather the opinions of the inhabitants (Photo 3.4.1).

(2) Implementation

- Via the facilitator, questions are asked to the participants on the concrete content of the main problems of the village and their causes, and answers classified.
- Questions are posed to participants on means and plans to solve these problems, and classified responses.

Case of this study

Table 3.4.1 presents the problems identified through the workshop and the means and plans of resolving them.

Table 3.4.1 Problems identified and studied countermeasures

Main constraints	1. Medical care	2. Income generating activities	3. Decreasing vegetation	4. Educational infrastructure	5. Drinking water	6. Livestock management
Cause	1-1) lack of medical tool	2-1) inactive vegetable garden	3-1) overcutting of firewood	4-1) no accommodation facility for teacher	5-1) lack of well for drinking water	6-1) lack of material for rearing
	1-2) high incidence of malaria	2-2) lack of water in dry season	3-2) small rain	4-2) no junior high school	5-2) no technic of maintenance and repair of well	6-2) lack of follow-up by veterinarian
Counter measure / Solution	1-1) pharmacy, medical tool	2-1) procurement of vegetable seed and material of vegetable garden,	3-1) tree planting, production of seedling, using of Improved Cook Stove	4-1) construction of accommodation facility	5-1) construction of deep well	6-1) install fence for rearing
	1-2) medicine to prevent malaria, mosquito net, improvement of public health	2-2) construction of dam and reservoir, (securement of water)	3-2) no solution	4-2) construction of junior high school	5-2) training for local engineer	6-2) training for local veterinarian

3.4.3 Development of the proposed action plan and activities screening

The scope of treatable area by the project is limited and the planner or the office manager must select areas objects of the project. And the proposed action plan in the selected fields will be developed by the inhabitants. The procedure for this is as follows.

(1) It is necessary to explain the area and treatable problems by the project to the inhabitants and get their agreement.

(2) The planner or the office manager must explain the method of preparation of the action plan proposal for the area and treatable problems by the project to the inhabitants.

(3) The planner or the office manager must select the specific activities treatable by the project on the basis of the action plan proposal prepared by the inhabitants and define these activities as activities of the project targets.

(4) The concrete action plan for each activity will be set after final adjustments by the implementing organization of the project with the inhabitants.

What is important here is that the planner or the office manager must explain to the inhabitants and get their agreement at the time of the definition of activities as project activities. In addition, many people often have the misconception that the project will solve all identified problems, or to undertake all the actions proposed in the draft action plan. Therefore, when explaining the development of the draft action plan at the time of the holding of the workshop, the planner or the office manager must explain to the inhabitants at any time that the treatable areas by the project are limited, and that even if the areas are not limited, there are limits to the number, scope and area, etc. because the activities must be carried out on the possible extent of inputs such as funds and personnel.

If treatable areas by the project are limited and the content and duration applicable to the activities are limited, the planner or the office manager must organize the workshop and develop the proposed action plan, or reduce the number of processes, for example by deleting some of the processes, after giving them sample explanations about it. But the will to participate in developing the action plan of the inhabitants crumbling with the reduction effort provided for these processes, motivation and ownership of the action plan and project activities themselves by people who are the objective pursued, tend to become difficult. The planner or the

office manager should also consider these points keeping an eye on the processes of the entire the project.

Case of this study

The "income generating activities" and "decrease in vegetation" are treatable in this study among the main problems indicated in Table 3.4.1, and content of the following activities has been defined.

Table 3.4.2 Problems faced and content of defined activities

Problems to face	Content of activities
Lack of water during the dry season	Small-scale irrigation introduction utilizing solar energy (vegetable growing for markets in dry season → professional security during the dry season, revitalization of horticultural activities)
Non-dynamic market gardening	
Insufficient income generating activities	Introduction of trees planting, fruit trees including, agroforestry (fruit and firewood, etc. → income in cash, control the decrease of vegetation)
Decrease of vegetation due to excessive cutting to obtain firewood	Introduction of improved cook stoves (reduced fuelwood consumption (limiting the decrease in vegetation))
Vulnerability of the school infrastructure (lack of electric lamps)	Introduction of solar lights

When defining the content of activities, an opportunity to explain to the village chief and members of CVD was intended to explain that only selected activities will be carried out in the project, the content of these activities and that some support for funds, materials and labor will be required for participants to obtain their understanding.

After these courses, the different activities started to implement.

3.5 The actions undertaken (content of defined activities and general concept)

Case of this study

Vegetation decrease may be mentioned as one of the problems faced in rural areas of Burkina Faso. To solve this problem, it was planned to introduce improved cook stoves to reduce firewood consumption, plant trees and perform agroforestry to cover vegetation and use solar energy for supplying water to the plant, etc. A co-benefit approach was also used in this study for both the fight against climate change and rural development. The figure below shows the concept of the study.

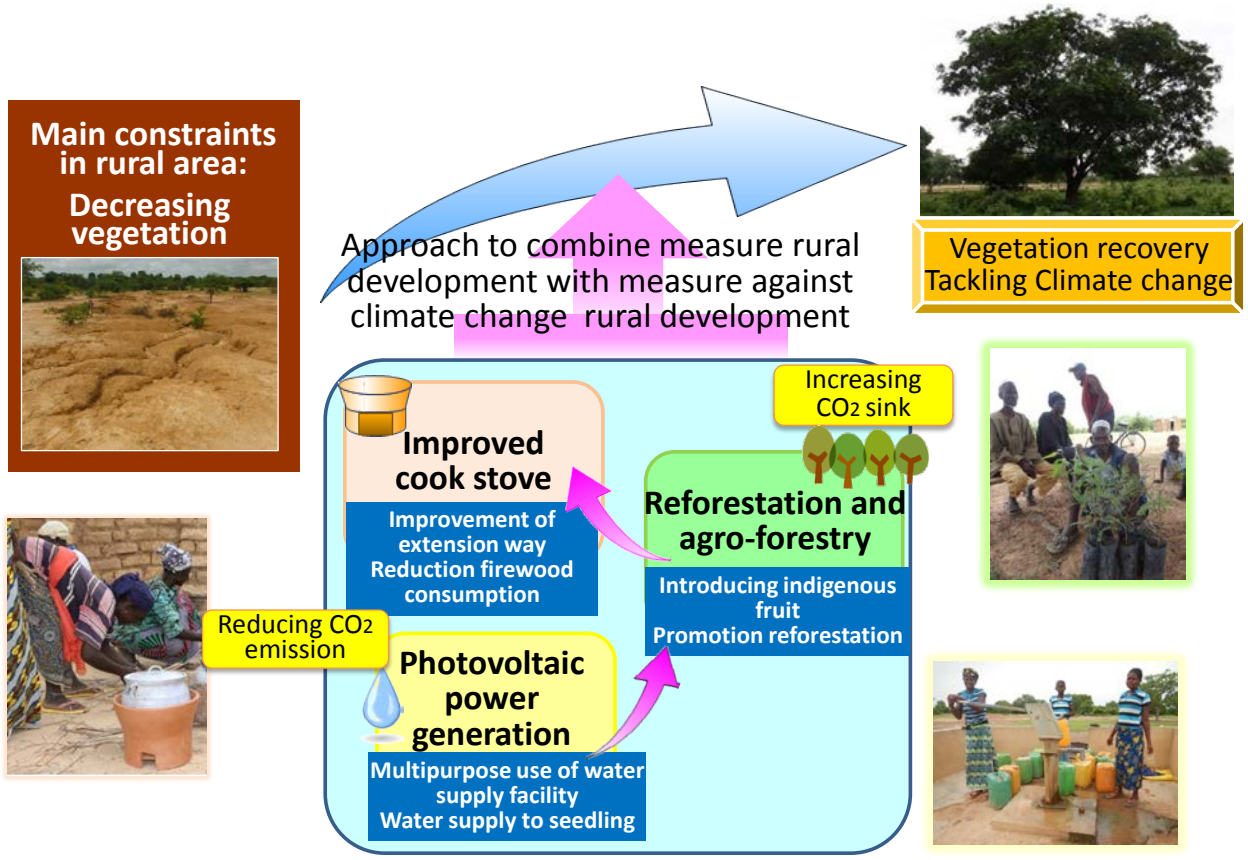


Figure 3.5.1 Conceptual diagram of the present study

3.6 Using the Document

Regarding the three past activities screened as indicated above, is summarized in Table 3.6.1 their relationship with the measures recommended in the draft NAP. Measures which are deemed to have a close relationship are marked by "○" and those having a relationship to some extent by "Δ".

Table 3.6.1 Recommended Actions and Relations with the Low Carbon Emission Project

Long-term objectives	Recommended Actions	Content of the Low Carbon Emission Project activities	The report level
Agriculture	Practices of efficient use of irrigation water technology	Small-scale irrigation using photovoltaic power generation	○
	Use of water conservation techniques and soil (agroforestry)	Reforestation and agroforestry	Δ
Forests	Practicing good forest management and agroforestry	Reforestation and agroforestry	○
	Local participatory forest management	Reforestation and agroforestry	Δ
	Increase the efficient use of non-permanent forest products	Reforestation and agroforestry	○
	Agroforestry practice to seamlessly manage natural resources	Reforestation and agroforestry	○
Energy	Enhancing the effectiveness of energy	Improved cook stoves, Small-scale irrigation using photovoltaic power generation	Δ
	Diversification of energy sources (solar PV)	Small-scale irrigation using photovoltaic power generation	○
	Promoting the use of improved	Improved cook stove	○

	cook stove to greatly reduce the consumption of firewood and charcoal		
Water resources conservation and improvement of access to drinking water and sanitation	More efficient use of water resources	Small-scale irrigation using photovoltaic power generation	○

For measures deemed to have some relationship with the project, methodologies and effect of their main activities or part of activities have already been verified during the study and quantitative evaluation method of reducing GHG has been implemented. Thus, use/effective application of the methodology of JIRCAS the main activities or part of activities could be proposed as a means to make a NAP project. It is recommended to use this Document because the orientation and/or the methodology for the implementation of projects which are the subject are classified broadly and consistently.

Chapter 4 Implementation – Improved Cook Stove–

4.1 Context and Goal

4.1.1 Current Situation of firewood in Burkina Faso

Human and animal pressures increase the phenomenon of desertification through the overexploitation of vegetal resources. Bush fires, excessive cutting of firewood, and clearing of vegetation for agricultural use reduce vegetal resources. Thus, about 105,000 ha of forest disappear each year (MEE, 2002). From 1980 to 2000, the forest in Burkina Faso decreased from 15.42 million hectares to 11.29 million hectares (FAO, 2000).

Concerning the use of firewood that causes forest degradation, over 90% of the energy need is covered by traditional fuels, essentially firewood and charcoal. The firewood is the main source of energy for cooking and the household sector is the largest consumer; accounting for some three million tons per year, or 98.00% of the primary energy demand by the households and 89% of the final energy demand. Thus, the firewood issue is one of the barriers to energy policy.

In the villages, 99.1% of households use firewood as a source of energy. Therefore, the problem related to firewood is more serious in the villages than in urban areas.

4.1.2 Co-Beneficiary measures against Climate Change

Burkina Faso is facing natural, social, and economic problems such as drought, poverty and population growth. Forest degradation is one of the largest problems in Burkina Faso. Thus, the conservation of forests and vegetation is one of the most important national goals for development.

Burkina Faso is also currently exposed to the influence of climate change such as the frequent occurrence of droughts and floods. It is assumed that these effects are likely to become more serious in the future. Thus, forest conservation is also a big problem of the adaptation component to climate change.

Therefore, forest conservation has two characteristics: the objective of social and economic development, and the objective of adaptation to climate change. Therefore it is the most appropriate measure for the co-beneficiary approach against climate change, which produces both two profits, being the national development and the adaptation to climate change.

According to the IPCC fourth assessment report on climate change, "A typical example of the synergistic effect between sustainable development and reducing the emission of greenhouse gases is the replacement of traditional cook stoves with more efficient thermal cook stoves. It is possible not only to reduce the emission of greenhouse gases, but also to relieve women and children from the firewood collection task. This will reduce the demand for natural resources." It means that the introduction of Improved Cook Stoves (hereinafter referred to as FA) in Burkina Faso is one of the most appropriate action that brings a profit against climate change, and one of the measures to achieve the goal of development with the prevention of forest degradation. So it is an efficient measure for the economic and social problems and climate change in Burkina Faso.

4.1.3 Objective

FA dissemination projects were held in Burkina Faso and there is hope for its development. To support these activities, the objective in this document is as follows.

- The development of the method of evaluating quantitative effect on reducing the emission of greenhouse gases by the FA project
- Presentation of an example of the method of dissemination of FA in rural areas through the results of the experimental verification of introducing FA in one village.

As for the method of assessing the impact of the emission of greenhouse gasses, CDM methodology is used worldwide in the context of climate change of IPCC for effective evaluation.

4.2 Study Organization Chart

4.2.1 Plan of the Study Organization Chart

The plan of the study organization chart is laid out on the following diagram "4.2.1".

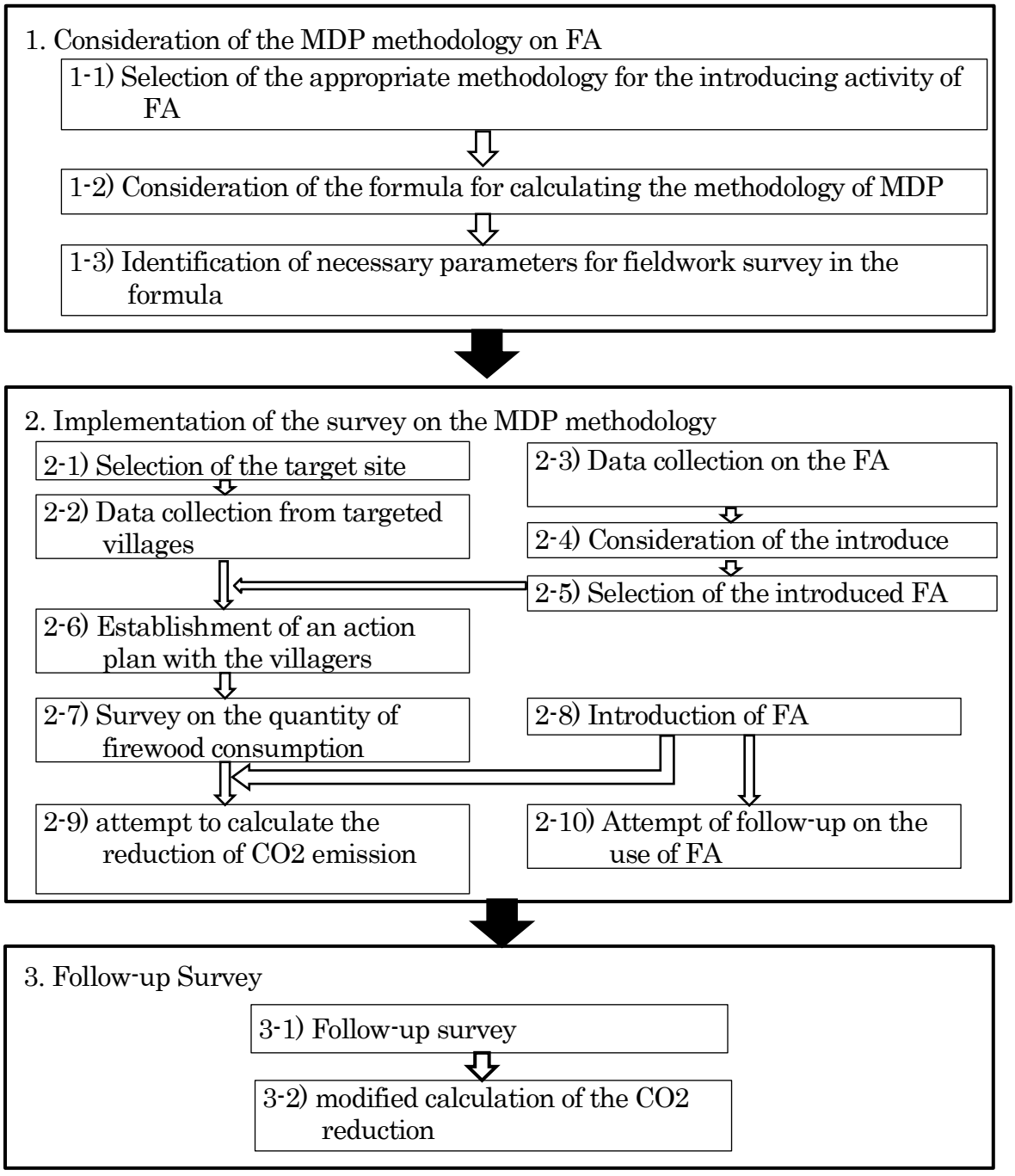


Figure 4.2.1 Plan of the Study Organization Chart

The plan of the study organization plan has three levels as follow:

- Consideration of the CDM methodology on FA
- The survey on the CDM methodology
- Survey follow-up

4.2.2 Consideration of the CDM Methodology on the FA

We chose an appropriate methodology to the activity of introducing FA in the CDM methodologies to calculate the amount of the reduction of CO2 emissions in order to get the factors needed to calculate according the understanding of the methodology. Thereafter we define the factors that require the field survey on the basis of the result of the previous process.

CDM methodologies consist of two types of projects: large-scale projects and small-scale project. The latter is chosen in this document, given the current situation in developing countries.

Yet, the conditions for the application of each methodology are identified and it is necessary to check them. This point is mentioned separately in the section "4.3 Method of calculating the reduction of the CO_2 emission."

4.2.3 Implementation of the Survey on the CDM Methodology

This second section consists of five steps: the precision of the target area, the determination of introduced FA, the survey in the amount of firewood consumption, the implementation of introducing FA, and the calculation of the reduction of CO_2 emissions based on the previous four steps. However, the activities of "2-1) Selection of the target area" and "2-2) Data collection from targeted villages" are omitted in this chapter because they are mentioned separately due to the fact that the survey is included in three areas of activities.

4.2.4 Follow-up Survey

The third level includes the follow-up survey to record the number of FA used and the usage condition of the introduced FA and to modify the calculation of the reduction of CO2 emissions.

4.3 Method of Calculating the Reduction of the CO2 Emission

4.3.1 Selection of the Calculation Formula of the CDM Methodology

The formula of CDM methodology is determined by UNFCCC (United Nations Framework Convention on Climate Change) depending on the activities. One can search the methodology of small-scale CDM from the home page of the UNFCCC CDM-Methodology (http://cdm.unfccc.int/methodologies/index.html). We selected "AMS-II.G Measures.: Energy efficiency in thermal applications of non-renewable biomass --- Version 6.0" as the most appropriate methodology for the activity of introducing FA. The methodology must be confirmed by the above website because the methodology will be revised or replace with a new methodology, one after the other. And it is better to use the latest methodology. The above formula of calculation is the version of March 2015.

4.3.2 The Methodology of AMS-II.G.

This methodology has five chapters: "Introduction", "field, applicability and validity admission", "definition", "basic methodology" and "monitoring". An overview of each chapter is given below. In addition, details of each preview are exposed as reference in Appendix "4.3.1 Methodology" section of this document.

(1) Introduction (Chapter1)
The types of instrument that is applicable to the methodology are included in this chapter and are the stove which fuel is non-renewable biomass, the oven, and the dryer.

(2) Field, applicability and validity admission (Chapter 2)
2-1) Field
Thermal efficiency is defined for the applicable stove and it is necessary to be more than 20% because it was mentioned in this article; as the effectiveness of project stoves must be based on the certification by a national organization Standards, we adopt the measured value by the Research Institute of Applied Sciences and Technologies (IRSAT) in Burkina Faso.

2-2) Applicability
It is defined as the amount of total energy reduction per single project activities which must not exceed the equivalent of 60GWh per year. It means a maximum level of the size of a proposed small-scale CDM. When measured under the following conditions;

i. Maximum level of the reduction of energy = 60GWh
ii. Quantity of firewood consumption per year per person = 400 kg
iii. Average number of people per family = 8 people
iv. Improvement of the thermal efficiency of stove; 10% → 20%
v. Number of households introducing an FA per household = N
vi. Confer "Table 4.3.1" for the calculation formula

$B_{y,savings} = 0.4 * 8 * (1/4) * (0.1/0.2)$

$= 0.4$ t per year and per household

$60 \text{ GWh} > B_{y,savings} * N * f * NCV$

$f = 0.9$, $NCV = 0.015 * 10^{12}$ J

$60 * 10^{9} * 3.6 * 10^{3} \text{ J} > 0.4 * N * 0.9 * 0.015 * 10^{12} \text{ J}$

$N < 40{,}000$ households

As a result of calculation, the maximum value is 40.000 households to obtain credit from the CDM. The purpose of this document is not the acquisition of CDM credit, but the development of the formula for calculating the CDM methodology as described in the article by "4.3.2". If we take into account the effectiveness and convenience project in developing countries, it is not as important to consider the progress of the dissemination as a condition and it is possible to apply the formula to calculate the small-scale methodology in this document regardless of the condition of the limit of the amount of the total CO2 reduction per project. But if we respect the harshness of the application of the formula of the CDM methodology, the area will be divided into two to take the upper limit of number of FA introduced by the project.

(3) Definition (Chapter 3)
The terms in the CDM methodology are defined.

(4) Methodology Database (Chapter 4)

4-1) Project Limit

This paragraph is for the limits of the project area. The detail is described in the sections "3.1 Selection of target areas" and "3.2 Selection of villages and determination of target villages."

4-2) Formula for determining the reduction of gas emission

This article describes the formulas for calculating the amount of the reduction of the CO2 emission. A formula for the domestic stove is selected and is presented in Table 4.3.1.

The *ERy* parameter is the quantity (unit; ton) of CO2 emission reduction by the FA introduced by the project within a year *y*. *y* means the number of years from the project start and *i* means the FA type.

Table 4.3.1 Calculation Formula of the amount of reduction of emission for the application and the introduction of FA

$$ERy_{,i} = \sum B_{y,savings,i,a} \times N_{y,i,a} \times (\mu_{y,i} \div 365) \times f\,NRB,y \times NCV\,biomass \times EF\,projected\_fossilfuel - LE_y \quad \cdots\cdot \text{(a)}$$

$ERy_{,i}$: Amount of the reduction of CO2 emissions in a year *y* by the type *i* FAs that are introduced by the project (unit; ton)

$\sum By,savings,i,a$: Amount of the reduction of woody biomass by a FA type *i* in year *y* (unit; ton)

$f_{NRB,y}$: Fraction of woody biomass saved by the project activity in year *y* that can be established as non-renewable biomass using survey methods, government data or by default the values of the non- renewable specific portion of woody biomass for each country

NCV biomass : Net value of calorie substituted with the non-renewable woody biomass

$EF_{projected\_ossilfuel}$: Emission factor of fossil fuels which are intended to be used as the substitution of woody biomass and non-renewable by similar consumers

$N_{y,i,a}$: Number of type *i* FA, the age and year *y* from the beginning of the project (the number must be verified by follow-up survey)

$\mu_{y,i}$: Average number of duration days of type *i* FA and year *y* used

LE_y : Amount of the leakage emission in year *y*

$\sum B\ y,savings,i,a$ means the amount of reduction of the consumption of woody biomass, which is practically the firewood, by a type *i* FA in the year *y* from the

beginning of the project. If explained in a table, it must be as in "4.3.2". The factor *a* is the number of years duration of the FA usage and which means that FAs of each *ax* year are used and the value of *B savings* is the total depending on factors *y, a, i*.

Table 4.3.2 Concept of $\sum B_{y,savings,i,a}$

Type of ICS		Type of *i*					
Beginning year (y) of the project		*y 1*	*y 2*	*y 3*	*y 4*	*y 5*	*y 6*
Usage duration (a:year)	introduction year: *y*=1	1	2	3	4	5	6
		a_1	a_2	a_3	a_4	a_5	a_6
	introduction year: *y*=2		1	2	3	4	5
			a_1	a_2	a_3	a_4	a_5
	Introduction year: *y*=3			1	2	3	4
				a_1	a_2	a_3	a_4
$B_{y,savings,i,a}$		By_1,i,a_1	$By_2,i,a_{(1+2)}$	$By_3,i,a_{(1\sim3)}$	$By_4,i,a_{(2\sim4)}$	$By_5,i,a_{(3\sim5)}$	$By_6,i,a_{(4\sim6)}$

The other factors are such as the explanation of Table 4.3.1.

4-3) Understanding the variables of the formula (a)

4-3-1) $\sum B_{y,savings,i,a}$

The equation 5 of option 2 in paragraph 17 of the methodology is adopted.

$$B_{y,savings,i,a} = B_{old,i} \times (1 - \eta_{old} / (\eta_{new,i,a=1} \times \Delta\eta_{y,i,a})) \quad \cdots\cdots \text{(b)}$$

$B_{old,i}$: Amount of the annual average consumption of woody biomass by a traditional stove that is used before an FA is introduced (Unit; ton / year) It can come from historical data of the usage by a survey of the sample.

η_{old}: Value of the thermal efficiency of a traditional stove. The paragraph 17 explains on η_{old} as follow, "A default value of 0.10 can optionally be used if the unit used before the project is the type of three stones stove which fuel is firewood." Therefore, after confirming that the three stones stove is largely used and that the fuels are firewood according to the field survey, the default value of 0.1 can be adopted in this document.

$\eta_{new,i,a=1}$: Initial value of the thermal efficiency of introduced FA type *i*

$\Delta\eta_{y,i,a}$: Factor of the value of thermal efficiency of type *i* FA in year *y* against the initial value to account for the loss by the number of years.

$$\Delta\eta_{y,i,a} = \eta_{new,i,a} / \eta_{new,i,a=1} \quad \cdots\cdot(c)$$

The formula "$\eta_{new,i,a=1} \times \Delta\eta_{y,i,a}$" which is a part of the equation (b) is known as follow.

$$\eta_{new,i,a=1} \times \Delta\eta_{y,i,a} = \eta_{new,i,a=1} \times \eta_{new,i,a} / \eta_{new,i,a=1}$$

$$= \eta_{new,i,a}$$

As a result,

$$B_{y,savings,i,a} = B_{old,i} \times (1 - \eta_{old} / \eta_{new,i,a}) \cdots\cdot(e)$$

= (Amount of the average annual firewood consumption by a traditional fireplace that is used before a type *i* FA is introduced) x (1- (Value of the thermal efficiency of traditional stove) / (Value of FA thermal efficiency in year *a*))

4-3-2) $N_{y,i,a}$ et $\mu_{y,i}$

$N_{y,i,a}$, ; number of FA usage and $\mu_{y,i}$, ;average number of days of the FA usage, verified during the first recording of FA. It is entered through the follow-up survey.

4-3-3) $f_{NRB,y}$

$f_{NRB,y}$, is as follow according to paragraph 28 on condition demonstrated in paragraphs 26 and 27.

$$f_{NRB,y} = \text{NRB} / (\text{DRB} + \text{NRB}) \cdots\cdots\cdot (f)$$

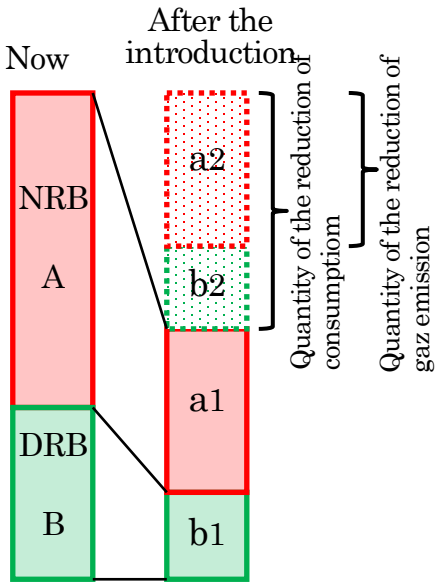
DRB; Amount of renewable and demonstrative woody biomass

NRB; Amount of non-renewable woody biomass

The woody biomass consumed has a quantity of the annual growth of the tree which is the renewable portion and an amount of non-renewable woody biomass which is taken and burned for the overload of the demand against the amount of growth.

As the figure 4.3.1 shows, the non-renewable part in the amount of the reduction of firewood consumption is only a purpose of calculating the amount of the reduction of

the emission of gases. Therefore, it is necessary that the coefficient of $f_{NRB,y}$ be multiplied in the calculation formula of the methodology.



DRB: Amount of renewable and demonstrative woody biomass

NRB: Amount of non-renewable woody biomass

A+B=B_{OLD}: Quantity of the current consumption

a2+b2=$B_{y,saving}$: Amount of reduced firewood consumption

A1 : Amount of non-renewable woody biomass after the introduction

B1 : Amount of consumption of renewable woody biomass after the introduction

A2 : Amount of the reduced consumption of non-renewable woody biomass after the introduction

B2 : Amount of reduced consumption of renewable woody biomass after the

Figure 4.3.1 Scheme of the conception of $f_{NRB,y}$

The default value of $f_{NRB,y}$ of Burkina Faso was approved in the document in Annex 22 by the CDM Board of Directors in March 2013. It is 0.9.

4-3-4) *NCV biomass*

Paragraph 13 of the methodology determines the IPCC default value of *NCV biomass* which is 0,015 TJ / ton.

4-3-5) *EF projected_ossilfuel*

Paragraph 13 of the methodology determines the IPCC default value on *EF projected_ossilfuel* which is 81,6 tCO_2 / TJ.

4-3-6) LE_y

It is possible to multiply the gross value by the adjustment factor of 0.95 to have the net value excluding the leakage according to paragraph 30 of the methodology. Thus, the default factor of 0.95 is adopted.

4-4) Summary of the coefficients

Coefficient	Content
$B_{old,i}$	After the decision for the FA type, the value of $B_{old,i}$ is sought by the field survey on three stones stoves corresponding to FA type introduced
$\eta_{new,i,a}$	After the FA type of decision, the FA thermal efficiency is measured for each type of FA. IRSAT can take the test. Regarding the test method, "the test Methodology Sahelian improved cook stoves" of the method of WBT recommended by the CILSS, is adopted.
η_{old}	η_{old} is 0,1 is the default value of paragraph 17 using a three stones stove with firewood as fuel
$f_{NRB,y}$	$f_{NRB,y}$ = 0,9 which is the default value of IPCC
$N_{y,i,a}$	L'enquête sur le terrain est pratiquée lors de l'introduction de FA et le suivi
$\mu_{y,i}$	The field survey is practiced during the introduction of the FA and the follow-up
$NCV_{biomass}$	$NCV_{biomass}$ is 0,015 TJ/ton is the default value of IPCC in paragraph 13
$EF_{projected\ fossilfuel}$	$EF_{projected\_fossilfuel}$ is 81.6 tCO2 / TJ is the default value of IPCC in paragraph 13
LE_y	LE_y is 5%. It's the default value of IPCC in paragraph 30

4.4 Selection of target areas and collection of information on the current situation in the target villages

4.4.1 Selection of target area

You must refer to "3.1 Selection of target areas" and "3.2 Selection of villages and determination of the target villages for this article.

4.4.2 Collection of information on the current situation in the target villages

The process of identification of the preconditions for the application of the formula of the methodology is called scenario of the base of the methodology. We must apply the formula after confirming compliance prerequisites of the base scenario with them

under "4.3 Method of assessing the amount of the reduction of CO_2 emissions." The base scenario is checked according to the following survey.

It is better to entrust the survey to the CVD of the village because he knows the villagers enough and may ask the district representatives to do the survey. Thus, the project must prepare a questionnaire following.

- Process: The unit of the survey is a village.
  This is the survey of all households.
  The summary of the survey is done by district.

- Content: Number of people of a family, last name and first name of the head of the family., number of stoves by type, name of principal fuel

A sample questionnaire and questionnaires summary are shown below.

Table 4.4.1 Example of survey questionnaire and questionnaire recapitulation

Questionnaire on the actual cook stove by the scenario on the basis of the methodology

Interviewer: _____ Date of survey:
Name of the village
Last and first name of the head of household:
Number of persons in the family:

	Type	Result	Note	
Cook Stove	Three stones	(piece)		Select a type of primarily used fireplace (✓)
	Clay FA	(piece)		
	Metal FA	(piece)		
	other	(piece)		
Fuel			① firewood ②charcoal, ③petrol, ④propane	

Base questionnaire Summary

Village Name:

Name of quarter	Family number	Cook Stove								Fuel			
		Three stones		Clay FA		Metal FA		Other		①	②	③	④
		Number of pieces	✓	Number of pieces	✓	Number of pieces	✓	Number of pieces	✓				

* Select a type of primarily used cook stove

4.5 Selection of the Introduced FA

4.5.1 Chart of the Introduced FA Selection

The manager in charge of the project plan selects the FA introduced by the project according to the chart of Figure 4.5.1. However, eventually introducing an FA type must be coordinated with the demands of the villagers, explaining the reasons for the selection to avoid problems.

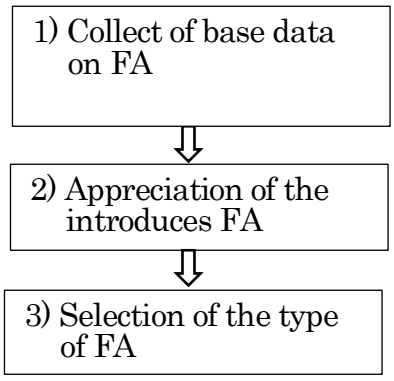


Figure 4.5.1
Organization chart for the selection of the FA

4.5.2 Collect of baseline data on FA

This article is based on the results of "Study on the Establishment of methodologies for low-carbon rural development through the efficient use of local resources (hereinafter referred to as MECADE)". However, additional survey will be made in case a difference in comparison with that of MECADE.

Case of the current study: baseline survey on FA

MECADE results are mentioned below.

(1) FA dissemination history in Burkina Faso

The importance of conservation of natural vegetation has brought a lot of awareness with the appearance of problems of desertification in the 1970s. Since the 1980s the dissemination of FA has begun, considered as an action against desertification and a measure for reforestation as well.

Since the 2000s, CILSS (Permanent Inter-State Committee to Fight against Drought in the Sahel), governmental organizations and aid agencies have become facilitators of FA and also promoted training manufacturers and merchants to disseminate FA, primarily in urban environment. Today, the FAFASO, public organizations, and NGOs engaged in the FA dissemination activities. The clay FA was introduced mainly in rural areas in order to facilitate the preparation of materials and reduction of manufacturing costs. The metal FA is basically popularized in urban areas.

(2) Collection of basic data on FA

The types of FA that are sold or used are metal, ceramic and clay. The baseline survey on the FA was performed and the data is used as information to select the type of FA to introduce. The survey points are as follow.

i. General: Name FA, Fuel, manufacturing materials, model, method of manufacture, lifetime expectation
ii. Efficiency: Thermal efficiency, Proportion of the amount of reduction consumption of firewood to three stones stove
iii. Dissemination: dissemination area, dissemination start, price of the seller, dissemination system

Targeted FAs in the survey are those that are able to be obtained in the project area or around the project area and which quality as the stability of the thermal efficiency is ensured.

FA information can be provided by the Department of Renewable Energies and Domestic Energy (DERED) from the Ministry of Mines and Energy, the Forestry Direction (Difor) of the Ministry of Environment and Sustainable Development, Research Institute in Applied Sciences and Technologies (IRSAT) of the Ministry of Scientific Research and Innovation, and FAFASO. DERED and Difor are in charge of the FA dissemination as a governmental organization, and IRSAT handles the operation, improvement and test of the FA. FAFASO is a project of GIZ for the FA dissemination in collaboration with government structures.

(3) Dissemination Situation of clay FA

The clay FA was mainly disseminated in rural areas since the 1980s. The project used in this document targets the rural area which is an important area for the FA. Thus, this type of FA may become an important option of introduced FA. Yet, it was impossible to assess because the information on the results of the dissemination of the clay FA were not found. In addition, they say the dissemination of clay FA is difficult for some people in charge of the FA activities. Therefore, a survey into the current situation of the use of clay FA was made in three villages where the clay FA projects were realized.

The result of the survey has shown that only two women continued to use the clay FA among the 29 women who participated in the project activities. Thus, it has been evaluated that the dissemination of clay FA was difficult.

(4) Result of the collection of baseline data on FA

Table 4.5.1 Result of the collection of baseline data on FA[1,2]

	Number	1	2	3	4	5
	Name of FA	Ceramic cook stove	The burkina mixte	The multi pot	The ouaga metallic	Three Stones
Général	Fuel	Firewood	Firewood and coal	Firewood and coal	Firewood	Firewood
	Model	suze: №2～ 3	size: №2～ 6	size: №3, 6, 10, 15, 20 et 30 Each model fit several size pots	size: №2 ～ 30	TS fit all size pots
	Material	Ceramic cook stove	Steel (new or used)	Steel (new or used)	Steel (new or used)	Stone
	Technic of production	ceramist, pot kiln	steel metal worker	steel metal worker	steel metal worker	production by user
	Period of durability	3 years	2,5 years on the average	2,5 years on the average	2,5 years on the average	longtime
Efficiency	Percentage of the thermal efficiency	N°2 : 20% ± 4% N°3: 26% ± 3% ND	N°2 : 24% ± 3% N°3: 23% ± 1% N°4: 23% ± 1%	N°2 : 19% ± 2% N°3: 18% ± 4% N°4 : 22% ± 1%	N°2 : 25 % ± 2 N°3 : 23% ± 4% N°4 : 24% ±3%	ND ND N°4 : 13.2% ± 0.8%
	Percentage of the firewood consume reduction volume (Laboratory)	ND	Contolled Cooking N°2 : -25%	Contolled Cooking N°2 : -20%	Contolled Cooking N°2 : -42%	–
		ND	water boil N°4 : -51%	water boil N°4 : -44%	water boil N°4 : -44%	–
Diffusion	Area of the diffusion and the diffusion start time	1982	All over the country, 1985	All over the country, 1986	All over the country, 1984	–
	Price of market (FCFA)	from 750 FCFA	N°2 : 2.000 N°3 : 2.500 N°4 3.000	N°3 : 3.000 N°6 : 6.000	N°2 : 1.500 N°3 : 2.000 N°4 : 2.500	–
	System of diffusion	Salers and steel metal workers	Salers and steel metal workers	Salers and steel metal workers	Salers and steel metal workers	–
Remarque						

Table 4.5.1 indicates the result of the collection of baseline data on FA. There are still some types of FA sold on the market except FAs mentioned in Table 4.5.1. However because the quality of these types of FA are not stable and bad, we do not adopt them in this document at this time.

[1] Original text: Dr. SANOGO (IRSAT)

[2] Photos from the technical files of improved cook stoves ‹Roundé›

4.5.3 Appreciation of the introduced FA

A variety of FAs is selected in order to choose the most appropriate FA to introduce based on the collected data. Criteria are established for the selection. The criteria of selection are the following.

i. The type of most popularized FA in Burkina Faso
ii. The type of FA which has good quality stability
iii. The most popular FA type used by urban women

Case of the present study: Selection of introduced FA candidates

We have one example of selection method of the introduced FA

Four types, including three metal types and one ceramic type, FA that FAFASO presents are on the list in Table 4.5.1, because they have a positive result for dissemination. FAFASO provides ensuring quality through the training of manufacturers in the criteria prospects i and ii. And two additional types of FA, in ceramic and Multi pot metal, are chosen based on criterion iii.

4.5.4 Selection of Introduced FA Type

The criteria are set to finally select the introduced FA from the list. The criteria of selection of candidates are the following.

iv. FA: most used for everyday cooking
v. FA: with the higher thermal efficiency, and more than 20%
vi. FA: the most affordable

It is recommended that the project planner seek advice on the outcome of the selection of the introduced FA to the following people.

- The people in charge of FA activities in the institutions of INERA, MEDD, FAFASO etc.
- People who have much knowledge of FA

The final decision will be taken at the end of the process.

Case of the present study: Selection of introduced FA

We show an example of the introduced FA selection.

Regarding the criterion v, the methodology of CDM requires from the project FA the value of the thermal efficiency to be over 20%. We respect this regulation this

time. But in case the project is being implemented, the criterion v can be removed according to local circumstances.

Table 4.5.2 is an example of the result of the introduced FA selection, and this is the result for the type No. 3 ceramic FA.

Table4.5.2 Example of the result of the introduced FA selection

Criteria of selection	Ceramic Stove		Multi pot	
iv type	No3	No5	No3	No. 4
v T.E.	26% ± 3%	ND	18% ± 4%	22% ± 1%
vi affordable	1,000	1,750	3,000	3,000

* The type matches the size of the pot
Original text on T.E. (thermal efficiency) is IRSAT
Price at the manufacturer level is in(CFAF)

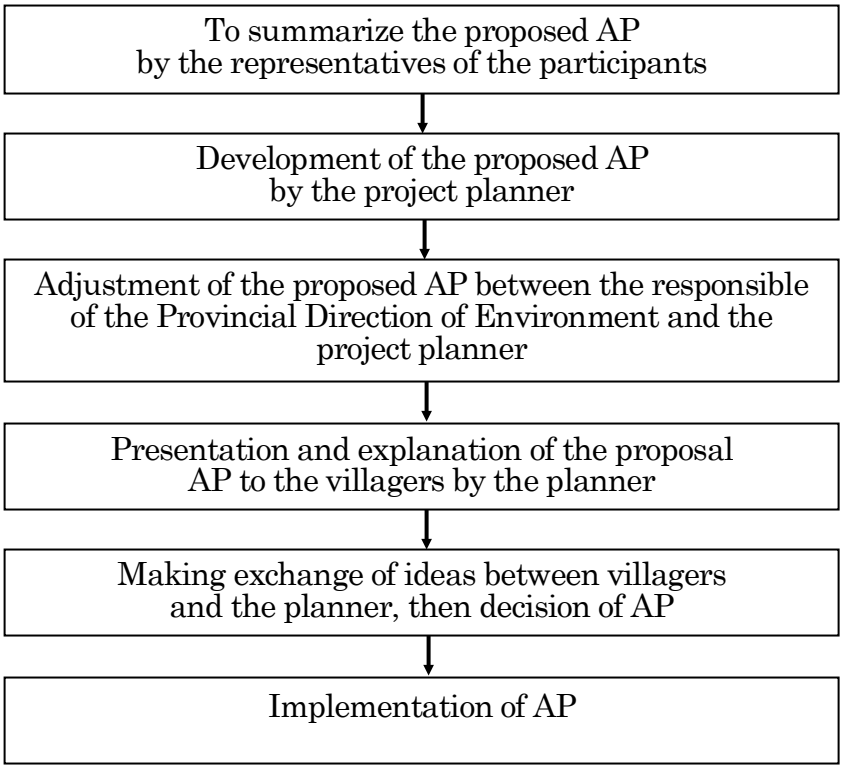
The explanation on the outcome of the FA selection came from FAFASO, INERA and the provincial direction of environment and sustainable development of Kourwéogo (DPEDD/KWG) and the agreement on FA selected have been confirmed between them.

4.6 Development of an Action Plan (AP) with the villagers

The concrete action plan is developed after confirmation of the agreement of the FA activity in Section 3.4 "Analysis of the problems identified, examination of methods and solutions, and selection of main problems"

4.6.1 Method of the development of an Action Plan

The proposed AP of the villagers is to summarize according to the opinion of the participants to the activity with the support of the planner. The planners develop the AP proposal based on the proposal of the villagers by the exchange of ideas with the responsible of the Provincial Direction of Environment, and he presents and explains it to the villagers, especially to the representatives and participants of the village. At the end the AP is developed with their agreements.



Fifure4.6.1 Flowchart for the development of AP in a participatory way of the villagers

4.6.2 AP Elements

Elements of the AP include "participant", "Activity objective", "Activity content", "activity schedule" and "participant subscription".

Table 4.6.1 is an example of the proposed AP of the participants.

Table 4.6.1 Example of registration of the AP proposal of the participants of the FA activity

Element	Content
Participant	Development of a table where the number of participants in each neighborhood is registered names database of those who wish to participate
Activity Objective	Inscription of few goals that the participants aim as expected results based on the verified opinion from"3.4 Review of the methods of these solutions and selection of main problems".
Activity Details	Registration on the type and size that the FA that the participants wish to introduce.
Activity Schedule	Registration of activity time

Participant subscription	Register for the proposal of contributions by the participants

The planner develops a proposal of AP that the project will propose to the participants based on the AP written on FA activity by participants. The points to note for the development of the proposed AP by the project are as follow.

Mainly anyone who wants to participate in the FA activity can be a participant; however the number of participants can be adjusted according to the size of the project.

The objective of the proposed activity by the participants is prioritized over the one targeted by the project. The participants and the project planner together will verify the result of the activity at the end of the project.

Regarding the activity detail, the result of the introduced FA selection is proposed by the project. However, the project must sufficiently explain the reason for the selection if the opinion of the participants is different from that of the project. If the project has no agreement with the participants, it should be revised.

The project program and activity schedule of the introduction of the FA is after entering the FA supplier status and the capacity of manufacturing FA. The project decisions must take into account religious events and the agricultural work season.

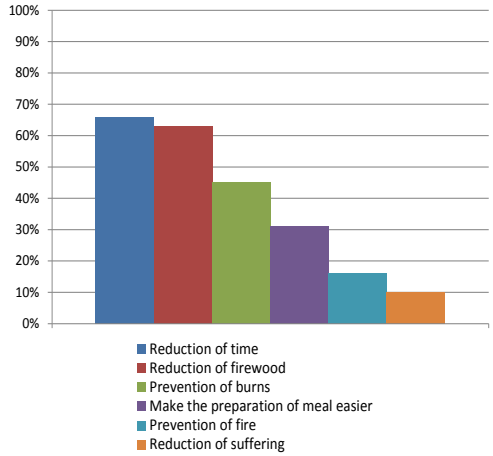
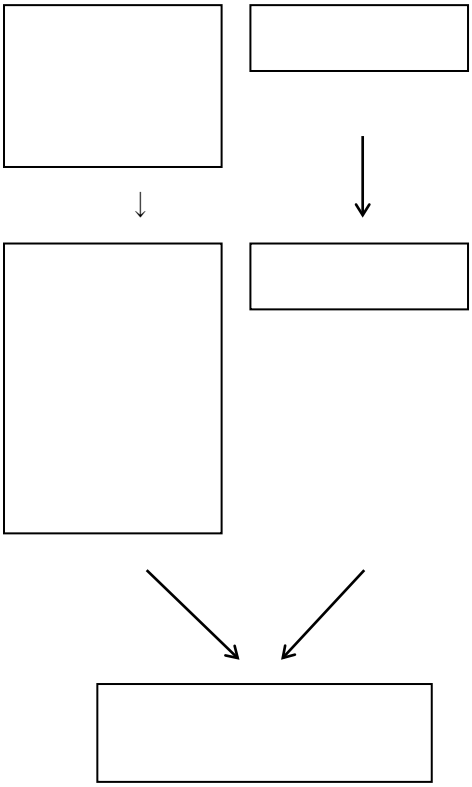
The project of FAFASO which disseminates FA in Burkina Faso has a policy for the sustainable dissemination. However, the project does not give subvention FA and the buyer pays all expenses. The project respects the policy. However, if there is no FA sales network near the village, the project is responsible for FA shipping costs. It is important to reflect on this assistance.

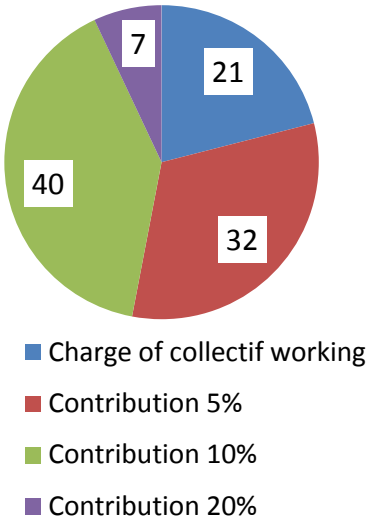
Case of the current study: AP Development

An example of the study performed in 2014 is as follows. The introduction of the FA was approved as a measure against the problem of forest degradation in the master plan level. Each villager who wants to participate to the FA activity registers the AP elements on a formula. After the project has summarized the registration, JIRCAS has developed the AP's proposal taking into account that of the participants.

The table comparing the proposed AP among participants and JIRCAS is as follow.

Table 4.6.2 Sample AP village of Gu

Action Plan for all households in Gu village		
	The villagers' proposal	JIRCAS' proposal
Participants	101 women	The particitants will be dicided at the start of the research
Objective of the activities		
Contents of the activities	Type : Metallic Numbre 2 FA (big and small) : 96% 3 FA (big, midle and small) : 4%	Type : Ceramic No.3 Merit: cheap (1.250FCFA) portable Period of durability: 2~3 years
Programme of activities	May ou June de 2014	From september in 2014
Lieu de l'activité	Court of each house	Court of each house

The share of participants		Participant: 90%=1.250×0.9 =1.125FCFA JIRCAS 10%=1.250×0.1 = 125FCFA Reason: If there are plenty of support, women must lose the intention of using FA for long time.

JIRCAS explained the proposal in the table above to the members of the Executive CVD and two municipal councils who are the village officials, with the help of the director of the Provincial Direction of Environment of Kourwéogo. After the exchange of opinions to have the approval of the village, we defined the AP. At the end, the representatives presented the defined AP to the participants.

4.7 Survey on the amount of firewood consumption

4.7.1 Survey Overview

The objective of the survey is to assess the value of the measurement $B_{old,i}$,, which is the average amount per year consumption of woody biomass by a previous stove corresponding to an introduced type *i* FA. The schedule of the survey includes a selection of targeted women, an explanation of the survey, a demonstration and a practice of the survey before the introduction of the FA. If one wants to know the practical quantity of reduced firewood consumption, the survey of firewood consumption after the introduction of FA is carried over as a free option.

4.7.2 Problem of the survey and measurement

(1) Determination of a targeted three-stone fireplace to the survey

$B_{old,i}$ is the average amount of annual consumption of woody biomass by a previous stove corresponding to the introduced type *i* FA. Thus, it's good to determine a three-stone fireplace corresponding to FA and measure the amount of firewood consumption when preparing with it. But every rural household usually has three or four stoves in three stones; one or two are used differently according to the menu or the preference of the woman in charge of cooking that day. For this, it is difficult to determine a targeted stove.

With that in mind, at first we did a survey of the different meals and pots used for each meal at each targeted household. Secondly we determine the pot which has the same size as that used on the introduced FA in the kitchen at that time. If the pot which has the size specified above should still be used in the preparation of the food the amount of firewood consumption is measured under the conditions of use of this specified size pot, and $B_{old,i}$ can be measured. According to this idea, we adopted a rule of the survey, "prepared meals are specified with the same size pot in the coinciding pot with the introduced FA. Targeted woman only consumes the firewood provided for the survey at the time of cooking of the food specified." With this rule, $B_{old,i}$ can be obtained by measuring the weight difference from before and after survey.

Photo 4.7.1 Current status of three stone fireplaces in the household courtyard

(2) Presence of women who are in charge cooking in the households
The woman taking part in the survey is from a household. But there are few women who cook food in a household. It should be mentioned it's one woman who attends this survey since they share the kitchen work per day or cooking session.

With regard to the second issue, we take a measure that during the survey, the targeted woman always cooks with the pot that has the same size as that of the introduced FA. Since that measure has an effect on the distribution of domestic work, the survey outline should be explained request the cooperation of her husband who is the head of the household.

4.7.3 Duration of the survey

The duration of the survey is seven days taking into account the work load of the targeted women and the surveyors, and also the volume of work collecting the firewood to be used for the survey.

All meals are prepared in the general kitchen during 7 days. Therefore, we think that the amount of the daily and average consumption of firewood can be evaluated in case the survey would be implemented for 7 days. The survey should not be done during the period of high firewood consumption such as the days of religious festival, wedding parties, or the Ramadan period, etc.

4.7.4 Selection of the targeted women (hereinafter referred to "typical women")

About three villages are selected from the villages where the introduction of FA by the project is planned, then ten women are chosen per village, and thirty women are selected in total as typical women. However, in case it would be only one village to carry the project, the thirty typical women were going to be selected from the same village, getting the women from the different districts of this village. The selection criterion comprises three points:

- The number of persons in a family is between seven and nine people (the average in rural areas of Burkina Faso is seven point five (7.5))
- The woman who has enough trust from other women
- The woman who wants to collaborate with the project

For the selection, it is appropriate to entrust it to the CVD, established in each village in Burkina Faso.

4.7.5 Explanation of the survey details and the FA demonstration

The explanation of the details of the survey is presented to all typical women of every village. The details include the purpose of the survey, the process, and points to note.

At the end of the explanation, the project exchange on the survey with the typical women to make sure of their comprehension of the details. The objective of the survey is mentioned in "4.7.1 Survey Overview". The process is described below. The points to note are the following:

- Only firewood provided for the project should be used each time the typical woman cooks food, and should also be with the same size pot for the introduced FA.
- It's her alone who always cooks with the pot which has the same size as the one of FA.
- It is forbidden to expose the firewood to the rain.
- She cooks in the kitchen as usual.
- She seriously manages the firewood
- She consumes no other firewood except the firewood that is provided for the survey, every time she cooks.
- She puts the rest of the firewood to the storage after confirmation of complete extinction.
- She observes the indication of the surveyor

Then the planner or project leader explains the benefits of FA, and the demonstration of other stoves to compare the quality between the introduced FA and other types of FA, and a three-stone fireplace is implemented.
For demonstration he divides the typical women into three teams. Each team takes care separately of a stove and they cook common dish of their region. In the end, we compare the amount of firewood consumption, the length of cooking and the smoke volume of the three stoves. After this result they not only can verify the benefits of the introduced FA but also its initiatives rise.

4.7.6 Survey Process

The process of the survey is as follow:

i. The project surveyor provides the firewood of the same tree species that women used to consume daily before the survey. If he plans the survey after the introduction of FA, he prepares at the same time separate firewood for the

second survey. This is so that the difference in the proposal and humidity of the firewood before and after the introduction of FA is negligible.

ii. He measures the weight of the firewood of each tree species and stores it in the box. The box is cover to avoid exposure to rain.

iii. Before the start of the survey, it he makes sure that the typical women do not use FA and asks them question about the family composition, the different meals, cooking frequency, and used cooking pot at each cooking session.

iv. The study lasts for seven days. The typical woman consumes the firewood stored in the box for the survey from the first morning of the survey until the last evening of the survey. She puts the rest of the used firewood back to the firewood box after putting out the fire.

v. The surveyor or project leader checks the consumption of firewood daily, various dishes cooked and cooking frequency (see Annex 4.7.2).

vi. The surveyor or project leader measures the weight of firewood of each tree species in the box in the next morning of the day after the last day of survey.

Case of the current study: Survey of the amount of firewood consumption

A sample survey made by MECADE is following,

(1) Period of survey

It was during seven days in mid-June, which is just before the rainy season in 2014

(2) Typical Women

The targeted village of Gu has six quarters and a typical woman was selected in each district by the CVD, making a total of six typical women. The criteria for selection of the typical women are as mentioned above. The choice was confined to six women, because this survey was done to operate and check the method of the survey and guided by the budget limit.

(3) Explanation of the details of the survey and FA demonstration

Photo 4.7.2 The explanation about the survey

Photo4.7.3 FA Demonstration

The presentation of the project to the typical women was held before the start of the survey, , and then the investigator asked them some questions about the details of the survey as pre-test to deepen their understanding, and at the same time resolve any misunderstanding related to the survey. The facilitator of FAFASO (organization of FA dissemination) presented the benefits of FA and the remarkable points on the FA use.

At the end we made the demonstration comparing the ceramic FA, metal FA and the three stones by cooking some fat rice. As a result of the practiced cooking with the three types of stoves we noticed that the amount of firewood consumption by ceramic FA was half compared to that of the three stone, and that the duration of the kitchen was by 20% shorter. This has served as a convincing point to participate in the survey.

Table 4.7.1 condiment List for FA demonstration

	Food	Unit	Quantity
1	Rice	k g	6
2	Oil	bottle	1
3	Tomato	box (500g)	3
4	Onion	kg	1
5	Meat	kg	3
6	Magi	cube	9
7	Salt	box	1

The project provided the FAs, pots and rice, and the women have provided water, firewood, the three stones stove and the labor.

The list of condiments for the fat rice of the three pots of № .3 is in Table 4.7.1.

The list of typical women is in Annex 4.7.3, an example of TOR for the survey, in case the survey is requested by a research department (Annex 4.7.4).

(4) Preparation before survey on the field

The project surveyor asked the women to gather enough firewood for the survey. He measured the weight of each tree species and stored them in the box prepared and covered it with a plastic bag.

Photo 4.7.4 Firewood storage

Photo 4.7. Measuring firewood weight

(5) Result of the survey

The quantity of firewood consumption for seven days by a three stones stove which corresponds to an introduced FA with the pot Nº.3 was evaluated. The results were from 12.0kg to 19.0kg (see Figure 4.7.1) and the average was 14.0kg (2.0kg per day) with a three-stone fireplace with the pot Nº 3.

However the tree species for firewood are different with respect to the preference of individual women. The most preferred is branches of the *Combretum micranthum*.

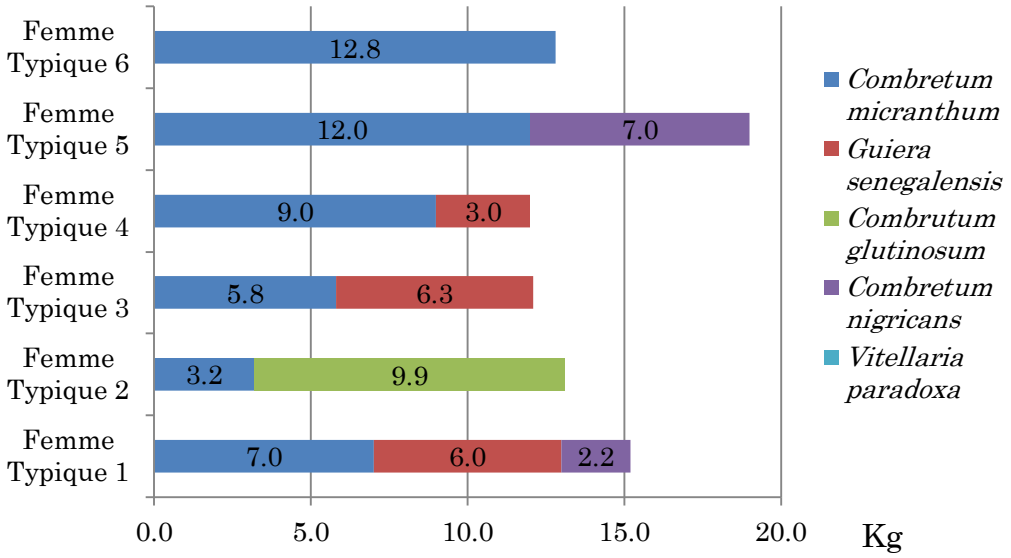


Figure 4.7.1 Quantity of the consumption of firewood for seven days with a three-stone fireplace with the pot N° .3

4.8 Attempt of Introducing FA

4.8.1 FA Introduction Policy

The FAFASO, which succeeded the dissemination of FA especially in urban areas, adopted the policy that it is necessary that the project does not offer financial aid to beneficiaries. Therefore, this policy is also adopted in the case of the introduction of FA in rural areas. The agreement and cooperation of men is essential to women whose social position is low for the activity of introducing FA. For this we form an organization composed mainly of women, though it was necessary to have men's participation in managing the activity of introduction (or sale) of FA.

4.8.2 Period of the introduction

The rainy period is not appropriate for the introduction of the FA because women are busy with agricultural work, and it is also better to avoid the period of school resumption (September, October) because revenues are low for women at this period.

4.8.3 Process of introducing FA

This document assumes that there is no basis for the production or sale of the introduced FA in the target area. There had to be the mediation of the project between the targeted women of the village and the sellers, who are manufacturers or traders, to establish the FA. Therefore, the FA is introduced in the village by the following process for the project to support women's initiatives activities.

i. Creation of an organization for the activity of introducing the FA
ii. A meeting to explain the activity of introducing FA to all the village women and men who are interested
iii. Demonstration of the FA
iv. Distribution of FA posters (Annex 4.8.1) and registration papers (Annex 4.8.2) and recollection of registration papers
v. FA prepayments collection
vi. FA Order
vii. Distribution and FA registration

Yet in case there would be no site for the production or sale of the introduced FA in the target area, it is important that at the same time another project programs to train people for the introduced FA manufacturing in cooperation with the organization that is already working on the dissemination of the introduced FA. But

this document does not mention the training of those because that is the task of the organization that has the objective of FA large dissemination

4.8.4 Creating an organization for the activity of introducing FA

This document is mentioned in case it's in a village.
A man (hereinafter referred to as "typical man") and a woman (hereinafter referred to as "typical woman") are chosen in each quarter as project leaders, and the CVD directs them as a representative of that organization to advance the project of the FA introduction.

The selection criteria for the typical man and woman are as follow:

i. The person who is entrusted by the villagers
ii. The person who will actively participate in the activity

The head of CVD selects them under the above criteria.

The typical of women are in charge of the above mentioned activities from ii to vii on their own initiatives. Typical men assist them, for example in taking action against problems or promoting comprehension of the villagers on the activity.

4.8.5 Explanation meeting on the activity of introducing FA to all village women and men who are interested

The introduction of a large number of FAs needs the prior motivation of introducing the FA and the understanding of the villagers. For this, the explanation meeting of the FA activity is open to all women and men who are interested in order to know the details of the activity.

4.8.6 FA Demonstration

The activity of the demonstration has two objectives. This includes the demonstration of the function of the introduced FA by women and the exaltation of the motivation of the activity of the typical women.

The demonstration of the comparison is presented to the audience of the meeting through the cooking practice of fat rice by the typical women using the introduced FA and the three stones stove.

4.8.7 Works from distribution registration papers, introducing FA, to the FA delivery

(1) Process of work

The process from the registration survey of the FA introduction until the FA delivery, after cashing FA prepayments is mentioned in Table 4.8.1.

Table 4.8.1 the work process until delivery of FA introduced

N o	Duration	Process work	Leaders
1	One or two days after explanation meeting	Distribution of registration papers of FA for all households	Typical Women
2	One week	Recovery of registration papers	Typical Women
3	One or two days	Submission of Project Registration papers	Typical women and the chief of CVD
4	One or two days	Recapitulation of registration	Project
5	One week	Collection of payments	Typical Women
6	One or two days	Submission of payment to the project	Typical women and the chief of CVD
7	One day	Order	Project
8	Two or three weeks after order	Transportation and FA Delivery	Project

It is mainly the women who take care of the work from the FA registration up to the receipt of prepayments. However, it is the project that provides them with the necessary forms for the activity.

(2) Distribution of FA registration forms

Each typical woman distributes the FA registration form to women in her neighborhood (see Annex 4.8.2) and displays the A4 FA advertisement (see Annex 4.8.1), and simultaneously she explain how this form is completed, and the submission date of the form. However, if the typical woman who makes the explanation has some problem in the literacy level, the project may allow their child (high school or college student) to help her. The project previously prepared sheets needed for the project and delivers to the typical women.

(3) Recovery of registration forms

The typical woman gets the FA registration sheet for women who want to FA in a week time, and confirmed the content of the form is completed correctly on site. If

she would have problems with literacy, she may perform this activity with the help of her child (high school or college student).

(4) Return of registration forms to the project
The typical woman collects the FA registration forms and delivers them to the CVD. He informed the project planner of the completion after confirmation of return of all forms from all the typical women.

The planner receives the form from all the villages and checks registration mistakes or some uncertain part on each form. And there are some uncertain points, he asks for clarification to the CVD, and in case it would be impossible he immediately visit the concerned woman for clarification.

(5) Registration Summary
The planner of the project develops a list of participants who have FA registration (see Annex 4.8.3) and the synthesis of subscriptions for improved cook stoves (see Annex 4.8.4) on the basis of registration forms. He must consult the CVD or the typical woman on uncertain points.

(6) Prepayment collection
The planner prepares a list of the participants who make prepayment (see Annex 4.8.5) and receives (see Annex 4.8.6) on the basis of the list of participants who made the FA subscription, and he gives to the typical women. At that time he still tells them the goal and the way of two registration forms draws attention to avoid payment problems.

The typical woman visits the woman who presented FA entry form according to the list of participants that made the prepayment and collects the prepayment. She makes the woman who made the prepayment sign the list as proof of payment, and at the same time she gives her the receipt that is not yet signed. She informs the need to bring the receipt to the distribution because this receipt must be signed by the project during distribution FA.

(7) Prepayment Submission to the Project
The typical woman goes to the CVD with the typical man from the same neighborhood to return the money received and the list of participants who signed the prepayment. The CVD confirms the equivalence between the amount on the list and the money received, and in case of a difference must address the problem locally. He informed the planner of the project completing the collection and gives him the money and the list.

(8) Order

The planner must determine an FA manufacturer and seize his production capacity, transport route and transport time before starting the activity. And when ordering he asks to print serial numbers on all stoves to distinguish them. The serial number contains the project brand, type name, and year number.

The project planner prepares the summary table of participants who have prepaid (see Annex 4.8.7) for the list of participants that make the prepayment and order the FA according to the table.

(9) FA Transport and Delivery

The activity of the distribution is done by district to avoid confusion. Therefore, the planner of the project plan on the start time of the distribution of each district, taking into account the transport time and number of FA, and informs the typical women the distribution time of each district and she accompanies the women who have made the prepayment (hereinafter referred to as receiver).

The project planner prepares an FA distribution space in the center of the village and has three teams which are for reception, FA delivery, and the registration of the FA user. At the reception the receiver is checked based on the list of participants who made the prepayment and the receipt is sign. He fulfills the necessary information not including the number serial number on the delivery form (see Annex 4.8.8) after the recognition of the receiver and returns it to her.

The receiver who received the form moves to the delivery area and passes it to a delivery agent. He confirms the type and number of FA on the form and delivers her the FA corresponding to the profile. In that time he finds the serial number on the FA and fills the form. At the end he gives her the FA.

The receiver goes to the FA registration desk and submits the form to the one who takes care of the registration. He entered the necessary information such as the name and serial number on the paper from the FA user registration table (see Appendix 4.8.9) on the form and questions the receiver.

The receptionist calls the next typical woman after confirming the end of the previous distribution district, and announces the start of delivery for the next district.

Case of the current study: the introduction of FA

(1) Survey Overview

The CDM methodology requires the field survey a few terms (e.g. Number of FA and number of days of use) with which the equation is solved, and it is necessary to develop the method of field survey for the terms. And also the development and verification are required as part of the follow-up survey. Therefore you have to plan a survey of introducing FA and perform this survey verification through a trial project for the introduction of the FA on the field. This test project was implemented in the village of Gu in the department of Boussé.

First we had the intention to only introduce the N° 3 FA ceramic type, however, was added another No 5 ceramic FA type because women strongly want this type of stove.

(2) Period of survey
The survey period was from 2015 until September 15, October 8, 2015.

(3) Survey Process
This was the same as "4.8.3 the process of introducing FA" mentioned above, but the order is executed before the prepayment cashing because the duration was short.

(4) Establishment of an organization to the activity of introducing FA
An organization was established as described in paragraph 4.8.4. The 6 typical women and men were selected in six quarters. They participated to the explanation meeting of the objective, the activity and the program, and they promised to take care of the activities on their own initiatives.

The activities of the typical women were active. We were worried that they would face obstacles because of the literacy problem, but they filled a series of the work according to the program from the distribution of FA registration forms to FA delivery without any problem. Therefore, we realized that it was nice that they had interest in the activities and that they carry them with such motivation.

Regarding the activity of the selected typical men, it did not work well. However, it is necessary to establish the position of the typical man to push the activity of women on the basis of their understanding.

(5) Explanation meeting on the activity of introducing FA to the entire village interested women and men
The meeting was made focusing on the following points for the most possible attendance of the women.

- The typical women have at first informed all the women about the meeting.

- The date and time of the meeting was two o'clock in the afternoon (2pm) on Friday, just after the prayers at the mosque to facilitate participation.
- The duration of the meeting was short, for 30 minutes.

As a result, the 65 women, representing 20% of all women of the village of Gu and the 40 men, 14% of all men in this village, attended.

The presentation of the activity was done with an explanatory chart (see Annex 4.8.1) and a sample of introduced FA, and given information on the objective of introducing FA, the FA type (ceramic FA No 3 and No 5), the remarkable points on the usage instructions, characters such as the advantage and weakness, the price (1,000 FCFA for No 3 and 1,500FCFA for No 5, the market price, not including shipping costs) and the timeline of activities (Subscription, prepayment, delivery and so on).

We need to win confidence through sincere explanation on the advantage and weakness. These are the points presented that advantage ceramic FA is that it reduces the amount of firewood consumption and the price is one third compared to the metal FA. As weakness points, the grid and its support of the FA are fragile. In terms of notable points on the usage instruction, they are shown not to put a lot of firewood in the FA, not to use a different size pot and not to wet the FA during use.

The participants attended the presentation till the end without leaving. Therefore we can estimate the method and process of the meeting was effective.

(6) FA Demonstration

The demonstration of the comparison is presented to the audience of the meeting through the practice cooking fat rice by the typical women using three different types of stoves: the ceramic FA, metal FA and the three stones stove. The village women were able to actually verify the result by the demonstration, and at the end the typical women explained the benefits they have noticed.

We can estimate the demonstration effective because;

- Participants were many
- The number of participants has increased over time
- There was no one who has left the demonstration session
- The clapping of hands were strong

After the demonstration, the women were able to make visual confirmation of the effectiveness of the FA functions, and participants' interest rose as well as the motivation of the use of this type FA.

(7) Process from the distribution of registration forms to FA delivery

It took at least two weeks to make the ceramic FA after the order. Because the time given to practice the survey was 20 days and it was very short, we modified the timetable a little from the normal program (see Table 4.8.3). And we tried to practice the activities in the table 4.8.1, same as the respective people in charge.

Table 4.8.3 Example of work processes

No.	Date (2014)	Work Process
1	18/09	Distribution FA registration form for all households
2	22/09	Recovery of registration forms
3	23/09	Submission of the forms to JIRCAS and registration Recap by JIRCAS
4	24/09	Order
5	24/09~29/09	Prepayment collection
6	30/09	Submission of prepayment to JIRCAS
7	7 ~ 8/10	Transportation and FA Delivery

It was expected that there would be very few women who would want to buy the FA under the condition of no subsidy, and because of the literacy problems we also thought the typical women could not cope with challenging activities, which are registering for work on a form and confirmation on the content of the registration, making the list of people and cashing prepayment on the basis of the list.

But fortunately many women were involved and the typical women were able to resolve registration activities with the support of their high school students or college kids.

(8) Result of the survey

The table 4.8.4 shows the results of the survey.

Table 4.8.4 FA result of the introduction of the village of Gu

District	Number of household	Number of women	Number of FA		
			N° 3	N° 5	Total
Sa	15	20	17	4	21
Ga	15	15	15	5	20
Vo	13	13	11	2	13
Ya	15	17	12	5	17
Ta	15	15	15	8	23
Si	15	15	14	3	17
Total	88	95	84	27	111

The number of households introduced was 88 households, 59% of the number of all households in the village of Gu (150 households). The number of introduced FA per household was 1.3, and the proportion of FA by type was 76% for the N° 3 and 24% for N° 5. It was estimated that the introduced FA will be used daily, because the type of N° 5 would be used for cooking rice or tô, which are the main food and the N° 3 will be used for cooking soup or sauce.

We can evaluate that this survey has produced an excellent result. This is because 59% of households purchased the FA although it was the market price excluding shipping fees and although it was also the period of school resumption, when women had only little money. We can estimate that the reasons mentioned below have produced good results,

- The introduced FA is more affordable
- Practice of explanation not only of advantage points, but also of the weakness
- Practical demonstration
- Organization to distribute the FAs

4.9 Evaluation of the reduction of CO_2 emission

4.9.1 Method of evaluation

NAPA (National Adaptation Program of Action) implemented in Burkina Faso for the implementation of measures against climate change and at the same time as a National Development Plan in a win-win situation. The FA dissemination project has been adopted as one of the measures of the NAPA. Also the quantitative assessment of the volume of reduction of CO_2 emission of the FA by the project must be an essential and effective data to apply the measure.

The value of calculating the amount of CO_2 emission reduction per year according to the project of the FA dissemination is sought by the formula (a) of paragraph "4.3 Method of calculating the amount of reduction of the emission CO_2" with the following terms:

i. $B_{old,i}$; The average amount of woody biomass consumption per year by a previous stove matching the a type i introduced FA. This value will be evaluated through the survey on the amount of firewood consumption.

i. $N_{y,i,a}$; The number of used FA introduced by the project
ii. $\mu_{y,i}$; The average number of usage days of the FA. It is evaluated by the follow-up survey, yet here we present an example of the assessment provided in the standard value of 365 days.

Case of the current study: The value of calculating the reduction of CO_2 by the FAs

It is estimated the quantitative effect of mitigation against climate change on the basis of survey data in the village of Gu in the department of Boussé in case the No3 type of ceramic FA will be introduced in rural areas of Burkina Faso.

In this case, the adopted data is from the MECADE survey; $B_{old,i}$= 730kg/an, $N_{y,i,a}$ = 50%/village, $\mu_{y,i}$ = 365jours, $\eta_{new,i,a}$ = 0.26, and the number of total household in the rural area in Burkina Faso[3].

These are the formula (a) and (d) that are used here. The calculation result is the Table 4.9.1.

[3] 2006 villages Census file in Burkina Faso

Table 4.9.1 result of some calculations to test the amount of the reduction of the emission of CO_2 by introducing FA

Case	Number of household in the rural area in BF	Proportion of household introducing FA	Number of FA introduced by one household	$ER_{y,i}$	$B_{y,savings,i,a}$	$B_{old,i}$	η_{old}	$\eta_{new,i,a}$	$N_{y,i,a}$	$\mu_{y,i}$	$f_{NRB,y}$	$NCV_{biomass}$	EF_{p_f}	LE_y
1	1,725,965	**50%**	**1**	**405,505**	0.449	0.730	0.1	0.26	862,983	365	0.9	0.015	81.6	1
2		50%	2	811,009					1,725,965					
3		100%	1	811,009					1,725,965					
4		100%	2	1,622,019					3,451,930					

The amount of the CO_2 emission reduction equals 405,505 tCO_2 per year if 50% of households in the rural area Burkina Faso were introduced one FA. The rate of the effect of mitigation through the introduction of FA in the forestry sector and change of land use will reach 9% (405.505/4.521.000[4] = 0.09).

In other words, the amount of CO_2 reduction equals 811,009 tCO_2 per year if every household in the rural area of Burkina Faso were introduced one FA, and It will reach 18% (811.009/4.521.000 = 0.18).

Like this, we can quantitatively evaluate the effect on the mitigation against climate change by introducing FA if the methodology of the CDM formula is presented.

[4] National communication of Burkina Faso, p64,12/2001, SP/CONAGESE

4.10 Survey Method on the follow-up

4.10.1 Survey Objective on the follow-up

The objective of the monitoring is mainly to confirm if the introduced FAs are used. Not only we can quantitatively verify the effect on climate change from this confirmation, and also this survey may serve to last the effect of the project by finding the problems and finding measures.

4.10.2 Elements of the survey on the monitoring

(1) Survey of employment confirmation FA
It is necessary to note 4 points FA by type as the database. These points include the FA introduction date, name and surname of FA user, the FA usage site (address), identification of FA (serial number)[5]. These data are recorded on the FA[6] user registration Form table during FA delivery.

The FA usage frequency (number of FA usage days per week) is additionally questioned with the above 4 points to the calculation formula of the methodology. It serves to determine $\mu_{y,i}$ of the formula (b).

The frequency of this survey is once every two years.

The size of the sample is evaluated with the 4.10.2- formula (1) by FA type and by year of introduction of FA. This formula requires that the percentage of the standard error divided by the expected proportion *(P)* is less than or equal to 10% under the condition of 95% of Coefficient of confidence by population.

(See Annex 4.10.1; Document Sampling and surveys for CDM project activities and programs of activities version 03, p16 formula (1))

$$n \geq \frac{1{,}96^2 N \times P(1-P)}{(N-1)\times 0.1^2 \times P^2 + 1.96^2 \times P(1-P)} \qquad 4.10.2\text{- (1)}$$

n = sample size
N = Population
P = expected Proportion
1.96 = coefficient value of the confidence interval of 95%
0.1 = Percentage of the expected accuracy of the standard error

[5] cf. Paragraph 33 from the methodology of CDM

[6] cf. Annex 4.8.9

$(1{,}96\times(P(1\text{-}P)/n)^2)$ devided by P

However, if N: the population is over 5,000, the formula of Wald 4.10.2- (2) is adopted.

$$n = \frac{1{,}96^2 \times (1\text{-}P)}{0{,}1^2 \times P} \qquad 4.10.2\text{-}(2)$$

Confer-to Appendix 4.10.2 which is a test of the calculation of the required sample size.

(2) Survey of periodic thermal efficiency of FA after introduction

The CDM methodology of this document requires to measure the thermal efficiency per year and per type of FA after the introduction of FA, assuming it decreases over time (see Paragraph 17 and 34 (b) of the CDM methodology). We measure the thermal efficiency of each year only with the introduced FAs in the project first year and benefit the values of the introduced FAs from the second year. If it is hard to do this survey because of the budget problem, note the situation in the calculation result.

The sample size is evaluated with formula 4.10.2- (3) by type of FA. This formula requires that the percentage of the standard error be divided by the average thermal efficiency be less than or equal to 10% in the condition of 90% coefficient of confidence by population.

Confidence per population.

$$n \geq \frac{1{,}645^2 N V}{(N\text{-}1)\times 0{,}1^2 + 1{,}645^2 \times V} \qquad 4.10.2\text{-}(3)$$

V = (SD / mean) ^{2}
n = sample size
N = Population
mean = expected means
SD = standard error expected
1.654 = coefficient value of the confidence interval of 90%
0.1 = Percentage of the expected accuracy

However, if N: if the population is large enough, the calculation is formula is as below

$$n = \frac{1{,}645^2 \times V}{0{,}1^2} \qquad 4.10.2\text{- (4)}$$

Confer-to Appendix 4.10.3 which is a test of the calculation of the required sample size.

Case of the current study: The follow-up survey

First the necessary data were recorded on the form during FA delivery in the village of Gu by asking questions. A follow-up survey test was preceded on the basis of these data 4 months after the delivery. The samples were all households where the FAs were introduced.

The formula of the FA user registration table was verified as appropriate to the follow-up survey after the test result of the follow-up survey. The percentage of continued usage of the FA was 78%, although there was few FA which had poor durability. Because we have assumed that it would have been 100% if it were not for this, we can estimate the percentage of FA continued usage to 80% minimum.

Regarding the problem of fragility that is found in the follow-up survey, we have informed FAFASO, leader of dissemination project of the introduced FA and asked them to improve the quality of the ceramic FA. And three points were also proposed to the woman association manufacturers of FA 1: consideration of the causes of immediate breaks of FA, 2; discussion of the measures with everybody and 3; the implementation of improved techniques. They accepted them.

However, due to the limited duration of the survey, it was not possible to carry the two-year follow-up survey.

Chapter 5 Practical Implementation-Tree planting and agroforestry-

5.1 Study background and objectives, etc.

5.1.1 Context

In Burkina Faso, forests occupy 5,589 million ha, which roughly corresponds to 20.4% of the surface land (World Bank, 2011). The impact of the expansion of agricultural land resulting from population growth and recent droughts, etc. due to climate change have led to a rapid reduction of the area of forests and forest lands; and, 1.2 million ha of forests (17.5%) and 850,000 ha of forest land (14.5%) have disappeared over the last 20 years (Table 5.1.1).
Such reduction of forests makes vegetation restoration a problem to solve urgently.

Table 5.1.1 changing the forest area in Burkina Faso
(FAO, 2010[1])

Division	Surface (1,000 ha)			
	1990	2000	2005	2010
Forests	6,847	6,248	5,949	5,649
Other wooded land	5,861	5,435	5,222	5,009

Note: The "forests", here, means an area of more than 0.5 ha covered by trees that reached a height of over 5 m or the maximum height in a suitable land, with a coverage rate above 10 %. And "other wooded land" means an area of more than 0.5 ha covered by trees that have reached more than 5 m and the maximum height in a suitable land, with a coverage rate of 5 to 10%. Shrubs coverage rate (less than 3 m), small shrubs (less than 1 m) and other higher trees, will be 10%. However, in all cases, the land suitable for agriculture and urban areas are excluded.

Moreover, the forest, which provides a variety of non-timber forest products such as firewood, charcoal, timber, fruit, medicinal materials, etc., is a valuable source of income for rural residents who represent about 45% of family income[2]. Among these products, the importance of fruits and edible nuts increases because they are intended not only for family consumption but also for sale and their development is important for the increasing livelihoods of farmer's families.

Furthermore, projects in line with NAPA, an Action Plan of Burkina Faso, are implemented to deal with climate change. These projects are defined as a priority "essential products, activities and emergency projects to help people in areas affected by the negative influence of climate change", which is the fight against climate change with the two aforementioned effects.

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[1] FAO (2010) Evaluation of Global Forest Resources, National Report Burkina Faso http://www.fao.org/docrep/013/al468F/al468f.pdf (last visited Aug. 28, 2015)
[2] Japan Association for International Collaboration of Agriculture and Forestry (JAICAF, 2013) "Agriculture and Forestry in Burkina Faso"

The 5th of the 12 priority projects proposed in this Programme for the recovery of non-timber forest products (NTFPs) and planning, rational management of natural formations and promotion of non-timber forest products and tree planting and agroforestry for this purpose are considered as major state policy.

And tree planting and agroforestry using local fruit trees have 3 advantages: restoration of vegetation, improvement of living standards in rural areas and climate change mitigation, which is a forest conservation methodology very profitable for Burkina Faso.

However, in Burkina Faso, planting trees and agroforestry using local fruit trees is at the experimental stage and is hardly practiced. It is now expected to consolidate a technique in experimental verification of agricultural plots to expand throughout the country, and advance project development.

5.1.2 Objectives

Experimental verification study will be conducted to establish a technique for tree planting and agroforestry using verification by local fruit trees in agricultural land, which has the advantage of restoring vegetation, improve the means livelihoods and alleviate climate change.

This Document, therefore aims to bring together the knowledge and lessons that can be derived from this audit study to help develop more tree planting and agroforestry using local fruit trees.

5.1.3 Implementation Plan of the study

The main elements of the implementation plan required for the implementation of the proposed tree planting and agroforestry using local fruit trees are listed as follows. This document was written based on these elements.

1) Identification of wishes, etc. of candidates for participation

- Candidates for participation
- Varieties and number of trees to plant desired

2) Analysis for the development of the action plan (balance between wishes and feasibility)

- Selection of varieties of trees to plant
- Preparation plants possibilities
- Scope of the burden for beneficiaries

3) Fixing farms for distribution

- Setting of participants in activities

4) Training centered on planting local fruit trees on agricultural plots

5) Distribution of seedlings of local fruit trees etc.

6) Planting of local fruit trees, etc. Farming Land

7) Intercropping on agricultural plots

8) Monitoring after planting on agricultural plots

9) Checking the calculation of the profitability of tree planting and agroforestry activities

5.1.4 Identification of wishes, etc. of candidates for participation

The various information such as wishes regarding tree planting activities (candidates for participation, and many varieties of trees to plant desired, etc.) are identified before turning to activities in the target village.

Based on the information obtained, the content to be executed, the scope and size of the load, etc. are studied in the light of the objectives, direction, budget and duration, etc. of the project.

5.1.5 Proposal for a plan of action developed by the inhabitants

For the approximate information, we may use the action plan proposal developed by the inhabitants.

Case of the current study:

In this study, the need for "tree planting" as part of tree planting activities-agroforestry has been recognized as described under "3.4.2 Problem Identification and study of countermeasure problems", we asked the village to present us a draft action plan on this.

This proposed action plan includes the following: (1) people interested in participating in the activities (candidates for participation), (2) objectives of the activities, (3) content of the activities (tree planting varieties) (4) program of activities, (5) activities places, etc.

65 independent farms and one group wanted to participate. The group was a women association producing shea butter, which wanted shea trees to plant. Other varieties of desired trees, fruit trees which generate profits such as mango, African locust, tamarind, cashew, etc. were numerous.
A planting action plan of participatory trees was established on this basis.

5.2 Analysis for the development of the action plan (balance between wishes and feasibility)

The points below are normally analyzed from information based on the wishes, etc. of residents to develop a feasible action plan.

- Selection of varieties of trees to plant
- Possibilities to prepare tree seedlings
- Scope of care for beneficiaries

5.3 Gathering information and testing for the selection of trees varieties to plant

(1) Orientation and criteria for the selection of trees varieties

1) Selection orientation

The criteria for the selection of tree species vary according to the objectives of the planting activities. For example, we select eucalyptus, a variety with early maturity for the restoration of forests and vegetation, or African locust or eucalyptus, Local fruit trees, for the promotion of the use of non-timber forest products. For both the revegetation and improved livelihoods, in addition to varieties such as eucalyptus and neem (tree), we select varieties useful for agroforestry introducing commercial crops such as fruit trees.

2) Selection criteria

- Variety selected by the farmer himself
- Variety adaptability which has been verified in a similar cultivation environment
- Variety whose cutting down is prohibited by law, and whose restoration and conservation are necessary
- Variety easy to grow in the area of intervention

In the event of carrying out activities on a farm, respecting the will of participating farmers is essential.

In an ordinary reforestation project, varieties of useful trees are selected after identification of the cultivation environment and varieties whose adaptation to an environment of the project area has been verified. As adapted varieties, there are varieties of Local fruit trees such as shea tree, African locust and baobab tree, and tree species from Africa such as Acacia Nilotica and the exotic varieties such as eucalyptus and neem.

(2) Recommended Varieties of trees in other projects

- Consider the cost of tree seedlings, results, ease of cultivation, etc.
- In ordinary reforestation project, we normally choose the Eucalyptus and Neem for their fast-growing and resistant to drought
- Among the fruit trees, it is recommended that exotic varieties such as mango, citrus and jujube trees and Local varieties such as African locust, baobab, and shea vine saba.

The tree varieties recommended in other projects are the following

Table 5.3.1 Varieties Recommended in other projects

	Scientific name	Local Name (Moore)	French Name	English name
10 priority tree varieties selected by the Ministry of Environment of Burkina Faso and JICA (2013)				
1	*Acacia Nilotica*	Pegenega	Nèbnèb, Gommier rouge	Nile acacia
2	*Acacia Senegal*	GB-payande	Gommier blanc	Arabic Gum tree, Acacia Gum
3	*Adonsonia digitate*	Toeega	Baobab	Baobab
4	*Azadiracha indica*	Nimma	Neem	Neem
5	*Eucalyptus sp.*	Kalbatiisi	Eucalyptus	Eucalyptus
6	*Albida (Acacia albida)*	Zaanga	Cad, kad	Winter thorn tree
7	*Mangifera indica*	Mangi-tiiga	Manguier	Mango
8	*Moriga oleifera*	Arzan-tiiga	Moringa	Moringa
9	*Parkia biglobosa*	Roaaga	Néré	African locust
10	*Ziziphus mauritiana*	Mugenega	Jujubier	Chinese apple, Indian plum
Varieties of local trees recommended by the Promotion Agency Non-Timber Forest Products (APFNL)				
11	*Vitellaria paradoxa*	Taanga	Karité	Shea Tree
12	*Saba senegalensis*	Wedga	Liane saba	Weda
13	*Tamarindus indica*	Pusga	Tamarinier	Tamarind

1. The Neb Neb (acacia nilotica - Red gum) is a spiny tree, resistant to drought, measuring up to 20 m even in the Sudanese climate zone. It is adapted to sandy soils or including gravel. Its applications are numerous: medicinal ingredient, firewood, timber, dyeing of skins, making crafts, etc. and also serves as fodder for livestock. For this reason, it is appreciated and cultivated by ethnic Fulani nomads.
2. The white gum tree (Acacia Senegal), from the same family as the acacia nilotica, measuring up to 6 m. This widely distributed tree in West Africa from Senegal to Cameroon and Sudan grows without problem on sandy soils or including many gravel. It is used as a medicinal ingredient, for firewood, timber, dyeing clothes, tanning hides; handle for agricultural tools, etc.
3. The baobab tree is a common tree in the Sahel, Sudan to Guinea, which can measure 25-30 m. There it seems the trees of over 100 years; it is widely used as a medicinal ingredient, as food (soup leaves, fruit juice processing, etc.), and also as fodder for cattle, for crafts and for shelter from the sun.
4. The Neem tree is Local to India midsize can measure 5-20 m. Very resistant to drought; it is used for soil improvement in dry areas. It is also used as a medicinal ingredient for firewood, timber, as cattle fodder for dyeing clothes, crop management and soap making, etc.
5. Eucalyptus is very resistant to drought and grows very fast to almost 20 m, even in the Sahel. It is mainly used as a medicinal ingredient, for firewood, timber, shelter from sunshine, etc.

6. Cad or Acacia albida (kad) measuring up to 20-25 m regardless of the nature of the soil in areas with annual rainfall of less than 300 mm. It loses its leaves during the rainy season but is growing rapidly. It serves as fodder for livestock, and also for firewood, timber, and as a medicinal ingredient.
7. The mango is a tropical fruit tree from the wetland, measuring up to 10 m. From near the Himalayan Mountains in India, it likes sandy soils. In addition to the use of fruit, it serves as fodder for livestock, as a medicinal ingredient, for firewood and shelter from the sun.
8. Moriga oleifera (Moringa) is a tree local to India fast growing and highly resistant to drought, can measure up to 6 m in the dry area, deciduous. The leaves are used as an ingredient for soup, as fodder for livestock and as a medicinal ingredient.
9. Parkia biglobosa (African locust) grows in Burkina Faso, even in areas with annual rainfall of 500-700 mm, and in the Sahel region from Sudan to Guinea. Its fruits are transformed into "soumbala" (protein-rich condiment), and serves as a medicinal ingredient, for firewood, dyeing clothes, handicrafts, etc.
10. Ziziphus mauritiana (jujube) is a thorny tree with deep roots, measuring up to 4-5 meters. Local to Central Asia, it has spread to Sudan. These fruits (jujubes) are edible, and apart from the cattle fodder, it serves as a medicinal ingredient for firewood, and crafts.
11. Vitellaria Paradoxa (Shea) local to West Africa, is known as the tree whose nuts are used to make the shea butter. Its growth is slow, usually reproduces by seed, planting a range of 8 to 10 m is required, and the fruits can be harvested 15-20 years after planting.
12. Saba senegalensis (liana saba) is a vine fruit, the fruits are edible raw, and are processed into juice, etc. The fruits collected from wild trees are sold in markets and recently grafted plants are also produced, and attract attention.
13. Tamarindus indica (tamarind) is a tree of the family of legumes local to Africa, widely cultivated in the tropics, particularly in Asia, evergreen capable of measuring 6-20 meters. Ordinarily, it is reproduced by seeds, planting a range of 8 to 10 m, and the fruits can be harvested 8-15 years after planting.

(Reference documents)

- Ministry Of Environment and Tourism, the new Printing Centre (1993): "Agroforestry Manual (2nd edition)"
- Ministry Of Environment / JICA (2013): "Varieties priority tree in Burkina Faso"[3] and varieties recommended by the Forest Department-Ministry Of Environment / JICA (2013): "Varieties priority tree in Burkina Faso"
- UNDP (2008): "Promotion Project for the use of NTFPs in Burkina Faso" and varieties of local trees recommended by Products Promotion Agency Non Timber Forest (APFNL)[4]

[3] Presentation of priority tree varieties selected by JICA project in Japan (based on the survey of M. KAMBONE, Forest Department)

[4] The Promotion Agency of Non Timber Forest Products (NTFP) is an agency under the Ministry of Environment of Burkina Faso set up after the proposed use of indigenous fruit trees (traditional use as food or medicinal ingredient fruits and leaves) as non-timber forest products (NTFPs) implemented by UNDP and FAO.

(3) Cultivation Tests on experimental plots of JIRCAS

To study the varieties adapted trees to cultivation environment, cultivation tests were conducted on the experimental plots set up in the city of Boussé. Tests have shown that the survival rate of Neem for planting, the African locust or Baobab, local fruit trees was high under ordinary rains, and these varieties are considered helpful in restoring vegetation in the semiarid climate area of the Project.

【Test Content】

1) Tree varieties
   The selected tree varieties were eucalyptus and neem usually considered priority varieties for planting and African locust, tamarind and baobab local varieties slow growing but very resistant to drought.
2) Planting date
   Planting took place in late July 2014, no fertilizer under normal weather conditions.
3) Interval planting
   It was decided that the interval for planting varieties for planting would be 4m x 4m in the case of conventional growing, and 6m x 6m in the case of mixed culture. And for fruit trees, it would be 10m x 10m for conventional cultivation and 5m x 5m for intensive farming.

4) Cultivation environment

Weather data were recorded with the weather observation device (Vantage Pro2) installed in the field of the environmental office of the city of Boussé. It has virtually not rained between October 2014 and April 2015, the tests were then carried out under severe conditions.

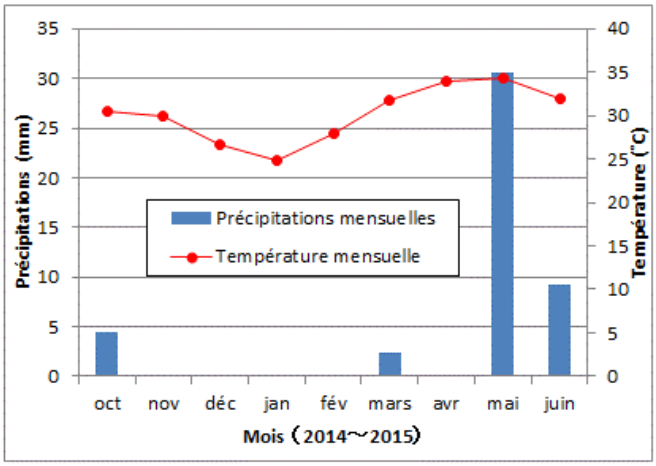

Figure 5.3.1 Temperatures and rainfall in the city of Boussé

5) Results of the tests

Table 5.3.2 Interval planting and seedling survival rate

N	Variety	Plantation Interval	Plantation Hole size (m)			Number of planted trees	Number of Surviving	Rate of Survival (%)
			Length	Width	Depth			
1	Eucalyptus camaldulensis	4m×4m	0.3	0.3	0.3	56	20	**35.7**
2		6m×6m	0.3	0.3	0.3	30	2	6,7
3	Neem	4m×4m	0.3	0.3	0.3	49	38	**77.6**
4		6m×6m	0.3	0.3	0.3	25	18	**72.0**
5	African Locust	5m×5m	0.6	0.6	0.6	36	29	**80.6**
6		10m×10m	0.6	0.6	0.6	9	1	11,1
7	Tamarind	10m×10m	0.6	0.6	0.6	9	4	**44.4**
8	Baobab	10m×10m	0.6	0.6	0.6	14	11	**78.6**

Note: The study of survival rates was made six months later and one year later. As planting plots where the Eucalyptus plants were planted at intervals of 6m and those of African locust and tamarind at intervals of 10 m were infertile with many stones, the seedlings were unable to adapt to these growing conditions.

(4) Dissemination of the growing of fruit trees

In Africa, as part of agroforestry (AF), the introduction of the plantation of fruit trees, both local and exotic trees, is encouraged to improve the nutrition and obtaining cash income.

Exotic fruit trees

- Dissemination of mango trees, citrus and jujube
- More than 30 improved varieties of mango are disseminated
- The production of grafted seedlings of improved varieties has also been well established and they are mainly sold to the capital city.

In Burkina Faso, it has long been practice on the initiative of INERA, the production of grafted seedlings and extension of the plantation of exotic fruit trees such as mango and citrus. Moreover, in several improved varieties introduced in the past such as mango, citrus and jujube trees, the production of grafted plants was well established and the supply to the capital city is stable.

For seedling production, the training of technicians for the production of grafted plants was achieved through large-scale projects of international aid organizations, especially the French government. In particular, the introduction of improved varieties of mango trees, exotic tree, and the production of grafted plants are made long ago and more than 30 improved varieties among which the "Kent" was found.

Production of grafted plants is conducted primarily by independent farmers who have acquired the knowledge and experience of planting seedling by attending various training courses conducted by research organizations and international organizations. Fruit trees whose the production of grafted plants took root in Burkina Faso are among other mango and citrus trees and recent production of jujube trees grafted seedlings is developed. But the problem is that the level of knowledge regarding improved varieties varies according to the farmers who sell their products. The grafted plants are distributed mixed with other varieties, and it happens that the variety is not identifiable.

5.3.1 Photo grafted mango seedlings (plants producer of the city of Boussé)

Photo 5.3.2 grafted jujube Plans (INERA)

2) Local fruit trees

- There are few experiences in introducing local fruit trees in reforestation projects of an international organization
- The grafting techniques to the domestication of plants are still at the research center
- The provision of seedlings, including grafted plants, in markets is limited
- In rural areas, local fruit trees are essential to everyday life and are used for food and as medicinal ingredients and dyeing materials.

As a mitigation measure of climate change, agroforestry[5] with local fruit trees adapted to the plantation environment attracts attention. Burkina Faso is committed to promoting the use of non-timber forest products derived from local fruit trees with UNDP assistance, etc.

But it should, it seems, more than 10 years between the planting and harvesting of fruits from local fruit trees, and management of long-term plantation is necessary. Despite the research and development for the short term harvest via the technique of grafted plants research organizations, dissemination is not progressing. For this reason, the fast-growing eucalyptus and mango trees to harvest after 3 years are considered a priority in reforestation projects. Furthermore, local fruit trees such as baobab and African locust, used for food, as medicinal ingredients and dyeing materials, are considered essential for everyday life in rural areas.

For local fruit trees, we generally use plants grown from seeds, but the production of grafted plants has also recently been performed as for exotic fruit trees. But the grafted plants are more expensive than plants grown from seeds. The main varieties of plants produced are the baobab, which they eat leaves and fruit, shea as ingredient for shea butter, the African locust main traditional material of fermentation condiment, and tamarind.
INERA and CNSF produce grafted shea plants and baobab after selecting varieties among wild varieties growing on main lands. In particular, CNSF produces grafted baobab plants from selected quality varieties (3 types for leaves, 3 types of fruit) collected and stored all over the country and sells them (600 FCFA for one plant).

[5] BM(2013):http://www.slmethiopia.info.net/index.php/download-center/summary/46-socioeconomic-marketing-and-others/99-wb-agriculture-and-rural-development-advance-web-edition (last visited Aug. 28, 2015)

Photo 5.3.3 10 months African locust (INERA)

Photo 5.3.4 grafted shea (Plant CNSF)

5) Varieties of trees whose felling is prohibited

- The trees to preserve and restore are African locust, baobab, shea, tamarind and red kapok.

In Burkina Faso, given the reduction in the number of forests and trees, saving varieties of rare trees and recovery is a major challenge of the state. The 2004 law prohibits the felling of 23 varieties of trees, and 5 varieties below are primarily protected varieties.

Table 5.3.3 Varieties protected primarily in Burkina Faso (5 varieties)

Tree Name / *scientific name*	In Moore Language	Priority of Protection	Main uses	Sales price on the marketplace (FCFA)
1 African locust/ *Parkia biglobosa*	Roaaga	◎	Food (fruit, seeds and pulp)	Seeds: 1.500 / kg Dehydrated pulp (powder): 225 /kg Soumbala(processed): 50/3 packages
2 Baobab *Adonsonia digitate*	Toeega	◎	Food(leaves, fruits,seeds, pulp)	Leaves: 50/1 heap Fruits: 50-200/piece
3 Shea *Vitellaria Paradoxa*	Taanga	○	Food (nuts, shea butter)	Fruit: 5-20/piece Nuts: 220-500/ kg Butter: 500-1000/ kg
4 Tamarind *Tamarindus Indica*	Pusga	○	Food (leaves, fruit)	Dried leaves: 250 /kg Dried fruits: 100/1 heap
5 Red kapok tree *Bombax costatum*	Voaka	◎	Food (flowers, fruits)	Dried flowers: 2.000/ kg Dried fruits: 1.000 / kg

Note: The price is the retail price on the market Boussé (July 2015)

(6) Selected varieties of trees by farmers

- The grafted plants like eucalyptus variety for planting, and mango trees for fruit trees are prized
- The reasons for the choices are: home consumption and income in cash

The varieties of trees desired by farmers were confirmed when developing the tree planting action plan and launch activities. Final trees varieties are as follows.

Table 5.3.4 Varieties of trees desired by candidate farmers planting and reasons for choice

Category	Variety	Number of choice	Reasons for choosing
Varieties of trees for planting	Eucalyptus	31	Use for firewood, timber, cash income, etc.
Exotic fruit trees	Mango (grafted tree)	53	Home consumption of fruit, use for shelter from the sun, cash income, etc.
	Orange (grafted plants)	1	Domestic consumption of fruits, cash income, etc.
Local fruit trees	African locut	3	Food (soumbala for traditional fermented foods)
	Shea (grafted plants)	1 (women's group)	Material for processing (shea butter)

Note: elements interviewed are the name of (the) representative (s), the objective of participation, varieties of trees and the number desired, materials and labor available, etc.

Eucalyptus has been popular as a variety of tree planting, and people wishing to plant grafted mango seedlings were most numerous among the fruit trees. The reason of choice most often mentioned by farmers was domestic consumption; the rest is sold for a cash income.

(7) Distribution of plants

Case of the current study: Distribution of plants

On the basis of points (1) to (5) the following plants were distributed in this study.

Table 5.3.5 Varieties tree seedlings distributed each year

Year Distribution	Varieties Qty	Varieties of trees
2014	8	• For planting: eucalyptus, neem, acacia Nilotica • Exotic fruit trees: grafted mango trees, cashew, lemon • Local fruit trees: African locust,Tamarind
2015	13	• For planting: Eucalyptus, Neem, Acacia Nilotica, Kuka, Moringa • Exotic fruit trees: Mango, Lemon, grafted jujube seedlings • Local fruit trees: grafted baobab seedlings, cashew, lemon, African locust, Tamarind, baobab, shea

(8) Price of tree seedlings.

Sales prices of tree seedlings of grower farmers around the capital city, and those of INERA and CNSF research organizations are.
But only for grafted mango seedlings, the price is set according to the size of the plants for sale.

Table 5.3.6 Retail price of seedlings of producers in the city of Ouagadougou (June 2014)

Name of the tree	Number of produced plants	Sowing period (reproduction)	Selling price (FCFA)
Cashew	500	April 2014	250
Mango	3 local varieties/ 7 improved varieties	Grafted in August 2013	1 .000 (1 m plant) 2 .500 (2 m plant)
Vine (red/white)	20	Grafted in April 2014	1.000
Lemon	100	No data	1.000
Orange tree	200	No data	1.000
Mandarin	100	No data	1.000
Coconut tree	50	No data	2, 500 (small) 5, 000 (large)
Eucalyptus (small)	1,500	April 2014	100
Eucalyptus	400	April 2014	400

(large)			
Hibiscus	No data	No data	500
Jasmine	No data	No data	750

5.3.5 Photo Farmer producer selling seedlings of grafted Mango plants

Table 5.3.7 Purchase price of plants from INERA and CNSF local fruit tree seeds (July 2015)

Tree name	Dried seeds (FCFA/ kg)	Plant from seed (FCFA / unit)	Plant grafted (FCFA / unit)	(Notes)
Baobab	12,500	500	1,000	Production only after receipt of order
African locust (Néré)	22,500	300-500	-	Grafted seedlings production on trials
Liane saba	-	500	-	Grafted seedlings production on trials
Tamarisk	15 .000	300-500	1,000	grafted seedlings production on trials
Shea	None Short-lived seeds	2,500 (plant of 1 year) 5,000 (plant of 2 years)	15,000 ~ 20,000	Grafted plants sales only for trials

5.4 Designation of farmers subject to distribution

In designating participants in activities (settling farmers subject to the distribution), conditions of participation in activities are submitted to candidates and people accepting these conditions are designated as participants.

5.4.1 Participation conditions in activities

Before presenting the studied action plan to the people, it is desirable to make a final adjustment with MEFR and members of CVD of the village, etc. The conditions for participation must be as a tree planting for more suitable and safe against the wishes of farmers. These conditions are, for example, participation in training for planting before its implementation, preparing the planting pits, taking measures to prevent damage caused by animals, etc.

For loads taken by candidates for participation we can propose the participants supply labor for free for planting and reforestation activities, and beside the Project which directs planting and agroforestry free supply plants.

Case of the current study: Conditions for participation in the activities

The conditions for participation in tree planting activities and conditions for the free distribution of tree seedlings were defined after having a coordinated action plan with members of CVD and villagers including educated people under the direction of the forest officer of MEFR.

The number of trees distributed was confirmed based on the wishes of farmers, and the final decision was taken by the members of CVD and forest officer of the MEFR.

Activities participation conditions are;
Selection of varieties of trees by candidates for participation

Participation in compulsory basic training before the implementation of the plantation

Without preparations for planting (digging pits), no distribution of tree seedling

Once the tree in place, rapid establishment of fences to prevent damage caused by animals

5.4.2 Points to consider for promoting participation

To promote tree planting, we must understand the peculiarities of land rights in the village. What must be considered so that people can participate in tree planting activities and agroforestry in an equal manner?

Examples

- Consideration of gender issues
- Consideration of issues related to ethnic groups

1) Consideration of gender issues

In the land system of traditional African patriarchal (father's donation of land to the son who succeeded him), usually, a woman cannot plant trees on the lands of her husband. For this reason, if a woman wants to plant fruit trees, etc., she must get the permission of the man who owns land rights[6].

Therefore, verifying the will of women's participation in tree planting activities, it is desirable to separately gather women and men to discuss. But we must also obtain prior permission of husbands before bring women together to discuss.

2) Consideration of issues related to ethnic groups

In patriarchal villages with various ethnic composition, in case of tree planting activities, take into account the ethnic minorities. In the target village, there are people of the Mossi for which the land right is perpetuated from generation to generation only son in the direct lineage and people of nomadic Fulani ethnic group who have settled. Of the 150 families, 36 (24%) are Fulani. Many come from elsewhere, and unlike the Mossi ethnic group with inheritance and land distribution by kinship, some of them do not possess ancestral lands.

The reasons why the inhabitants of the Fulani ethnic group living in the study area are reluctant to engage in tree planting activities are as follows.

- The land where the plantation is made can be recovered by the owner.
- Not having the right to plant trees even living long on the same land (e.g. more than 20 years), they cannot plant trees without the owner's permission (the Mossi).
- Water for livestock is a priority, you cannot use the water to water the plants.
- The usable land is limited, or the soils are stony and unsuitable for tree planting.
- Absence from the village during the study period, the wishes for the distribution of tree seedlings (February dry season), which falls on nomadic period

[6] Kiptot E. et Franzel S., (2011): *Gender and agroforestry in Africa: are women participating?*

Case of the current study: Consideration of issues related to gender and ethnicity

In the target area of this study, like many women use local fruit trees such as shea and African locust and were interested in the project, it was also a mechanism for women to participate in activities.

Also, the following actions were taken in this study to encourage women group activities.

1) Discussions with the village representative (man)
2) Negotiations regarding the use of land for planting trees
3) Labor demand to men when planting trees

Photo 5.4.1 Scene held a discussion with representatives of women's groups

Following the above arrangements, a plot of 25m x 25 m was given to the women's group, and when planting trees, providing work for the establishment of the fence, etc. could be obtained from the Land supplier (man).

- Consideration of issues related to ethnic groups

The following actions were taken in this study to encourage the planting of trees by the Fulani living in nomad.

1) Prior consultation with the representative and village elders before calling for the participation of Fulani
2) Recommendation of varieties can be used as fodder for livestock in the selection of tree species (e.g. Acacia Nilotica, kuka, jujube, etc.)
3) Upon return to sedentary life (beginning of the rainy season in late June - early July), selection of varieties of trees and confirming their wishes for the number

There were only 3 of the 36 Fulani families who agreed to participate in activities in 2014 (8.3%), but thanks to the actions mentioned above, this figure rose to 9 families (25.0%) in 2015.

5.5 Tree planting training centered on local varieties on these agricultural plots

Training for participant residents is carried out to improve their knowledge and techniques of tree planting and management of plantation focused on varieties of local trees on agricultural plots. The points to be considered for the training are as follows.

- Set the date of the training after discussions with residents
- Perform training in small groups over several days
- Explain also the management of the plants after planting (spray method, etc.) for mango, etc. requiring watering
- Perform basic training for planting by desired variety, understand the technical capabilities and wishes of participants, and if necessary examine the possibility of implementing a training for local fruit trees

Case of the current study: Execution of training in tree planting

5.5.1 Overview of training in tree planting

The method, content, etc. of the training of this study were as follows.
(1)Participants in training
All independent farmers and representatives of groups involved in tree planting activities
(2)Various trainers
Forest officer of the provincial environmental office assigned to the target area, CNSF technician, researcher at INERA
(3) Training content
Basic Training on varieties of trees planted and the method of planting and management of local fruit trees, etc., and applied training on the cultivation of local fruit trees (seedlings, graft), the establishment of a nursery , etc.
(4) Details of the training
The content of the training conducted in this study was as follows.
(5)Basic training
Basic method of planting and management method

Table 5.5.1 Basic Training

Number of times	Course Content	Trainer
1st time	Practical Course 1: Method of planting fruit trees 1) Measuring interval for planting varieties of fruit trees and trees for planting (use ropes of 4m /10 m with all nodes m) 2) Pit digging method for planting and planting method 3) Management after planting (setting up a fence, watering, measures against termites, etc.)	CNSF, forest officer

1) Applied training

The techniques applied were given: Technical germination of seeds of local fruit trees, drip irrigation, establishment of nurseries, etc.

Table 5.5.2 Applied Training

Number of times	Course Content	Trainer

1st time	Theory 1: Overview of the production of tree seedlings	CNSF, Forest. officer
2nd time	Practical Course 1: Method of Treatment of local fruit tree seeds before sowing 1) Treatment prior to sowing to improve seed germination 2) Treatment by immersion for 24 hours and treatment with acid. Varieties for trial: Nilotica acacia, tamarind, baobab, African locust, etc.	CNSF, Forest.
3rd time	Practical Course 2: seed treatment before sowing method Comparison of germination dividing by section pre-sowing treatment and without pre-sowing treatment section	Forest officer
4th time	Theory 2: Implementation nursery	CNSF, Forest.
5th time	Practical Course 3: Nursery establishment 1) Division of Participants in groups and site selection for a nursery 2) Distribution of materials needed by groups and setting up nurseries	Forest officer
6th time	Practical Course 4: Production of tree seedlings 1) Cultivation earth Fertilization 2) Sowing seeds pretreated 3)Points to consider during the growth of tree Seedlings	Forest officer
7th time	Theory 3: Overview of the production of grafted plants	CNSF, INERA, Forest officer
8th and 9th time	Practical course 5: Creating local grafted fruit tree seedlings	CNSF
10th time	Practical Course 6: Growing of local grafted fruit tree seedlings	Forest officer
11th time	Practical Course 7: Method of drip irrigation simply using a plastic can (25L) and dripper medical tubes Materials used for practical training ・Medical dripper pipe (200 FCFA) ・Plastic container with 25L (700 FCFA) ・Plastic bottle of cleaning product (50 FCFA)	INERA, Forestry officer
12th time	Theory 4: Sales Plan and management of tree seedlings 1) Establish an annual production plan for tree Seedlings 2) Fix the selling price of plants 3) Sale of plants and accounting management	Forest officer

Photo 5.5.1 Simple drip Irrigation (micro-irrigation) of mango seedlings from INERA in Banfora

【Training on drip irrigation system（micro-irrigation）】
Mango and cashew trees, etc. needing a volume of annual rainfall of over 1,000 mm, it is necessary to irrigate regularly after planting in an area such as the study area where rainfall is insufficient. For this reason, in this training, we have introduced and implemented a drip irrigation system simply practiced using a medical drip tube and a plastic container easily available locally.
This system was developed jointly by INERA Banfora and a private company. Unfortunately, there is no manual.
So far, this system has been introduced in the new plantations of mango and cashew trees (each planting area of 1 to 3 ha, 100-300 seedlings), and there are independent farmers who have introduced it with their own means.
The results of tests carried out by INERA Banfora for growth three years after planting, shows that this system is three times more effective[7] than rainfed cultivation.
1 set is installed per tree seedling. The introduction of fees is: Medical drip hose (200-300 CFA) and plastic container 20-25L (700-800 CFAF) available in the capital city.
【Treatment before sowing seeds of local fruit trees】[8]
・ Mechanical scarification of the pericarp (remove some layers of the pericarp)
・ Immersion in strong sulfuric acid (immersion for 2 hours)
・ Immersion in hot water (leave in hot water 48 h)

[7] According verbal surveys in February 2015 with INERA Orodara and Dr. Dakyo
[8] Refer to "8. Manual planting techniques "developed in 1999 by the Japan Green Resources Agency (J-Green)
(http://www.green.go.jp/green/gyoumu/kaigai/manual/sahel/french/vol08.pdf)

Photo 5.5.2 Training on Grafted plants

Photo 5.5.3 Training on simple drip irrigation

【Training materials of this study and cost】

(1) Training in the production of seedlings of trees to from seed

- Seeds (bought at CNSF): baobab (12,500 FCFA /kg), Moringa (18,000 FCFA /kg), tamarind (15,000 FCFA /kg), African locust (nere) (22,500 FCFA /kg), Acacia Nilotica (22,500 FCFA / kg), eucalyptus (8.125 F CFA /kg), others: plastic tubes (average: 200 units, small 800 units) = 30 FCFA/unitx 200 unit (average) + 15 FCFA /unit x 800 units (small) = 18,000 FCFA
- Watering can (1-2 for watering): 2.500 FCFA*
- Fence (20-25m x 2 units) = 24,000 FCFA x 2 = 48,000 FCFA
- Metallic wire (end): 1000 FCFA (wooden materials also usable for supports)
- Bucket (transport sand and water, etc.):2,000 FCFA
- Tricycle (transport of plants, etc.): 17,500 CFA

(2) Training on the production of grafted fruit trees seedlings

- Grafting knife:6,000 FCFA/unit
- Scissors size: 6,500 FCFA/unit
- Stone to sharpen: 6,000 FCFA/unit (if it is long, can be cut into two)
- Nylon tape (materials of packaging are also usable)
- Nylon bag (maintenance of moisture after grafting):450FCFA/ 100 units
- Plastic tube (large 100 unit) 50 FCFA /unit x 100 units = 5.000 FCFA

5.6 Distribution of fruit trees seedlings

5.6.1 Distribution method

- It happens that purchased tree seedlings are damaged during transportation
- The acquisition of land, the creation of the mechanism and the training of human resources are necessary for nurseries.

Seedlings distribution methods are the following:

(1) Distribute the plants purchased from farmer producers
(2) Establish a nursery, grow plants and distribute them
(3) Perform parallel (1) and (2)

For seedlings purchased transportation is necessary, but like many roads are not paved, it is done by donkey cart or tricycle, and plants can be damaged. In particular, in the case of grafted seedlings, damage and separation of the grafted portion occur easily, and many fade after planting.

Moreover, producing plants in the same planting site or its vicinity, we can prevent plant damage due to transport, but you must make sure to get the ground, creating the mechanism and train human resources for the production of plants. Moreover, it takes some time to get to regularly provide the required number of plants.

In this study, given the time limit, only the mode (1) has been tested in 2014 and the mode (3) in 2015

5.6.2 Number of plants to provide and distribution

- The number of plants to provide is set after checking if farmers have enough land for the number of plants requested, and if the labor required for planting is assured
- The distribution starts with the farmers who participated in training and have made preparations for planting
- The number of plants to be distributed from the 2nd time is considered on the basis of planting results, e.g. survival

Case of the current study: Number of plants to provide and distribution

(1)Planting area

The study of planting area of farmers wishing to participate in the planting has often given the result of 0.5 ha or 1.0 ha, that is to say 0.8 ha average

Table 5.6.1 planting area farmers wishing to participate in tree planting

(65 farmers)

Planting area	Number of farmers	%
2.0 ha	4	6.2
1.0 ha	20	30.8
0.5ha	21	32.3
0 to 0.4ha	1	1.5
No data	19	29.2

Note:

- 60 Farmers have actually participated in the tree planting activities Agroforestry, 5 farmers abandoned.
- This is not the amount of land owned by an individual, but the planting surface of trees, cropland presupposing the mixed cultivation can also be included. In February 2014

(2) Number of beneficiaries of the distribution

In 2014, the beneficiaries of the distribution were 60 independent farmers and 3 groups (school of women, women's group, and group planting). In 2015, they were 85 independent farmers and 5 groups (primary school, health center, women's school, , women's group, and group planting).

And the maximum number of seedlings distributed per farmer was 100 units (10m x 10m interval: 0.81 ha, 4m x 4m interval: 0.13 ha) to families with at least two adult men (over 15 years).

(3) Number of plants distributed

The plants distributed in 2014 and 2015 as part of this study were as follows.

Table 5.6.2 Variety and number of tree seedlings distributed in 2014

Variety	No. distributed	Beneficiaries	Use
(1) Eucalyptus	2,069	independent Farmers	Household consumption
(2) Acacia Nilotica	70	Independent Farmers (Fulani ethnic group)	Livestock forage (leaves, branches)
(3) Neem	43	School of women	Yard Limits
(4) Mango (grafted)	258	All participants (2 to 4 each)	Household consumption
(5) Cashew tree (without grafting)	171		Cash crops
(6) Lemon (without grafting)	5	Young Participants	Cash crops
(7) African locust (Néré)	310	Older participants	Household consumption (fruits)
(8) Tamarind	89	Household consumption of leaves and fruits	Household consumption (leaves and fruits)
8 species in total	3, 015		

Table 5.6.3 Variety and number of tree seedlings distributed in 2015

Variety	No.distributed	Beneficiaries	Use
(1)Eucaly-ptus	2, 131	Independent farmers	Household consumption (firewood, timber) Income in cash
(2)Acacia nilotica	140	Independent farmers (Fulani ethnic group)	Livestock forage (leaves, branches)
(3) Neem	120	Collective plantation	
(4) Kuka	20	Independent farmers (Fulani ethnic group)	Livestock forage (leaves, branches)
(5) Moringa	110	All participants	Home consumption (edible leaves)
(6) Mango (grafted)	268	Independent farmers Public institutions (health center, primary school, etc.) Collective plantation	Household consumption (fruits) Sunlight, Cash crops
(7) Jujube (grafted)	140		Household consumption (fruits) Livestock forage (leaves, branches)
(8) Lemon (grafted)	164	All candidates for participation	Household consumption (fruits), Cash crops
Lemon (Non-grafted)	43	Independent Farmers	Household consumption (fruits), Cash crops
(9) Cashew (Non-grafted)	12	Independent Farmers	Cash crops
(10) Shea (Non-grafted)	20	1 per participant requesting distribution	Household consumption (fruits, nuts)
Shea (grafted)	10	Groups of women (forecast)	Shea Butter, sale of surplus
(11) Néré	500	independent farmers, collective plantation	Household consumption (fruits)
(12)Tamarind	130	Independent Farmers, collective plantation	Household consumption (leaves and fruits)
(13) Baobab (grafted)	112	1 per participant requesting distribution Group of women	Household consumption (leaves and fruits)
Baobab (Non-grafted)	100	Independent farmers	Household consumption (leaves and fruits)
13 species in total	4,020		

5.7 Implementation of planting local fruit tree seedlings on farm plots

It is desirable that advice is given by tour visits for planting seedlings of local fruit trees on agricultural land is carried out properly according to the training.

Case of the current study: Implementation of planting

5.7.1 Interval planting

Planting intervals defined by objective and variety in this study are the following. These intervals were established on the basis of instructions given by the forest officer at the collective plantation, and the recommendations and instructions of INERA and CNSF. Moreover, the interval measurement made with a knotted rope, etc. was taught during the training for planting.

Table 5.7.1 planting intervals recommended by the objectives and varieties

Objective	Tree variety	Planting Interval
Timber for construction (single layer)	Eucalyptus, neem, Acacia Nilotica	4m x 4m
Timber for construction (single layer) + production of cereals	Eucalyptus, neem, Acacia Nilotica + Millet, sorghum, maize	6m × 6m
Fruit trees (scrubs) Intensive cultivation	Jujube, citrus, etc.	4m x 4m
Fruit trees (large trees) Intensive cultivation	Mango, cashew, African locust (nere), baobab, shea, etc.	5m × 5m
Fruit trees (shrubs or small trees) + Production of cereals	Mango, cashew, African locust (nere), baobab, shea, etc. + Millet, sorghum, maize, etc.	10m × 10m
Fruit trees (shrubs or small trees)+ Cash crops	Fruits + cowpea, groundnut, sesame, hibiscus, etc.	10m × 10m

5.7.2 Planting method

(1) Size of planting pits:
The size of planting pits defined in this study is the followings. As for planting interval, the decision was made based on the experience of the forest officer and CNSF.

Table 5.7.2 Size of the planting hole recommended by variety of tree

Goal	Variety of trees	Size of the planting hole
Afforestation varieties of trees (for timber)	Eucalyptus, Neem, Nilotica Acacia	60cm × 60cm × 60cm
Fruit trees	Jujube, citrus, etc. Cashew, African locust (nere) , baobab, shea, etc.	80cm × 80cm × 80cm
Fruit trees	Mango	100cm × 100cm × 100cm

(2) Fertilization
The land is often red soil of low fertility; the hole is not backfilled soil surface after planting, cattle feces, etc. are injected instead.

(3) Time of planting
The grafted plants dislike drought and the graft portion of the grafted fades easily. For this reason, it is desirable that the planting hole should be prepared after the start of the rainy season, and planting is done once the rains fell continuously. Particular attention is paid to planting early in the rainy season because the soil in the hole can compress and collapse and the plants may be planted too deeply.

5.7.3 Selection of intercropping with farmers

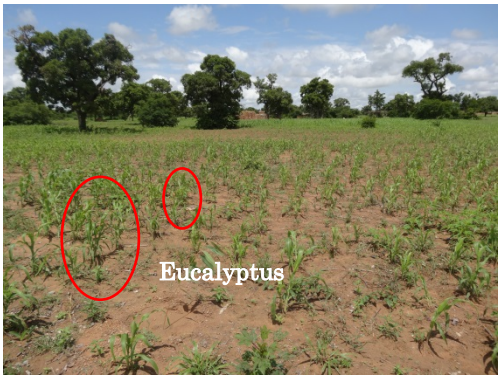

Photo 5.7.1 Intercropping of Eucalyptus and Millet

When selecting products to grow, we must of course choose crop plants on site and corresponding to the wishes of the farmer, but the introduction of new varieties for which test results by the research organization were positive should be studied.

5.8 Monitoring after planting on agricultural land

The state after planting is monitored to capture the management conditions of farmers and remedy tree planting activities, or to define the extent of planting the following year and select the varieties of trees to plant.

5.8.1 Management of tree planting and survival rate

Monitoring on the management of tree planting farmers and seedlings survival rate is conducted six months after planting. The topics of the monitoring are: contribution of fertilizer per tree variety, implementation of protective fencing, watering or not after planting and tree survival rates.

Case of the current study: Putting into practice intercropping and monitoring after planting

5.8.2 Practical implementation of intercropping by farmers

39 of the 50 farmers (78.0%) for whom follow-up study was achieved among the farmer participants performed intercropping after planting trees. The example of intercropping of farmers who made the tree planting in 2014 is given below. Many have produced sorghum and millet; there were also combinations sorghum and millet, millet and groundnuts, millet and maize, etc. The objectives of the selection of intercropping vary depending of farmers.
For example, if the cultivation surface is limited, and millet or sorghum is chosen because insurance of the staple food is a priority.

Table 5.8.1 Examples of intercropping with tree variety

Tree variety	Crops	Number of cases	(%)
Afforestation varieties (eucalyptus) 39 farmers	Sorghum	18	46.2
	Millet	8	20.5
	Peanut	3	7.7
	Sorghum millet +	2	5.1
	Millet + peanut	1	2.6
	Cowpea	1	2.6
	Unknown	6	15.4
Local fruit trees (locust bean) 11 farmers	Millet	4	36.4
	Sorghum	2	18.2
	Peanut	2	18.2
	Sorghum millet +	1	9.1
	Sesame	1	9.1
	Unknown	1	9.1

5.8.3 Monitoring Results

We checked through recognition on agricultural plots six months after planting trees if there was fertilizers input before trees planting and protection fence set up after, and tree survival rates.

Table 5.8.2 Reforestation Management in 2014 and variety of tree survival rates

Tree variety	Number of samples	fertilizer Input rate	Setting up a fence rate	Watering frequency rate after planting	Survival
Eucalyptus	40	2.5% (1)	7.5% (3)	7.5% (3)	38%
Mango	50	82% (41)	80% (40)	100% (50)	52%

Photo 5.8.1 state of eucalyptus plantation

Photo 5.8.2 State of mango trees planting

5.8.4 Number of days of work and inputs for trees planting

We studied the number of people and days assigned for planting to capture the work done by farmers for planting trees. The work of planting was done with family or relatives (especially consanguineous brothers); staff was employed to do so only in 2 cases.

Table 5.8.3 Comparison of labor input by number of planted eucalyptus

Scope of plantation	Number of farmers	Average age	Average number planted	Survival rate	Number of days of planting		Number of staff		Labor input
(number)	(Home)	(years)	(number)	(%)	Moy	Max	Moy	Max	Man-days
6～20	4	64.3	16.5	31.6	2.8	4	2.2	4	6.2
21～30	22	45.1	24.6	46.1	3.1	3	1.7	5	5.3
50	9	48.2	50	35.3	5.4	10	2.9	6.5	15.7
60	1	430	60	16.7	5	-	5	-	25.0
70	1	55.0	70	29.0	2	-	4	-	8.0
100	4	55.5	100	29.3	4.0	5	2.1	3	8.4
Total	41	50.0	38.1	36.3	3.7	-	2.0	-	7.7

Note: Children (under 15) are counted 0.5 persons among those involved in planting.

5.9 Example of calculating the profitability of activity of trees planting and Agroforestry

It is important to plan the profitability of tree planting and agroforestry to promote tree planting activities. To this end, mixed cultivation models of feasible agroforestry on agricultural plots are defined to estimate profitability.

Case of the current study: Evaluation of the profitability of tree planting activities and AF

The profitability of tree planting and agroforestry activities was assessed as below on the basis of data obtained in this study.

5.9.1 Definition of mixed cultivation for Agroforestry

(1) Calculation Conditions
The mixed planting of agroforestry models, varieties of trees planted, the unit price and quantity of seedlings and harvesting are indicated below.

Table 5.9.1 Mixed agroforestry cultivation Models

Trees		Intercropping		Main goals
Tree variety	Number of trees planted (number /year)	Crops	Area planted (ha)	
Eucalyptus	50	Cowpea	0.25	Timber sales and cereals
Mango	10	Sesame	0.2	Sale of fruits, cash crops
Nere	50	Sesame	1.0	Sale of fruits, cash crops

Table 5.9.2 Varieties of trees planted

Variety	Number of trees planted (number / year)	Interval plantin g	Felling	Beginnin g of the harvest	Survival rate	Notes
Eucalyptus	50	4m x 4m	3th, 7th, 10th year	-	35%	Reforestation period 10 years
Mango	10	10m × 10m	-	3th Year	50%	Grafted plants
Nere	50	10m × 10m	-	8th year	80%	Local fruit trees

Table 5.9.3 Unit price (results in 2014, 2015)

Item	Variety	Unit	FCFA	Notes
Fresh tree seedlings	Eucalyptus	seedling	150	
	Mango	seedling	1,500	Grafted plants
	Nere	seedling	300	
Timber Sales Price	Eucalyptus	Tree	1,500	
Fruit sale price	Mango	Piece	100	
	Nere	Kg	600	
Seed costs	Cowpea	Kg	300	Improved variety
	Sesame	Kg	1,000	Improved variety
Selling price	Cowpea	Kg	280	Improved variety
	Sesame	Kg	500	Improved variety
Chemical fertilizers		50kg	18,000	
Insecticides		200ml	5 000	
Simple drip Watering	For mango	Set/tree	900	Usable for 5 years

Table 5.9.4 planting and harvesting Quantities

Item	Variety	FCFA	Unit	Notes
Sowing amounts	Cowpea	10	kg/ha	
	Sesame	6	kg/ha	
Harvest unit	Cowpea	500	kg/ha	Improved variety
		250	kg/ha	Improved variety
	Sesame	300	kg/ha	Improved variety
Yield	Mango	10	Pieces/tree	3th Year
		20	Pieces/tree	4th year
		40	Pieces/tree	5th year
		50	Pieces/tree	6th year
		70	Pieces/tree	7th year
		80	Pieces/tree	8th year
		90	Pieces/tree	9th year
		100	Pieces/tree	From the 10th year
	Néré	5	kg/tree	8- 15 years
		10	kg/tree	16- 20
		20	kg/tree	21- 25
		30	kg/tree	26- 30

5.9.2 Cash flow of farming charges

(1) Timber and grain Sale: Mixed cultivation of eucalyptus and cowpea (improved variety)
Assuming a eucalyptus wood (51 trees) 0.25 ha (range 4m x 4m) is finally obtained
The farm and crop forecast plan reported here, and on the cash flow are shown below.

Table 5.9.5 Farm and harvest forecast plan when mixed with eucalyptus planting and cowpea (improved variety)

Tree planting and intercropping	Item	Unit	1st year	2nd year	3rd Year	4th year	5th year	6th year	7th year	8th year	9th year	10th year
Eucalyptus wood	Planting	Tree	50	50	50							
Surface 1.0 ha plantation	Cultivation	Tree	17	34	51							
Seedling survival rate 35%	Germination	3 units/tree				153	153	153	153	153	153	153
	Harvest	Tree			51				153			153
Cowpea												
0.25 ha cultivated area	Seedling	Kg	2.5	2.5	2.5							
	Chemical fertilizers	Kg	25	25	25							
	Insecticides	Ml	100	100	100							
	Harvest	Kg	125	125	125							

Table 5.9.6 Cash flow when mixed with eucalyptus planting and cowpea (improved variety)

Spending		Unit	1st year	2nd year	3rd Year	4th year	5th year	6th year	7th year	8th year	9th year	10th year
Eucalyptus	Seedlings costs	FCFA	7,500	7,500	7,500							
Cowpea	Seed costs	FCFA	750	750	750							
	Chemical fertilizers	FCFA	9,000	9,000	9,000							
	Insecticides	FCFA	2,500	2,500	2,500							
Total Receipts			19,750	19,750	19,750	0	0	0	0	0	0	0
Plantation Eucalyptus	Timber Sale	FCFA			76 500				229 500			229 500
Culture cowpea	Sale of grain	FCFA	35 000	35 000	35 000							
Total			35 000	35 000	111 500	0	0	0	229.500	0	0	229 500
Cash flow			15 250	15250	91,750	0	0	0	229.500	0	0	229 500
				30 500	122250	122250	122250	122250	351750	351750	351750	581250

(2) Sale of exotic fruit trees and cash crops: mango mixed planting and sesame (improved variety)

Assuming that a field of 15 mango trees (range 10m x 10m) is finally obtained

Farm and harvest forecast plan reported here, and on the cash flow are shown below.

Table 5.9.7 Farm and harvest forecast plan in the case of mixed mango and sesame crop (improved variety)

Tree planting and intercropping	Item	Unit	1st year	2nd year	3rd Year	4th year	5th year	6th year	7th year	8th year	9th year	10th year	From 11th year
Mango trees (0.2 ha)	Planting	Tree	10	10	10								
Surface 0.2 ha plantation	Planting	Tree	5	10	15	15	15	15	15	15	15	15	15
Seedling survival rate 50%	Drip Watering	set/tree	5	5	5			5	5	5			
	Harvest	Unit			150	300	600	750	1050	1200	1350	1500	1500
Sesame cultivation 0.2 ha acreage	Seedlings	Kg	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
	Chemical fertilizers	Kg	20	20	20	20	20	20	20	20	20	20	20
	Harvest	Kg	60	60	60	60	60	60	60	60	60	60	60

Note: Planting and plowing are made with family, and the price for shipment scheduled for sesame set at 500 CFA francs / kg.

(3) Sale of exotic fruit trees and cash crops: African locust (néré) mixed planting and sesame (improved variety).

Assuming that a field of 120 African locust (néré) (range 10m x 10m) is finally obtained

Table 5.9.9 Farm and harvest forecast plan in the case of mixed African locust (néré) and sesame crop (improved variety)

Tree planting and intercropping	Item	Unit	1st year	2nd year	3rd Year	4th year	5th year	6th year	7th Year	From 8th year	From 16th year	From 21th year	From 30th year
African locust (Néré)	Planting	Tree	50	50	50								
Surface 1.0 ha plantation	Crop	Tree	40	80	120	120	120	120	120	120	120	120	120
Seedling survival rate 80%	Harvest	Kg								600	1200	2400	3600
Sesame													
Cultivated surface 1.0 ha	Sowing	Kg	6	6	6	6	6	6	6	6	6	6	6
	Fertilizer	Kg	100	100	100	100	100	100	100	100	100	100	100
	Harvest	Kg	300	300	300	300	300	300	300	300	300	300	300

The farm and crop forecast plan reported here, and on the cash flow are shown below.

Table 5.9.10 Cash flow under mixed of African locust (Néré) and sesame crop (improved variety)

Spending			1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	From 8th year	From 16th year	From 21th year	From 30th year
African locust (Néré)	Plants	FCFA	15,000	15,000	15,000								
Sesame	Seeds	FCFA	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
	Fertilizer	FCFA	36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000
Total			57,000	57,000	57,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000
Receipts													
African locust (Néré)	Sale of fruit	FCFA	0	0	0	0	0	0	0	360,000	720,000	1,440,000	2,160,000
Sesame	Seed Sale	FCFA	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000
Total			150,000	150,000	150,000	150,000	150,000	150,000	150,000	510,000	870,000	1,590,000	2,310,000
Cash flow			93,000	93,000	93,000	108,000	108,000	108,000	108,000	468,000	828,000	1,548,000	2,268,000
				186,000	279,000	387,000	495,000	603,000	711,000	1,179,000			

(4) Results

Table 5.9.12 Profitability during the decade after trees planting by model mixed agroforestry crop

N°	Trees			Intercropping		Profit of agroforestry
	Variety	Size of reforestation (number of trees)	Area planted with trees (ha)	Crop	Area (Ha)	Decade after planting (FCFA)
(1)	Eucalyptus	51	0.25	Cowpea	0.25	588,750
(2)	Mango	15	0.2	Sesame	0.2	834,000
(3)	Néré	120	1.2	Sesame	1.0	2,115,000

Note:

- The Intercropping in eucalyptus finishes 3rd year, and only the sale of timber is carried out from the 4th year.
- In Case of maintenance of the mango field (15 trees) and the mixed cultivation with sesame (0.2ha) for 10 years, selling fruit and sesame brings in a revenue of 171,600 FCFA/year from the 11th year
- In case of African locust (Néré) field (120 trees) in mixed cultivation with sesame (1.0 ha), only the sale of Sesame will be made until the 7th year.

Table 5.9.13 List of all returns in the 20 years after the planting of trees by model mixed agroforestry crop

No.	Trees			Inter cropping		Profit for agroforestry
	Variety	Size reforestation (number of trees)	Area planted with trees (ha)	Culture	Area (Ha)	Decade after planting (FCFA)
(1)	Mango	15	0.2	Sesame	0.2	1,056,000
(2)	Néré	120	1.2	Sesame	1.0	1,548,000

Note:

-The Intercropping in eucalyptus trees finishes at the 3rd year, and only the sale of timber is made from the 4th year.

-In Case of maintenance of the mango field (15 trees) and the mixed plantation with sesame (0.2 ha) for 10 years, selling fruit and sesame brings in a revenue of 171,600 FCFA/year from the 11th year.

- In Case of African locust (Néré) field (120 trees) in mixed plantation with sesame (1.0 ha), only the sale of Sesame will be made until the 7th year.

5.9.3 Evaluation of profitability

1) Timber and cash crops: eucalyptus and cowpea

Eucalyptus is usable for mixed farming until its 3rd year after planting, and intercropping (0.25 ha) of improved cowpea variety of very commercial is performed. Calculation results show that we can expect a profit of FCFA 20,000 to 90,000 during the period of mixed farming and 230,000 FCFA of cutting eucalyptus (7th and 10th years).

2) Exotic Fruit trees and cash crops: mango and Sesame

The harvest of mangoes is possible from the 3rd year after planting, but it takes 10 years to stabilize the annual harvest of fruit of 100 units /tree. For this reason, sesame intercropping (0.2 ha) is performed to generate a profit.

Calculation results show that from the 11th year after planting when the fruit harvest begins to stabilize, with sales of sesame, we can expect an annual profit of 171,600 FCFA and from the 21st year an annual profit of 1,056,000 FCFA

3) Local fruit tree and cash crops: African locust (néré) and Sesame

There is no fruit harvest of African locust (néré) until the 8th year after planting, and therefore no income from the sale of fruit. And it takes 20 years maintenance until fruits harvesting is stabilized. Sesame intercropping (1.0 ha) is performed to generate a profit.

Results calculation show that from the 21st year after planting when the fruit harvest begins to stabilize, with sales of sesame, we can expect an annual profit of 1,548,000 FCFA.

Chapter 6 Practical implementation - Production of photovoltaic solar energy -

6.1 Particularities of the production of photovoltaic solar energy

In Burkina Faso, although the grid extension is required to meet the energy needs growing rapidly, energy resources are limited and the development of electricity infrastructure is not advanced.

Photovoltaic solar energy production can be a solution to solve this problem of power, because it helps provide electricity in an autonomous and decentralized manner, and can contribute to the supply of electricity even in areas difficult to access. Globally too, clean and inexhaustible photovoltaic solar energy is promising for the creation of a sustainable community. Below are explained the characteristics of the production of photovoltaic solar energy.

1) The production of photovoltaic solar energy consumes little energy, and high energy efficiency

Photovoltaic solar energy consumes very little energy in its life cycle from manufacture to disposal. Recent studies show that the period of solar energy required to recover the energy consumed in the life cycle is only 2.0 years[1]. No fuel is used to operate the system, and electricity being generated by absorption of the unlimited solar energy, energy is continuously produced with injection of a minimum of energy in the initial stage. Moreover, much energy is lost in the process of producing electricity with fossil fuel, and thus the energy injected in the life cycle cannot be recovered.

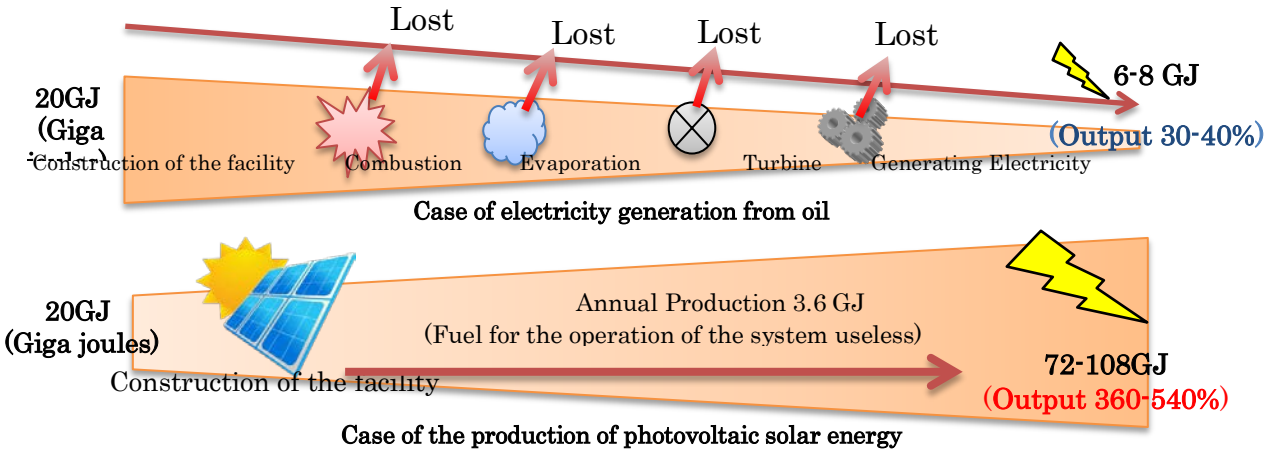

Figure 6.1.1 Energy Output in the life cycle of a photovoltaic solar plant

Source: Mizuho Information & Research Institute (2009): Established on the basis of the report of the NEDO (New Energy and Industrial Technology Development Organization)

[1] Research Association on the production of photovoltaic solar energy technologies (PVTEC, 2001): Report of the results of NEDO "Studies and Research Evaluation photovoltaic solar energy"

2) CO2 emissions during the life cycle of a photovoltaic system are very limited.

The CO_2 emissions during the life cycle of a photovoltaic system are very limited, and the production period for the recovery of CO_2 emitted is approximately 2.7 years [2]. Even including all that is evacuated e.g. at the time of construction, CO2 emissions are approximately 17-48 g CO_2/kWh in the case of a photovoltaic system. In the case of electricity generation from fossil fuels, CO_2 emissions are very important: from 519 to 975 g CO_2 /kWh.

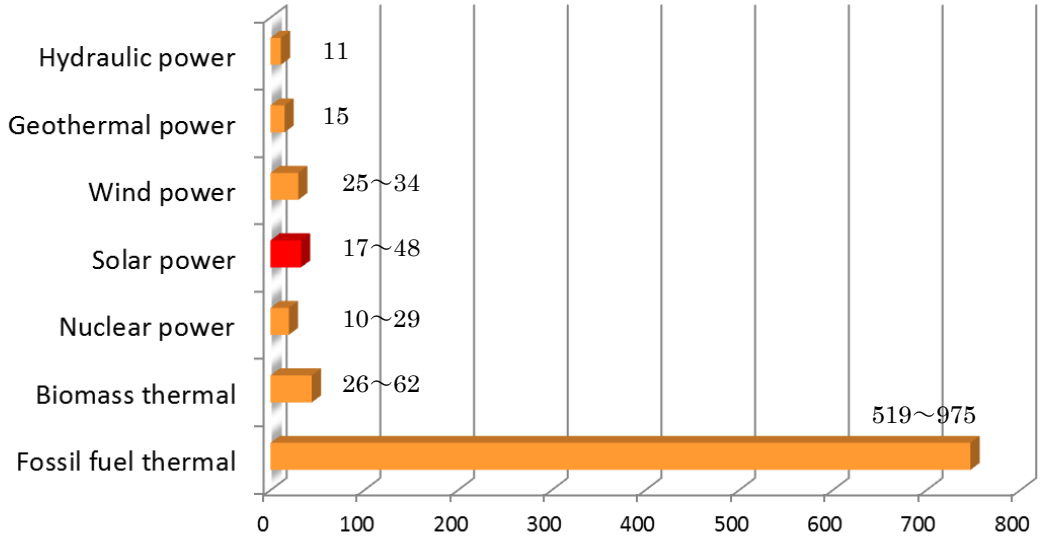

Figure 6.1.2 Comparison of greenhouse gas emissions of different energy sources for electricity production (g- CO_2/kWh)

Source: Prepared by referring to the home page[3] of Research Center on Photovoltaic Technologies (RCPVT) of the National Institute Advanced Industrial Science and Technology *(AIST) Research Center for Photovoltaic Technologies (RCPVT), National Institute of Advanced Industrial Science and Technology (AIST)*

3) High cost of Photovoltaic solar energy

The major problem of the photovoltaic system is the high cost of electricity production. Although the production cost decreases over the years through technological innovations, the cost difference with other systems is still important and is a major obstacle to its dissemination.

[2] Yoji UCHIYAMA, et al. (1991) : Study Report of the Central Research Institute of Electric Power Industry: Central Research Institute of Electric Power Industry Y90015

[3] https://unit.aist.go.jp/rcpvt/ci/about_pv/e_source/RE-energypayback.html#fig3, AIST, 2015.4.25

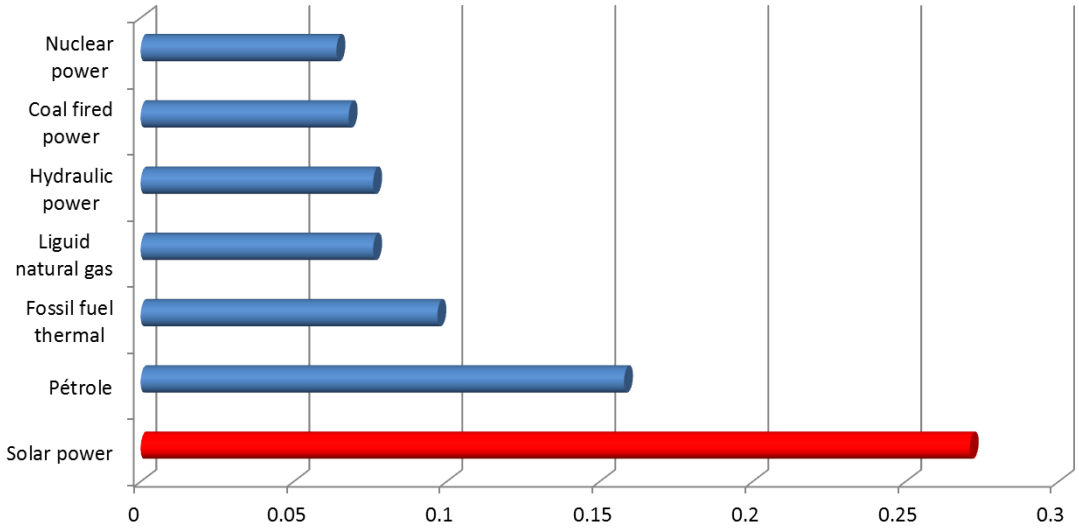

Figure 6.1.3 Comparison of the cost of production of electricity system

Source: Prepared based on the home page of Tokyo Gas Co., Ltd. (2010)[4]

6.2 CO2 emissions reduction by setting up a photovoltaic solar system and the creation of an income generating mechanism

6.2.1 Background and objectives of the present Study

Although the photovoltaic solar system is remarkably efficient of energy production, and the cost of implementation has declined, its distribution is not advanced particularly in low-income countries. In advanced search, the following points below are cited as causes of non-progression of its dissemination[5][6].

- The high cost of installation of the photovoltaic system and ancillary facilities
- The high cost of maintenance of the PV system (including crime prevention measures)
- The absence of income generating mechanism to contribute to the reduction of poverty

Furthermore, it indicates insufficient knowledge of the lifestyle and customs of the inhabitants of the area, and evaluation and research on the investment environment and the socioeconomic impact.

[4] http://www.tokyo-gas.co.jp/IR/library/pdf/investor/ig1328.pdf, 2015.4.25

[5] Mizuho Research Institute (2012): Working Papers "assistance Trends in the dissemination of photovoltaic solar system in low-income countries, and problems identified," p.2

[6] http://www.reegle.info/policy-and-regulatory-overviews/BF, 2015.4.24

The major problem of the photovoltaic solar system is the high cost of electricity production. To ensure its dissemination in developing countries, we must create income-generating activities for recovering the cost of production.

For this purpose, in this study, it was decided to conduct a verification of creating an income generating mechanism by setting up a photovoltaic solar system. Experimental verification study was done in the village of Gu by installing a photovoltaic solar system will allow energy savings in the collection and distribution of water, and the effect of a new income generating activity, namely market gardening in dry season for the sale on the market was studied. The village of Gu with no usable water resources during the dry season, the assurance of income during the dry season is a major problem.

This document compiles the methodology of efficient use of water by the introduction of photovoltaic solar system, the methodology of verification of the economic relevance of irrigated agriculture on a small scale, which is a new income generating activity, the methodology of Quantitative assessment of the reduction of CO2 emissions.

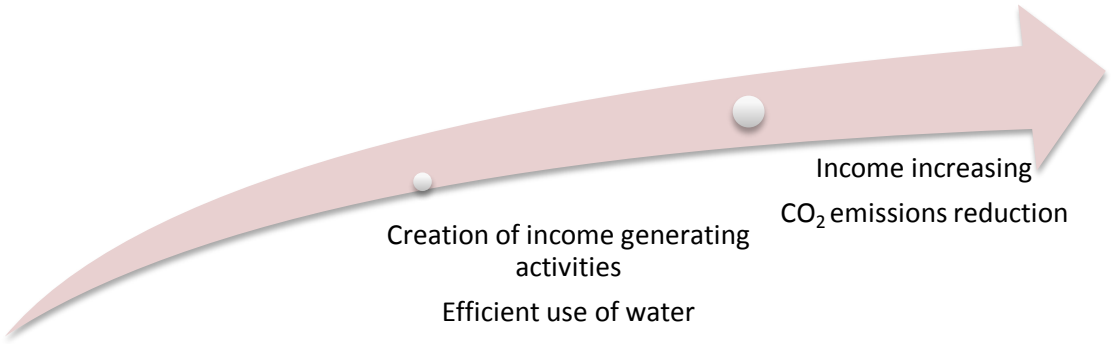

Figure 6.2.1 Image of the expected effects of the introduction of photovoltaic solar energy

6.2.2 Overview of the Study

In the village of Gu, Boussé City, in the province of Kourwéogo, where the study was conducted, surface water resources used during dry season are reduced, making farming difficult during the dry season and limits income generating activities. Therefore, to allow farmers to practice small scale irrigated agriculture as a source of income during the dry season, a solar PV system has been installed on the existing drilling hand pump, to save energy in the collection and distribution of water. Furthermore the introduction of water saving cultivation technique (drip irrigation) allowed the village association to start growing vegetables for sale on the market (hereinafter included "gardening (MG)") during the dry season. The time devoted to experimental verification of this study was 2 years from 2014-2015.

6.2.3 Conduct of the study

This study is divided into insurance part of the water supply equipment, design and maintenance of photovoltaic solar installation, and the non-material part of water use and facility management.

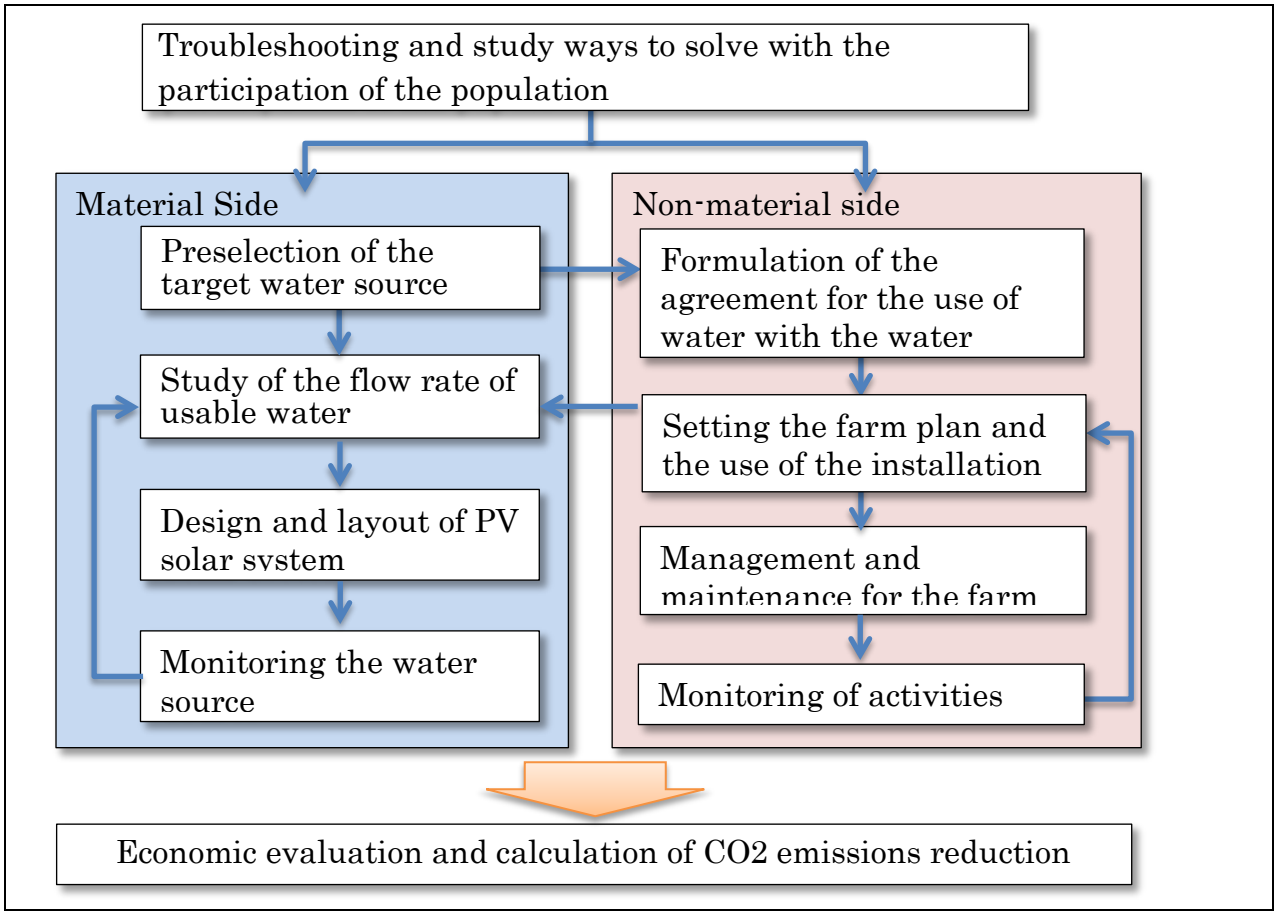

Figure 6.2.2 Conduct of the Study

Below are given the points to consider for each item of study, following the course of this study.

6.3 Selection of the existing borehole (source of water)

6.3.1 Preselection of target source water

There is no usable surface water source during the dry season in the village of Gu. For this reason, an underground source of water used for small scale irrigation was shortlisted among the eight drinking water supply facilities (wells with hand pump).

Preselection main conditions:
Nature of the soil in the area, slope of the land, access to the borehole, drilling depth, water quality, borehole construction years

1) Soil around and slope of the land
Soil type, exposure or not of the base and tilt of the field are checked to judge the adaptation as farmland. Whether to provide remote fields from the borehole, the cost of the construction of the pipeline and the cost of maintenance must be taken into account.

2) Access to the borehole
Maximizing of beneficiaries is taken into account. Nevertheless it is preferable to have a water source near the village given the management of the photovoltaic solar system and measures to crime prevention.

3) Drilling Depth
The depth of drilling affects the cost of introducing the submerged motor pump and the cost of maintenance.

4) Water Quality
For the study parameters, we can think primarily salinization, EC value as an index of pollution and sulfuric acid, ammonia, iron easily causing clogging of strainers casing drilling, etc.

5) Borehole construction year
Borehole service life depends on the quality of drilling construction, maintenance conditions and the state of the aquifer. The borehole service life is generally from 15 to 20 years, a borehole used for over 10 years will be judged as a precaution on the basis of the results of the pumping test and analysis of the quality of water.

6.3.2 Selection of the borehole (source of water) and definition of usable water yield for irrigation

For the successful borehole, the maximum allowable pumping rate of drilling is set via pumping tests spaced out. Although pumping data taken at the time of construction are available, it is desirable to repeat the tests because the drill is degraded.

Setting the water flow used for irrigation in view of consideration of safe pumping rate and water supply conditions

1) preliminary discussions with the Association of water users

The Association of water users is the manager of borehole, and priority uses of the facility are drinking water and water for daily needs. For this reason, we must obtain its agreement on the objectives and content of tests before starting pumping tests.

2) Pumping tests

The pumping rate is tested by pumping in spacing over 3 stages, and safe flow evaluated from lower water level compared to the pumping rate.

3) Study of the conditions of use of water

The number of people served, the supply time and the flow provided etc. are designed to identify the conditions for using the borehole water.

Case of the current study: setting the flow of usable water

1) Pumping Test

In this study, a pumping test was performed three times: twice (2 borehole x 1 for each) to identify the source of water, and 1 time (1 borehole x 1 time) to assess the maximum allowable pumping rate during the dry season.

A) Pumping test to identify the source of water

A phased pumping test was performed in 3 steps for No.1 (Figure 6.3.1). Figure Study of critical pumping rate (Figure 6.3.2) shows the absence of inflection point drop in the water level. The inflection point is a point at which occurs a change in inclination of the curve at 45˚, a point where the percentage increases in the drop in groundwater exceeds the percentage increasing flow pump. In other words, pumping 4.5m^3 /h during the rainy season was considered safe.

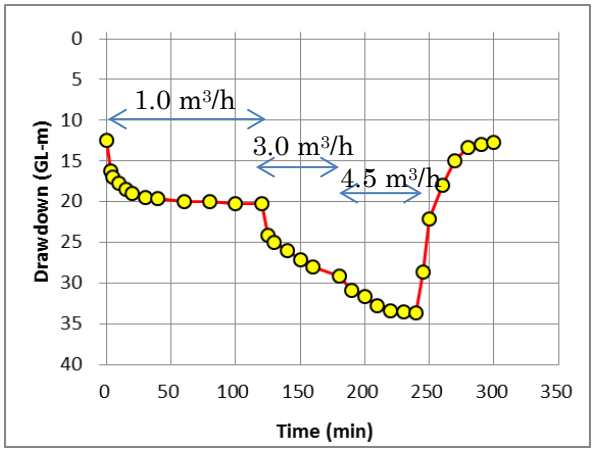

Figure 6.3.1 Results of the borehole pumping test N°1

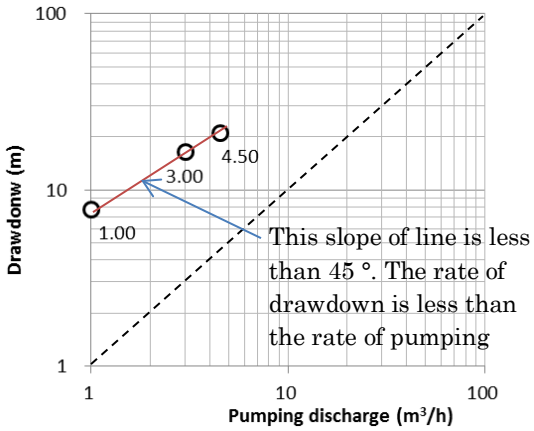

Figure 6.3.2 Study of the critical flow of pumping of the borehole No.1

A spaced pumping test in 2 steps was carried out for N°2 (Figure 6.3.3). The figure Study of critical pumping rate (Figure 6.3.4) shows that the slope of the graph is greater than 45°, suggesting that the pumping rate of 1.2m³ /h exceeding the critical flow pumping.

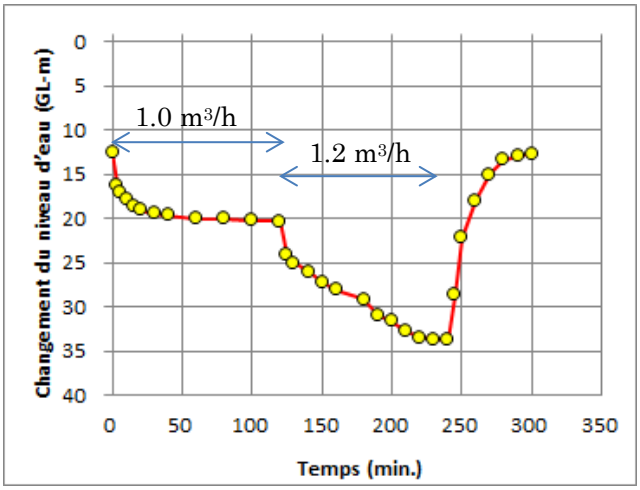

Figure 6.3.3 Results of the borehole pumping test N°2

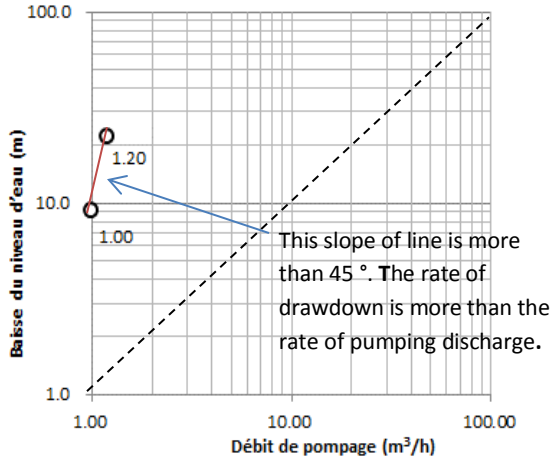

Figure 6.3.4 Study of the critical flow pumping of borehole N°2

The above points were used to select the borehole No.1 as water source usable for irrigation.

B) Pumping test to set the maximum allowable pumping flow during the dry season

The pumping test in the dry season (February 18, 2015) was performed on the selected borehole (Figure 6.3.5). But because of an execution system problem in the dry season, the pumping test was performed in 2 stages.
Figure Study of critical pumping rate (Figure 6.3.6) shows that in dry season the inclination exceeds 45˚ and increased pumping rate of 1.7m^3/h to 2.5m^3 is considered dangerous. The pumping rate at the inflection point to 45˚ that could not be found, the pumping rate of 1.7m^3/h, where the lower level of water to 8 m is stable, was defined as temporary maximum allowable pumping rate. A revision is possible according to future changes in the level of groundwater. Assuming 6 pumping hours per day (the average sunshine duration of 2004 to 2013 being 8.2 hours), the pumping rate was 10.2m^3/day.

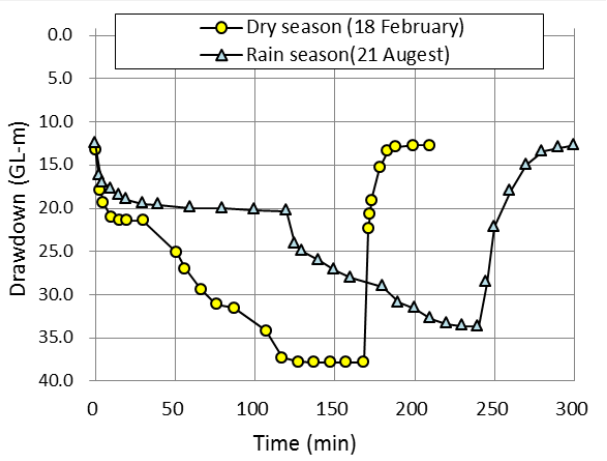

Figure 6.3.5 Results of the spaced pumping test during the rainy season

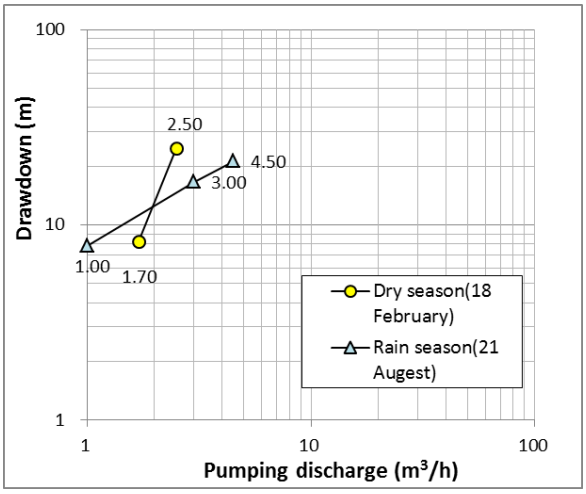

Figure 6.3.6 Figure of the Study critical flow pumping

2) Study of the borehole water use conditions

A study of the borehole water use conditions (Photos 6.3.1 and 6.3.2) was conducted to clarify the water supply situation from the selected borehole. According to the standards, criteria, and indicators of water (drinking water) supply provided in the PN-AEPA2015[7], the population served is estimated 300 pers. /day per structure in the case of a borehole with manual pump, and flow provided per person 0.02m^3/day, which is projected to provide a flow rate of 6m^3 /day.

Dates of study: from 1 to 4 February, and April 2 to 4, 2015, from 6 am to 18 pm

[7] National Drinking Water Supply Program and Sanitation on the horizon 2015

Elements of the study: names of neighbourhoods inhabited by water pumpers, pumping time, water flow by pumping, population served by pumping water use provided

Figure 6.3.7 shows the number of pumpers per hour for 7 days and the results of the study provided the water flow. Many residents are pumping between 3 and 6 PM, so if the water was used for irrigation in the morning, it would have little effect on the use of water for daily life. Moreover, the daily pumping rate is an average of 2.9m^3/ day and 3.2m^3 /day maximum of 2.5m^3/ ay minimum and the population served 228 people, which is less than the population served and the flow supplied standard with a manual pump borehole. Therefore, considering safety, the flow of water for daily life and drinking water was set at 4.0 m^3/ day.

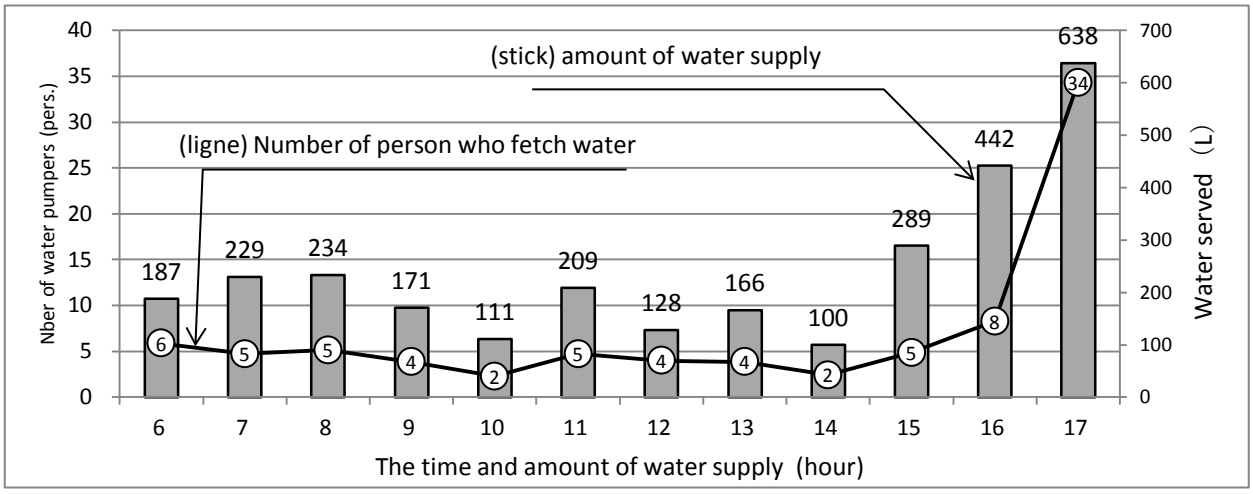

Figure 6.3.7 Number of pumpers and flow provided per hour


Photo 6.3.1 Study on water use


Photo 6.3.2 Water transport

3) Definition of water flow usable for irrigation

The study showed that 6.2m^3 /day are the flow of water used for irrigation of the source.

Table 6.3.1 Water flow used for irrigation of the borehole under study (dry season)

Borehole n°	Water supply for daily life (m^3/ day)	Maximum available pumping rate (m^3/ day)	Available water use for irrigation (m^3/ day)
	4.0	10.2	6.2

Note: irrigation water = available pumping rate - water supply for daily life

6.4 Design of solar pumping installation

Solar pumping installation is designed according to the usable water flow of the source of water concerned.

6.4.1 Structure of the small scale solar pumping system

The structure of the small-scale solar pumping system is as follows. In case of margin in power generation, system expansion is possible by the addition of battery.

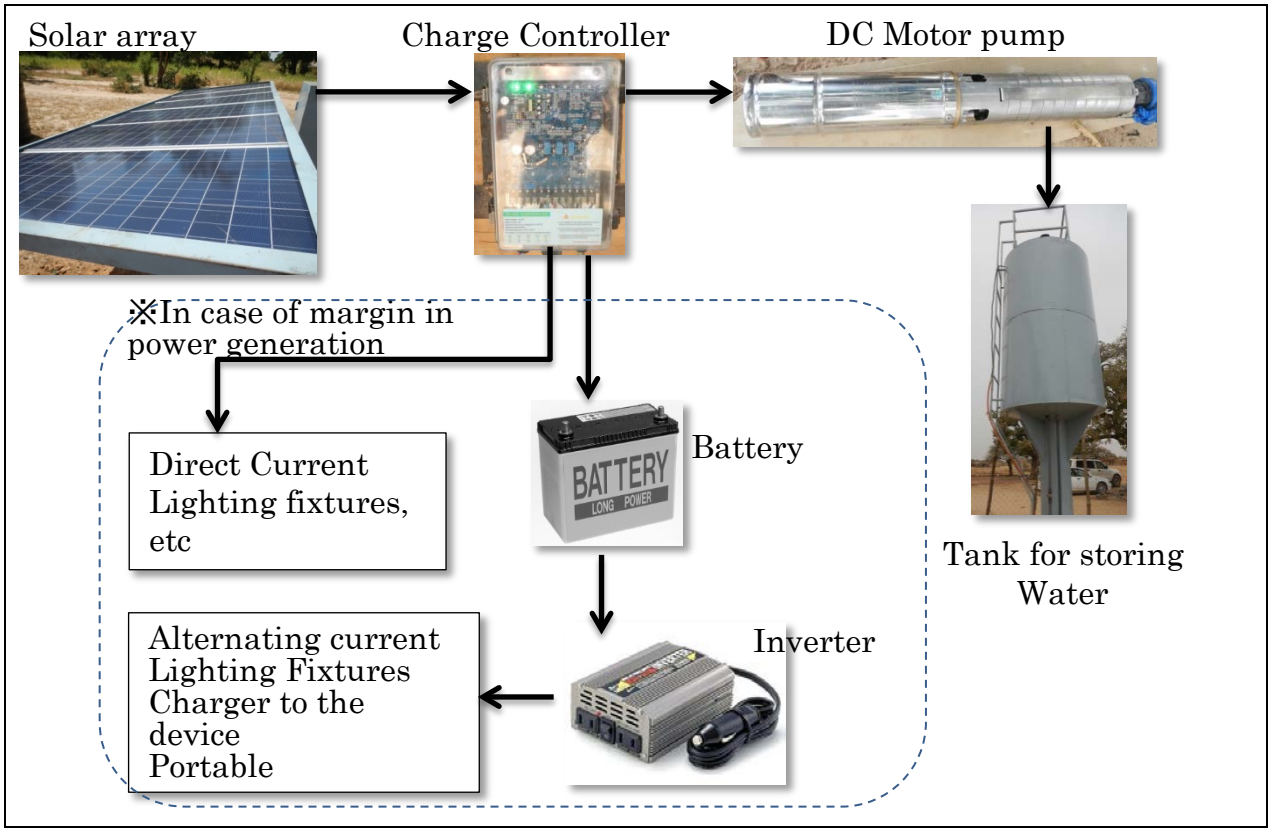

Figure 6.4.1 Elements constituting the small scale solar pumping system

Notes:

(1) Charge Controller

Necessary to convert the direct current voltage obtained from the photovoltaic cells voltage for equipment use. In addition, it monitors the battery voltage and prevents overcharging, over discharge, and the return of power to the photovoltaic cells.

(2) Inverter

Electrical circuit producing electrically alternating current from the direct current, or power converter including this circuit.

6.4.2 Stages of the design of the solar pumping system

Here are below the course of the design of the solar pumping system based on the existing borehole.

(1) Classification of hydrological data of the borehole

Classification of hydrological data such as groundwater level (level of ordinary water), maximum allowable pumping rate, etc. to study the installation depth of the return pump, its specifications etc.

(2) Setting of irrigation plan

Setting the irrigation plan: daily water flow irrigation of crops, irrigation frequency and irrigation time to study electricity and required pumping rate.

(3) Selecting the water elevation pump

Selecting the feed pump after setting hourly pumping capacity from the pumping rate required and the practical height of the reversal of the water flow.

(4) Determination of the number of photovoltaic arrays

Fixing the specifications and the number of photovoltaic arrays after calculating electricity needs from electricity for the pump

(5) Selection of Charge Controller

Selection of charge controller specifications from the electricity production of photovoltaic arrays and current, etc

6.4.3 Points to consider for the design of photovoltaic solar facility and examples calculations

1) Pumping Capacity

Set taking into account the irrigation plan.

The pumping speed is related to the volume of irrigation schedule, the frequency of irrigation, the irrigation period and the capacity of the water storage tank. For example, if the irrigation of all the fields is done only once in the morning, the pumping over a long period is possible, the smaller pumping capacity would be conceivable. However it is desirable to provide the pumping capacity of a certain margin and to construct a system for adjusting the flow of water pumped to respond to an extension of the cultivated area.

<Reference Examples>

The required pumping capacity is 0.5m^3 /hour when the irrigation volume is 3m^3/ day, 1 time at 7 am and pumping time from 9 am to 15 pm.

Offer / demand	Time slot	6	7	8	9	10	11	12	13	14	15	Total
Demand	Irrigation water		30	-	-	-	-	-	-	-	-	3.0
Supply	Pumping rate				**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**		3.0
	Water storage volume	3.0	0	0	0.5	1.0	1.5	2.0	2.5	3.0	3.0	

2) Reversal of the water flow height of the pump

We must take into account the practical water reversal height of the pump (distance between the total depth of the submersible pump and the top of the water storage tank).

For the practical reversal of the water flow height, loss of charge to the reversal (hose length 1/10) must be provided in case of long distance transmission of water between the borehole facility and the water storage tank.

<Reference Example>
Installation depth of the submerged pump 30m · · (1)
Height of the top of the water storage tank 5m · · (2)

Sending distance of drilling water to the tank 10m · · (3)
Practical reversal Height = manometric reversal height((1) + (2)) + charge loss to the reversal ((3) x 1/10)) = 36 m

3) Definition of the specifications and the number of photovoltaic cells

The method of assembling photovoltaic cells (in series, in parallel), the efficiency of power generation and the charge controller of the conversion efficiency must be taken into account.

The procedure of specifications definition and calculation of the number of photovoltaic cells is as follows: (1) calculation of electricity needs, (2) calculation of the capacity of photovoltaic cells, (3) determining the method of assembling photovoltaic cells and calculating the number of photovoltaic cells. The efficiency of the electricity production of the photovoltaic cells (temperature change, etc.), the charge controller of the conversion efficiency (loss when controlling the charge and discharge, etc.) are taken into account the safety factor of the design of the installation. And the use of a battery or of an inverter, the loss of charge and discharge, and the losses caused by the inverter are also considered.

<Reference Example>
【Design conditions】

- Consumption of electricity by the DC motor pump: 500 W
- Average daily operating time: 6 hours /day
- Voltage system production of photovoltaic solar energy: 48 V
- conversion efficiency of the charge controller: 0.83
- Maximum current generated by photovoltaic cell (Imp): 5,10 A
- sunshine time (time during which the product stream is maximum): 6 h /day
- Production of electricity output of solar panels: 0.85

(1) Demand for electricity (Wh/day)
Submersible pump (500 W) 1 unit
Electricity consumption by the pump x number of units x average daily operating time
500W x 1 unit x 6 hour/day = 3,000 Wh/day

(2) Capacity of photovoltaic cells (Ah/day)

Electricity demand /system voltage / conversion efficiency of charge controller

3000Wh / 48 V / 0.83 = 75.3 Ah/day

(3) Number of photovoltaic cells necessary

Capacity of a photovoltaic cell (maximum current generated by photovoltaic cell x sunshine time x electricity generation out)

75.3 Ah / day (5.10 x 6 A h x 0.85) = 2.89 ≈ 3 arrays

4) Selecting the charge controller and battery

The maximum input voltage of the charge controller becomes greater than the open circuit voltage in photovoltaic cells (Vco).

<Reference Example>

【Design conditions】

- Method of assembling photovoltaic cells: 1 serial line
- Voltage in a cell open circuit (Voc): 44.98 V
- Battery discharge depth 50%
- Number of days without continuous sunshine: 2 days

(1) Definition of the specifications of the charge controller

Charge current (A) = electricity consumed by the submersible pump: System voltage

500 W / 48 V = 10.42, therefore more than 10 A

Open circuit voltage of the photovoltaic cells (Vco) being 44.98 V x 1 line (in series), more than 45 V is required.

(2) Calculating the capacity necessary of the Battery

Capacity of a photovoltaic cell x number of days without sunshine DC: 50%

75.3 Ah /day x 2 days/0.5 = 301.2 Ah

Case of the current study: Composition of the pumping system by photovoltaic solar energy

The specifications of the pumping system by photovoltaic solar energy introduced in this study and the status of the installation (Photo 6.4.1) are indicated below.

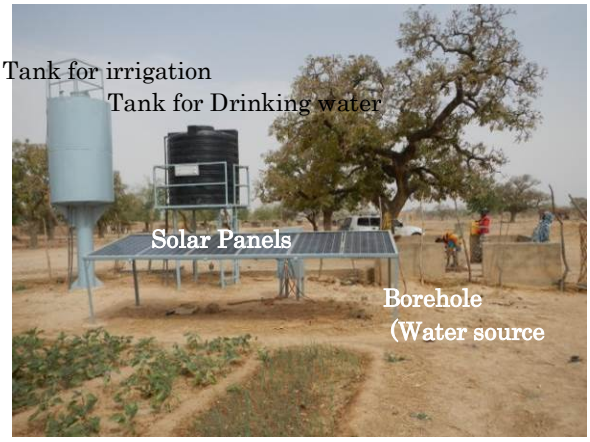

Photo 6.4.1 Pumping system by solar PV carried out in this study

Composition and system specifications

(1) Drilling: 64.1 m depth from ground level (GL) - level of ordinary water relative to ground level (GL) 13.2 m
(2) DC solar pump: 500W, 4m^3/h max, installation depth of 40 m.
(3) Hand pump installation depth of 33 m
(4) Solar Panels: 185 W x 6
4 in parallel + 2 in series
(5) reservoir of drinking water; 4m^3
(6) Reservoir for irrigation: 3.2m^3
(7) Other: charge controller 48V, water meters for direct reading of tank outlets for irrigation and drinking water

Case of the current study: Hybrid pump system

In this study, a hybrid pump system combining the existing hand pump with a motorized pump has been adopted because of cost related problem.

The main objective of the drilling installation is to provide 24 hours 24 water supply for daily needs and drinking water. Therefore, in case of supply only by solar pump, a battery system and / or a large water storage tank become necessary owing to the insufficient sunlight. But the introduction of these elements will increase the cost and maintenance expense. For this reason, we opted for a hybrid pump system combining the hand pump. However, in this case, the transformation of the upper part of the hand pump becomes necessary for the insertion of the motor pump.

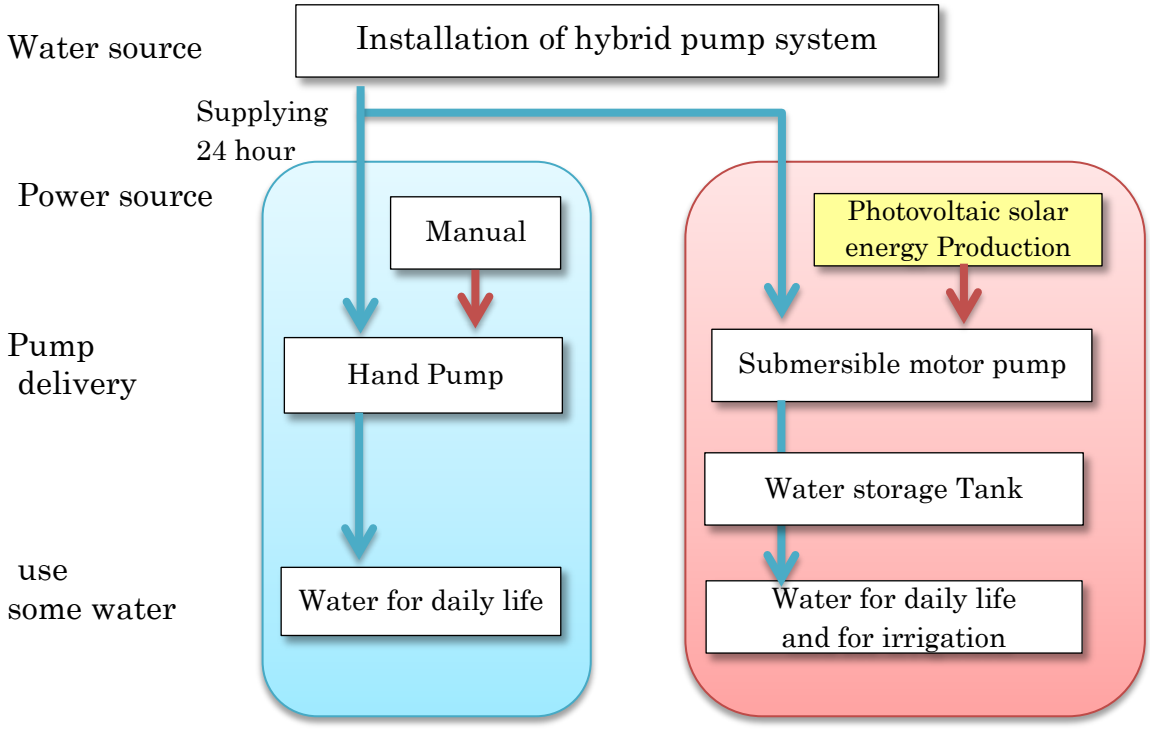

Figure 6.4.2 Summary presentation of the hybrid pump

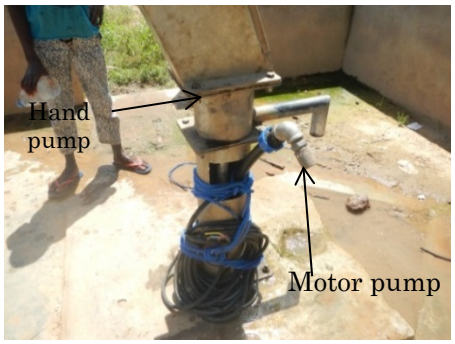

Photo 6.4.1 Installing the hand pump
And motor pump

Photo 6.4.2 Installing pumps

6.4.4 Setting up of water level sensors to prevent excessive pumping

Water level sensors are placed in the drilling and reservoir to prevent an accident due to the vacuum rotating the submersible pump and the degradation of the aquifer due to excessive pumping.

Water level sensors are set to "off" when the groundwater level is below the set level (the part between the two electrodes of the sensor portion is removed from the water) and the submerged pump is stopped.

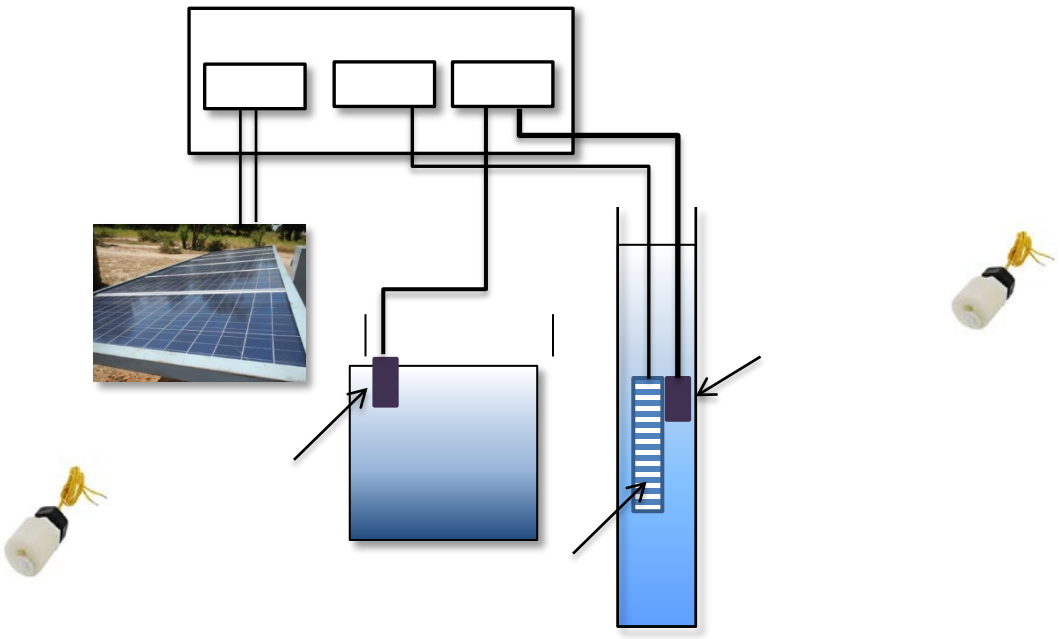

Figure 6.4.3 Installation of water level sensors

6.4.5 Level monitoring groundwater

The groundwater level monitoring is done for the preservation of the groundwater source and the pumping rate and water use plan is revised based on the results.

The pumping rate and water use plan is revised if an abnormality such as decrease in the water level is noticed through monitoring.

6.5 Participatory market gardening for sale in markets in dry season (Market gardening activity: MG)

6.5.1 Conduct of activities

The flow from the formulation to the implementation of the MG activities is as follows.

(1) Holding a workshop for the residents

A workshop is organized for managers of the facility and the candidates for participation in activities, and an agreement is made regarding the use of the existing borehole facility in other objectives.

(2) Establishing a MG group

A group MG is formed and activities orientation is set

(3) Development of MG plan and definition of exploitation methodology and facility maintenance

MG concrete plan, indicating e.g. farmed area, crops, number of participants is developed, and the distribution of roles in the operation and maintenance of the installation is defined.

(4) Implementation of MG activities

Better knowledge and capacity building through practical activities.

- Preparation and acquisition of the necessary equipment
- Various training based on practice (sowing and cultivation of tree seedlings, growing plants, use the drip-irrigation)
- Harvest, sales, accounting, distribution of profits

(5) Assessment and Improvement of activities

Case of this study: Implementation of MG activities

(1) Establishment of a MG group

- Gu village includes six neighbourhoods, and each locality has organized a group of women for MG. MG groups have total members of 156.
- MG groups from different neighbourhoods have formed an executive committee of Gu village MG group, which ensures operation and maintenance of MG activities and coordination between the different groups.
- The leaders of this committee meet 7 functions: ¨President, Secretary general, treasurer, advisor, advised è re, material manager, supervisor and coordinator. The leaders are 14 in total (provide a chef and an assistant for each position).
- The name of the 'village association is [Teega Wendé] (Translation: Rely on God)

Photo 6.5.1 Scène de réunion pour les activités MG

(2) Activities orientation

- Only women conduct MG activities, men do not participate. But men assist them for jobs requiring strength, and maintenance of the installation.
- MG activities will be conducted for the moment in groups, but in the future with the extension of the cultivated area, we plan to distribute plots to individuals and in making individual activities.
- Maintenance of the photovoltaic solar energy pumping system is ensured by MG groups.

(3) Land for plots

- MG plots of land close to the borehole facility are for an individual rented for free.
- The terms of use are implementing activities only during the dry season and the withdrawal of the drip-drip irrigation pipes after the end of activities
- MG cultivation period affecting crops during the rainy season, arrangements are made with the land owners, for planting and growing seedlings could begin in mid-October.

(4) Contents of the farm

- The initial crops were: tomato, cabbage and onions.
- Preparation for drip irrigation as shown in Figure 6.5.1.

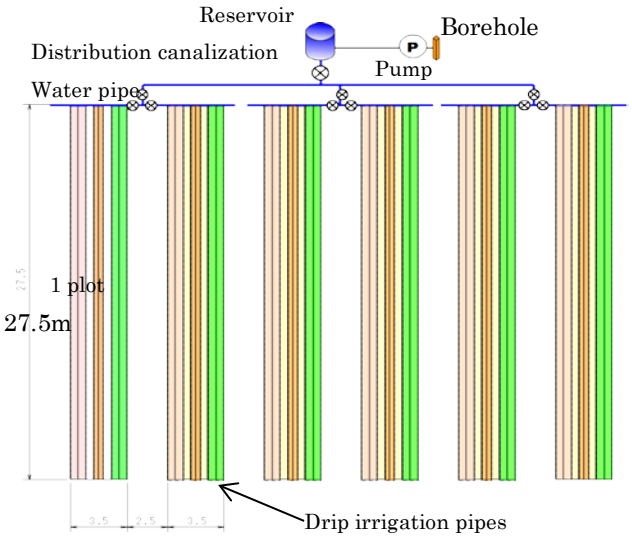

Figure 6.5.1 Elements constituting the drip irrigation system

1) cultivated Surface: 648 m^2 (243 m^2 each for tomato and cabbage, 162 m^2 for onion)
2) Projected daily irrigation rate: 5.0 mm /day.
3) irrigation time: from 7 am to 9 am
4) Laying drip irrigation pipe: 9 per plot 27.5 m/unit, laying interval 0.5 m x 4 furrows, 0.25 m x 2 furrows
5) Type of drip- pipe: S. Typhoon 12125, manufactured by Netafim

Photo 6.5.2 planting seedlings Scene

Photo 6.5.3 vegetable growing Scene

(5) Operation and maintenance of the Installation

- The daily activities are cleaning of solar panels with a damp cloth, and cleaning of the drip irrigation filter.
- The supervisor (man) opens/closes the valve of water storage tank, and MG groups open the taps valves of each plot.
- In case of installation problems, the MG leaders contact a technician after consulting the Association of water users.
- After harvest, the drip irrigation pipes are removed and kept.

Photo 6.5.4 Valve Opening for drip irrigation

Photo 6.5.5 Washing of drip irrigation pipe

(6) Quantity harvested and Quantity sold

The Table 6.5.1 shows the amounts harvested and the quantities sold at the 1st harvest. The main sales destination is the market of the village of Gu, but some of tomatoes were sold to the merchant of Boussé market, and some cabbage at an intermediate from Ouagadougou.

Table 6.5.1 Results of MG activities of the village of Gu in 2015 (Unit: kg)

Group	Quantity harvested				Quantity sold				Domestic consumption, etc. (a-b)
	Tomato	Cabbage	Onion	Total (a)	Tomato	Cabbage	Onion	Total (b)	
Gangandogo (36)	165	170	110	445	158	160	90	408	37
Tangzougou (27)	160	160	107	427	155	150	95	400	27
Yarsin (25)	145	150	108	403	130	145	85	360	43
Saabin (25)	145	150	108	403	110	140	75	325	78
Silmissin (22)	140	150	110	400	110	140	70	320	80
Voogsin (21)	130	150	107	387	107	125	95	327	60
Total	885	930	650	2465	770	860	510	2140	325
Average groups	148	155	108	411	128	143	85	357	54
Yield (t / ha)	36	38	40						

Notes:

- The figure in brackets after the group name indicates the number of participating members to MG activities.
- The sale price is 130 FCFA/kg for tomatoes, 90 FCFA/kg for cabbage and 140 CFA/kg for onion.
- The cultivated surface was 243 m^2 for tomato and cabbage, and 162 m^2 for the onion.
- Domestic consumption, etc. includes products sold individually, the products consumed in the

family, etc.

6.5.6 Photo Vegetable Sale in the village of Gu market

6.5.7 Photo Harvest onions

(7) Accounting

The turnover was 291 800 FCFA, this amount was not distributed among the participating members of the MG, but all placed on a UBTEC account.
(The UBTEC (Union of Boaré Tradition Savings and Credit) is a small-scale financial union founded in 1992 with the aim of improving access to financial services to farmers for the reduction of poverty and food security.)

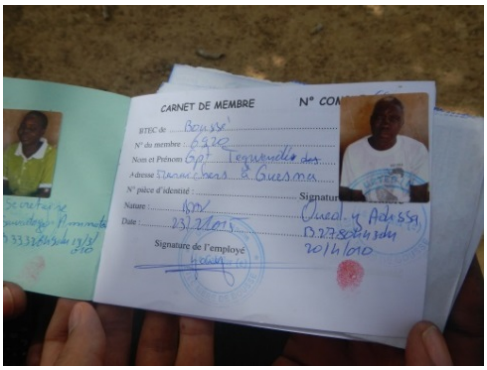

Photo 6.5.8 Booklet of MG activities

6.6 Economic Evaluation of market gardening activity with solar drip irrigation system on a small scale

6.6.1 Presentation

In case of introduction of photovoltaic solar energy system, sustainability of activities is not guaranteed if a profit equal to the cost of electricity production is not reached. For this reason, we tried to make an economic assessment by economic analysis and investment on the basis of introduction of the cost of installation and sales of market gardening project using a checked small scale solar drip irrigation system.

6.6.2 Economic Evaluation Method

(1) Analysis of the management

The cost-volume-profit (CVP) is an analytical methodology to determine the breakeven point and the conditions required to obtain a profit by analysing the correlation between the cost price, trade volume and profit.

(2) Investment Analysis

The return on investment in a business and profitability are determined by means of the Net Present Value (NPV) and Internal Rate of Return (IRR).
NPV is an assessment tool achievable profit in the future by the current value.
The IRR is the discount rate that cancels the net present value of the investment cash flow; we must at least prevent it from falling below the interest rate on the amount borrowed for investment. For this reason, the interest rate of the loan of UBTEC (financing condition: investment in equipment ceiling of 7 million FCFA) 9% was adopted as the standard value of the IRR assessment.

Case of the current study: Economic Evaluation of gardening activity with introduction of photovoltaic solar energy system

6.6.3 Management analysis by analysing the profitability threshold

(1) Conditions of the calculation

1) Project duration: 10 years
2) Cultivated Surface: 2000 m^2 and 5000 m^2
3) Crop: tomatoes

4) Required fees

Table 6.6.1 Required Fees

Fixed costs	Amount to be repaid for the loan (set of solar drip irrigation system), regular inspection and maintenance of the submersible pump, other maintenance costs, labor costs for agricultural work, costs surveillance
Variable costs	Seed prices, fertilizer prices, prices of insecticides

5) Yield: 30 t/ha (value of reference), 36 t/ha (Result for 2015)
6) Tomatoes selling prices of the producer: 4,000 FCFA/30 kg (result for 2015)

(2) Calculation of total expenses and ordinary profit

For the total cost, the calculation was: Fixed costs + variable costs, and for the ordinary profit: Turnover - Total expenses.

1) Amount to be reimbursed for the loan

The installation is supplied on loan at interest rate of 8% and repayment period of 10 years (duration of the project). The calculation was based on the method of repayment by fixed annual installments. Thus, the price of the installation at the end of the project will be zero.

Table 6.6.2 amount to be reimbursed over supply costs (unit: FCFA)

Rubric	Farmed area 2000 m^2		Farmed area 5000 m^2	
	Procurement costs	Annual repaid	Procurement costs	Annual repaid
PV solar system for producing	2,100,000	312, 962	2,100,000	312, 962
Submersible pump system	1,970,000	293,588	1,970,000	293,588
Water storage tank (5 m^3)	1,300,000	193,738	1,300,000	193,738
Drip irrigation	1,082,000	161,250	2,450,000	365,122
Total	6,452,000	961,538	7,820,000	1,165,410

2) Fixed costs

Fixed costs are independent of fluctuating cost of sales, mainly including labor costs and costs of the installation.
In the case of this project, as indicated in the table below, for installation account for about 85%.

Table 6.6.3 Fixed costs

Items	Fees (FCFA)		Notes
	2000 m²	5000 m²	
Annual repaid	961, 538	1,165,410	according to the table above
Regular inspection and maintenance of the submersible pump	100, 000	100, 000	300, 000FCFA on 3years
Other maintenance costs	51, 640	79, 000	Transportation costs, labor costs, material costs
Labor costs for farm work	42, 000	106 ,000	Rough calculation
Monitoring costs	15, 000	15, 000	1 supervisor
Total	1,128.178	1,359,410	

3) Variable costs

Variable costs are the costs varying with fluctuations in production volume, mainly the cost of materials. In the case of this project, as shown in the table below, the variable costs are very low compared to fixed costs.

Table 6.6.4 Variable Costs

Items	Fees (FCFA)		Notes
	2000 m²	5000 m²	
Seed costs	12, 500	30, 000	Value of actual results
Fertilizer prices	12,800	32,000	20kg /1000 m²
Insecticides Price	28,600	71,400	Value of actual results
Total	53,900	133,400	

4) Turnover

Turnover was calculated from the results of 2015 by prefixing a yield and unit sales price.

Table 6.6.5 Turnover

Harvest per unit area	Sales (CFAF)		Notes
	2000 m²	5000 m²	
Yield of 30 t/ha	800,000	2,000,000	Tomatoes 4000FCFA/30kg
Yield of 36 t/ha	960,000	2,400,000	Tomatoes 4000FCFA/30kg

5) Ordinary Profit

The ordinary profit per cultivated area and yield was as follows on the basis from 2) to 4).

Table 6.6.6 Ordinary Profit

Items	2000 m² (FCFA)		5000 m² (FCFA)	
	30 t/ha	36 t/ha	30 t/ha	36 t/ha
Turnover	800,000	960,000	2,000,000	2,400,000
Variable costs	53,900	53,900	133,400	133,400
Fixed costs	1,170,178	1,170,178	1,465,410	1,465,410
Ordinary Profit	▲ 424,078	▲ 264,078	401,190	801,190

(3) Calculation of turnover to profitability threshold and the rate of financial balance

The turnover at breakeven means sales breakeven in which profit becomes zero, this turnover is calculated by dividing the fixed costs by the margin on variable costs. The margin on variable costs can be obtained by deducting from revenue the variable costs and the margin on variable costs is calculated by dividing the margin on variable costs by the turnover.

$$\text{The turnover at breakeven} = \frac{\text{Fixed Costs}}{1 - \frac{\text{Variable Costs}}{\text{Turnover}}} = \frac{\text{Fixed Costs}}{\text{Marging on variable Costs}}$$

The financial balance rate indicates the position of turnover breakeven compared to actual turnover. The lower the financial balance rate, the higher profitability is, it is the stability index management.

$$\text{Financial balance rate (\%)} = \frac{\text{Turnover at breakeven}}{\text{Turnover}} \times 100$$

The result of the calculation of breakeven, etc. per operating size and yield is shown below.

Table 6.6.7 Breakeven, etc. per farm size and yield

Items	2000 m ² (FCFA)		5000 m² (FCFA)	
	30 t/ha	36 t/ha	30 t/ha	36 t/ha
Percentage of variable costs	7%	6%	7%	6%
Margin on variable costs	93%	94%	93%	94%
Breakeven	1,254,714	1,239,787	1,570,138	1,551,656
Financial balance rate	157%	129%	79%	65%

(4) Result of the analysis of the management to cultivated area of 2000 m²

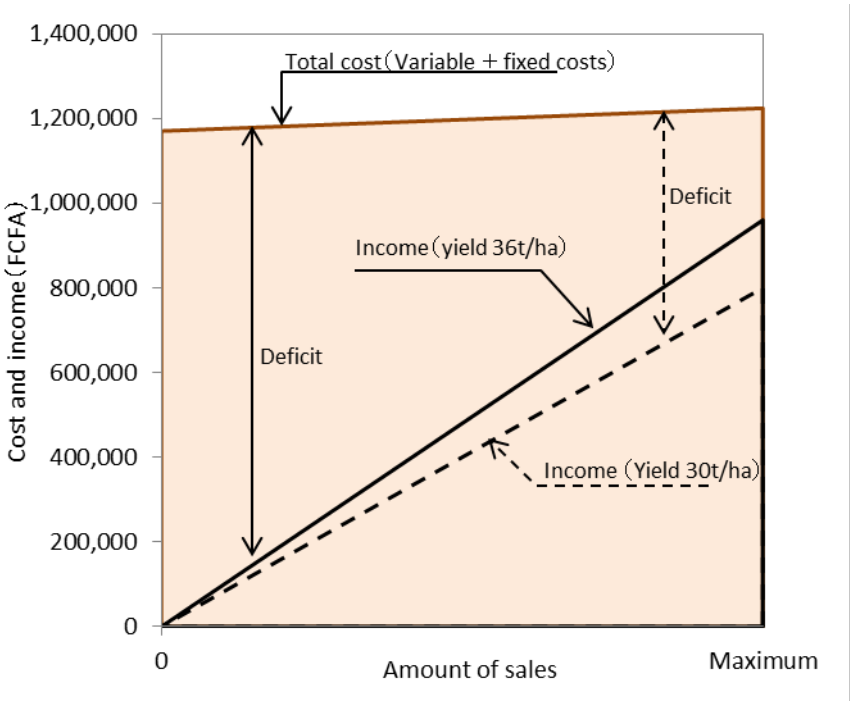

Figure 6.6.1 Breakeven 1

On a farm of 2000 m², the break-even rate exceeds 100% at unit yield of 30 t/ha and 36 t/ha, and therefore no profit cannot be reached.

(5) Result of the analysis of the management to exploited area of 5000m²

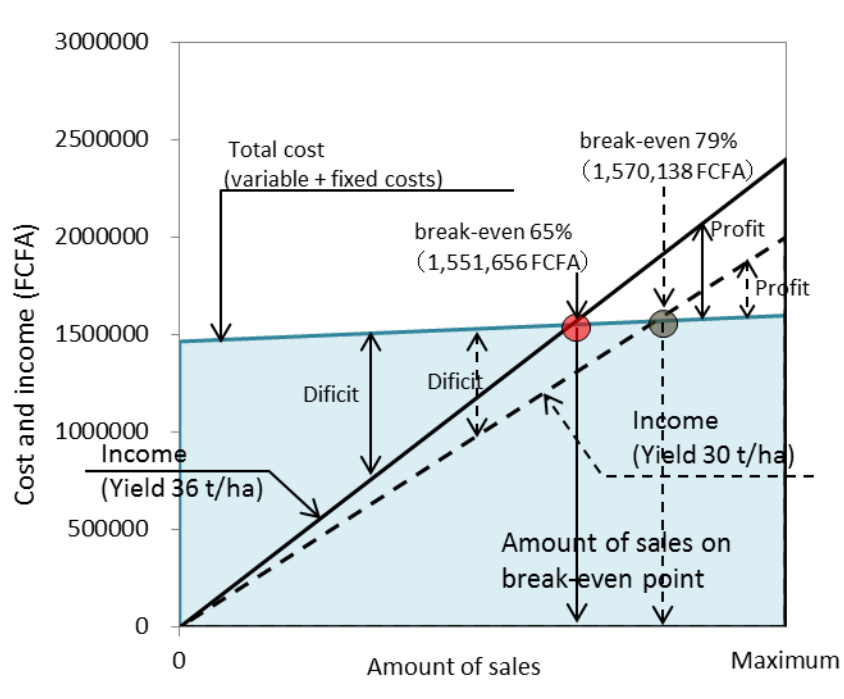

Figure 2 6.6.2 Break-even 2

On a farm of 5000 m2, the rate of breakeven is 79% for yield of 30 t/ha, and 65% for yield of 36 t/ha. Therefore, stability of management is large compared to the profit reduction.

The result of this analysis shows that the exploitation of an area of 5000 m² is necessary to ensure a stable management by introducing the solar drip irrigation system.

6.6.4 Analysis of investment profitability in the activity based on the internal rate of return (IRR)

The expenses necessary for the analysis are: investment costs, operating costs and maintenance and revenue. Internal rate of return (IRR) was calculated on the basis of annual expenditure (agricultural operating expenses + cost of operation and maintenance) and invariable revenue (revenue from the sale of vegetables).

(1) Initial Investment

Table 6.6.8 Initial Investment

(unit: FCFA)

System	Farm size	
	2000 m^2	5000 m^2
Photovoltaic solar energy system (740 W)	2,100,000	2,100,000
Submersible pump system (500 W)	1,970,000	1,970,000
Water storage tank (5 m^3)	1,300,000	1,300,000
Drip irrigation	1,082,000	2,450,000
Total	6,452,000	6,820,000

(2) Annual expenditure

1) Farming Costs

Table 6.6.9 farming costs

(unit: FCFA)

Details of expenses	Farm size	
	2000 m^2	5000 m^2
Seed costs	12,500	30,000
Fertilizer costs	12,800	32,000
Insecticides costs	28,600	71,400
Farm labor costs	42,000	106,000
Monitoring cost	15,000	15,000
Total	110,900	254,400

2) Maintenance costs of the facility

Table 6.6.10 maintenance costs of the facility

(unit: FCFA)

Details of expenses	Farm size		Notes
	2000 m²	5000 m²	
Regular inspection and maintenance of the submersible pump	100,000	100,000	FCFA 300,000 over 3 years
Other maintenance costs	66,640	94,000	Transportation costs, labor costs, material costs
Total	166,640	194,000	

(3) Annual revenue

Turnover was calculated to yield per unit 3 models.

Table 6.6.11 Annual Revenue

(unit: FCFA)

Farm size	Yield	Turnover
2000 m²	25 t/ha	667,000
	30 t/ha	800,000
	36 t/ha	960,000
5000 m²	25 t/ha	1,667,000
	30 t/ha	2,000,000
	36 t/ha	2,400,000

(4) Results of calculating the internal rate of return (IRR) (calculation of cash flow)

1) Size farm 2000 m²

Table 6.6.12 Investment Analysis for a farm of 2000 m² and a yield of 25 t/ha

	Investment amount	1 year	2 year	3 year	4 year	5 year	6 year	7 year	8 year	9 year	10 year		
Initial investment	-6,452,000												
Expenses for farming		-110,900	-110,900	-110,900	-110,900	-110,900	-110,900	-110,900	-110,900	-110,900	-110,900		
Maintenance cost for facilities		-166,640	-166,640	-166,640	-166,640	-166,640	-166,640	-166,640	-166,640	-166,640	-166,640		
Amount of sales		667,000	667,000	667,000	667,000	667,000	667,000	667,000	667,000	667,000	667,000		
Cash-flow	-6,452,000	389,460	389,460	389,460	389,460	389,460	389,460	389,460	389,460	389,460	389,460		
Total of Cash-flow	-6,452,000	-6,062,540	-5,673,080	-5,283,620	-4,894,160	-4,504,700	-4,115,240	-3,725,780	-3,336,320	-2,946,860	-2,557,400		
IRR												**IRR**	**-8.3%**
NPV													
Value factor (in case of discount rate 7.0%)	1.000	0.935	0.873	0.816	0.763	0.713	0.666	0.623	0.582	0.544	0.508		
Net present value of cash-flow	-6,452,000	363,981	340,169	317,915	297,117	277,680	259,514	242,536	226,669	211,840	197,982	**NPV**	**-3,716,596**
Value factor (in case of discount rate 9.0%)	1.000	0.917	0.842	0.772	0.708	0.650	0.596	0.547	0.502	0.460	0.422		
Net present value of cash-flow	-6,452,000	357,303	327,801	300,735	275,903	253,122	232,222	213,048	195,457	179,318	164,512	**NPV**	**-3,952,579**
Value factor (in case of discount rate 11.0%)	1.000	0.901	0.812	0.731	0.659	0.593	0.535	0.482	0.434	0.391	0.352		
Net present value of cash-flow	-6,452,000	350,865	316,094	284,770	256,549	231,126	208,221	187,587	168,997	152,250	137,162	**NPV**	**-4,158,380**

Table 6.6.13 Investment Analysis for a farm of 2000 m² and a yield of 30 t/ha

	Investment amount	1 year	2 year	3 year	4 year	5 year	6 year	7 year	8 year	9 year	10 year		
Initial investment	-6,452,000												
Expenses for farming		-110,900	-110,900	-110,900	-110,900	-110,900	-110,900	-110,900	-110,900	-110,900	-110,900		
Maintenance cost for facilities		-166,640	-166,640	-166,640	-166,640	-166,640	-166,640	-166,640	-166,640	-166,640	-166,640		
Amount of sales		800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000		
Cash-flow	-6,452,000	522,460	522,460	522,460	522,460	522,460	522,460	522,460	522,460	522,460	522,460		
Total of Cash-flow	-6,452,000	-5,929,540	-5,407,080	-4,884,620	-4,362,160	-3,839,700	-3,317,240	-2,794,780	-2,272,320	-1,749,860	-1,227,400		
IRR												**IRR**	**-3.7%**
NPV													
Value factor (in case of discount rate 7.0%)	1.000	0.935	0.873	0.816	0.763	0.713	0.666	0.623	0.582	0.544	0.508		
Net present value of cash-flow	-6,452,000	488,280	456,337	426,483	398,582	372,507	348,137	325,362	304,076	284,184	265,592	**NPV**	**-2,782,460**
Value factor (in case of discount rate 9.0%)	1.000	0.917	0.842	0.772	0.708	0.650	0.596	0.547	0.502	0.460	0.422		
Net present value of cash-flow	-6,452,000	479,321	439,744	403,435	370,124	339,563	311,526	285,804	262,205	240,555	220,693	**NPV**	**-3,099,031**
Value factor (in case of discount rate 11.0%)	1.000	0.901	0.812	0.731	0.659	0.593	0.535	0.482	0.434	0.391	0.352		
Net present value of cash-flow	-6,452,000	470,685	424,040	382,018	344,161	310,055	279,328	251,647	226,709	204,243	184,002	**NPV**	**-3,375,112**

Table 6.6.14 Investment Analysis for a farm of 2000 m^2 and a yield of 36 t/ha

	Investment amount	1 year	2 year	3 year	4 year	5 year	6 year	7 year	8 year	9 year	10 year		
Initial investment	-6,452,000												
Expenses for farming		-110,900	-110,900	-110,900	-110,900	-110,900	-110,900	-110,900	-110,900	-110,900	-110,900		
Maintenance cost for facilities		-166,640	-166,640	-166,640	-166,640	-166,640	-166,640	-166,640	-166,640	-166,640	-166,640		
Amount of sales		960,000	960,000	960,000	960,000	960,000	960,000	960,000	960,000	960,000	960,000		
Cash-flow	-6,452,000	682,460	682,460	682,460	682,460	682,460	682,460	682,460	682,460	682,460	682,460		
Total of Cash-flow	-6,452,000	-5,769,540	-5,087,080	-4,404,620	-3,722,160	-3,039,700	-2,357,240	-1,674,780	-992,320	-309,860	372,600		
IRR												**IRR**	**1.0%**
NPV													
Value factor (in case of discount rate 7.0%)	1.000	0.935	0.873	0.816	0.763	0.713	0.666	0.623	0.582	0.544	0.508		
Net present value of cash-flow	-6,452,000	637,813	596,087	557,091	520,645	486,585	454,752	425,002	397,198	371,213	346,928	**NPV**	**-1,658,687**
Value factor (in case of discount rate 9.0%)	1.000	0.917	0.842	0.772	0.708	0.650	0.596	0.547	0.502	0.460	0.422		
Net present value of cash-flow	-6,452,000	626,110	574,413	526,984	483,472	443,552	406,929	373,329	342,504	314,224	288,278	**NPV**	**-2,072,205**
Value factor (in case of discount rate 11.0%)	1.000	0.901	0.812	0.731	0.659	0.593	0.535	0.482	0.434	0.391	0.352		
Net present value of cash-flow	-6,452,000	614,829	553,900	499,009	449,558	405,007	364,871	328,713	296,137	266,791	240,352	**NPV**	**-2,432,835**

2. Size farm of 5000 m^2

Table 6.6.15 Investment Analysis for a farm of 5000 m^2 and a yield of 25 t/ha

	Investment amount	1 year	2 year	3 year	4 year	5 year	6 year	7 year	8 year	9 year	10 year		
Initial investment	-7,820,000												
Expenses for farming		-254,400	-254,400	-254,400	-254,400	-254,400	-254,400	-254,400	-254,400	-254,400	-254,400		
Maintenance cost for facilities		-194,000	-194,000	-194,000	-194,000	-194,000	-194,000	-194,000	-194,000	-194,000	-194,000		
Amount of sales		1,667,000	1,667,000	1,667,000	1,667,000	1,667,000	1,667,000	1,667,000	1,667,000	1,667,000	1,667,000		
Cash-flow	-7,820,000	1,218,600	1,218,600	1,218,600	1,218,600	1,218,600	1,218,600	1,218,600	1,218,600	1,218,600	1,218,600		
Total of Cash-flow	-7,820,000	-6,601,400	-5,382,800	-4,164,200	-2,945,600	-1,727,000	-508,400	710,200	1,928,800	3,147,400	4,366,000		
IRR												**IRR**	**9.0%**
NPV													
Value factor (in case of discount rate 7.0%)	1.000	0.935	0.873	0.816	0.763	0.713	0.666	0.623	0.582	0.544	0.508		
Net present value of cash-flow	-7,820,000	1,138,879	1,064,372	994,741	929,664	868,845	812,005	758,883	709,236	662,838	619,474	**NPV**	**738,936**
Value factor (in case of discount rate 9.0%)	1.000	0.917	0.842	0.772	0.708	0.650	0.596	0.547	0.502	0.460	0.422		
Net present value of cash-flow	-7,820,000	1,117,982	1,025,671	940,983	863,287	792,006	726,611	666,616	611,574	561,077	514,750	**NPV**	**558**
Value factor (in case of discount rate 11.0%)	1.000	0.901	0.812	0.731	0.659	0.593	0.535	0.482	0.434	0.391	0.352		
Net present value of cash-flow	-7,820,000	1,097,838	989,043	891,030	802,730	723,180	651,513	586,949	528,783	476,381	429,172	**NPV**	**-643,382**

Table 6.6.16 Investment Analysis for a farm of 5000 m² and a yield of 30 t/ha

	Investment amount	1 year	2 year	3 year	4 year	5 year	6 year	7 year	8 year	9 year	10 year		
Initial investment	-7,820,000												
Expenses for farming		-254,400	-254,400	-254,400	-254,400	-254,400	-254,400	-254,400	-254,400	-254,400	-254,400		
Maintenance cost for facilities		-194,000	-194,000	-194,000	-194,000	-194,000	-194,000	-194,000	-194,000	-194,000	-194,000		
Amount of sales		2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000		
Cash-flow	-7,820,000	1,551,600	1,551,600	1,551,600	1,551,600	1,551,600	1,551,600	1,551,600	1,551,600	1,551,600	1,551,600		
Total of Cash-flow	-7,820,000	-6,268,400	-4,716,800	-3,165,200	-1,613,600	-62,000	1,489,600	3,041,200	4,592,800	6,144,400	7,696,000		
IRR												**IRR**	**14.9%**
NPV													
Value factor (in case of discount rate 7.0%)	1.000	0.935	0.873	0.816	0.763	0.713	0.666	0.623	0.582	0.544	0.508		
Net present value of cash-flow	-7,820,000	1,450,093	1,355,228	1,266,568	1,183,708	1,106,269	1,033,897	966,258	903,045	843,968	788,755	**NPV**	**3,077,789**
Value factor (in case of discount rate 9.0%)	1.000	0.917	0.842	0.772	0.708	0.650	0.596	0.547	0.502	0.460	0.422		
Net present value of cash-flow	-7,820,000	1,423,486	1,305,951	1,198,120	1,099,193	1,008,434	925,168	848,778	778,696	714,400	655,413	**NPV**	**2,137,638**
Value factor (in case of discount rate 11.0%)	1.000	0.901	0.812	0.731	0.659	0.593	0.535	0.482	0.434	0.391	0.352		
Net present value of cash-flow	-7,820,000	1,397,838	1,259,313	1,134,517	1,022,087	920,799	829,549	747,341	673,280	606,559	546,449	**NPV**	**1,317,732**

Table 6.6.17 Investment Analysis for a farm of 5000 m² and a yield of 36 t/ha

	Investment amount	1 year	2 year	3 year	4 year	5 year	6 year	7 year	8 year	9 year	10 year		
Initial investment	-7,820,000												
Expenses for farming		-254,400	-254,400	-254,400	-254,400	-254,400	-254,400	-254,400	-254,400	-254,400	-254,400		
Maintenance cost for facilities		-194,000	-194,000	-194,000	-194,000	-194,000	-194,000	-194,000	-194,000	-194,000	-194,000		
Amount of sales		2,400,000	2,400,000	2,400,000	2,400,000	2,400,000	2,400,000	2,400,000	2,400,000	2,400,000	2,400,000		
Cash-flow	-7,820,000	1,951,600	1,951,600	1,951,600	1,951,600	1,951,600	1,951,600	1,951,600	1,951,600	1,951,600	1,951,600		
Total of Cash-flow	-7,820,000	-5,868,400	-3,916,800	-1,965,200	-13,600	1,938,000	3,889,600	5,841,200	7,792,800	9,744,400	11,696,000		
IRR												**IRR**	**21.4%**
NPV													
Value factor (in case of discount rate 7.0%)	1.000	0.935	0.873	0.816	0.763	0.713	0.666	0.623	0.582	0.544	0.508		
Net present value of cash-flow	-7,820,000	1,823,925	1,704,603	1,593,087	1,488,866	1,391,464	1,300,433	1,215,358	1,135,849	1,061,541	992,094	**NPV**	**5,887,222**
Value factor (in case of discount rate 9.0%)	1.000	0.917	0.842	0.772	0.708	0.650	0.596	0.547	0.502	0.460	0.422		
Net present value of cash-flow	-7,820,000	1,790,459	1,642,623	1,506,993	1,382,563	1,268,406	1,163,675	1,067,592	979,442	898,571	824,377	**NPV**	**4,704,701**
Value factor (in case of discount rate 11.0%)	1.000	0.901	0.812	0.731	0.659	0.593	0.535	0.482	0.434	0.391	0.352		
Net present value of cash-flow	-7,820,000	1,758,198	1,583,962	1,426,993	1,285,579	1,158,180	1,043,405	940,005	846,851	762,929	687,323	**NPV**	**3,673,425**

(5) Investment analysis results using NPV and IRR calculations

The table below shows the results of various calculations.
In the case of a farm of 2000 m², no profit is generated in all cases by yield and discount rate, which shows that the project is not profitable.
In the case of a farm of 5000 m², an IRR of 9% - the reference value for evaluation - can be obtained for a yield of 25 t/ha (70% of the results), but profit remains very low (558 FCFA). For a yield higher than 30 t/ha, the IRR is about 15%, the NPV exceeds 1 million CFA francs, in this case, the project becomes profitable.

Table 6.6.18 Results of investment analysis (NPV and IRR calculation)

Depending on farm operating size and yield		IRR	NPV (FCFA)		
			Discount rate 7%	Discount rate 9%	Discount Rate 11%
2000m²	25 t/ha	-8.3%	-3,716,596	-3,952,579	-4,158,380
	30 t/ha	-3.7%	-2,782,460	-3,099,031	-3,375,112
	36 t/ha	1.0%	-1,658,687	-2,072,205	-2,432,835
5000 m²	25 t/ha	9.0%	738,936	558	643,382
	30 t/ha	14.9%	3,077,789	2,137,638	1,317,732
	36 t/ha	21.4%	5,887,222	4,704,701	3,673,425

Given the results of the analysis according to the method of breakeven, a farm size of 5000 m² is needed to ensure the profitability and stability of the project. To do this, a source of water for the irrigation of 5000 m² is required. But if the farm size should be decreased because of the difficulty of obtaining the water source, it is possible to use a grant or financial assistance from the state, etc. or to move to a more profitable business, or even to add activities to ensure project profitability.

6.7 Reducing CO_2 emissions by introducing renewable energy

6.7.1 CO_2 emissions reduction by the project

In the reference scenario, the volume of emissions is based on the volume of CO_2 emitted in the production of electricity using fossil fuel according to the existing technique.
But the volume of forecast emissions will be zero according to the project scenario. Because we do not take into account the CO_2 produced in the life cycle of the renewable energy system from its construction to its disposal (solar panels, wind equipment), also solar energy and wind strength, etc. are energy sources used permanently, which do not emit CO_2 to the production of electricity.

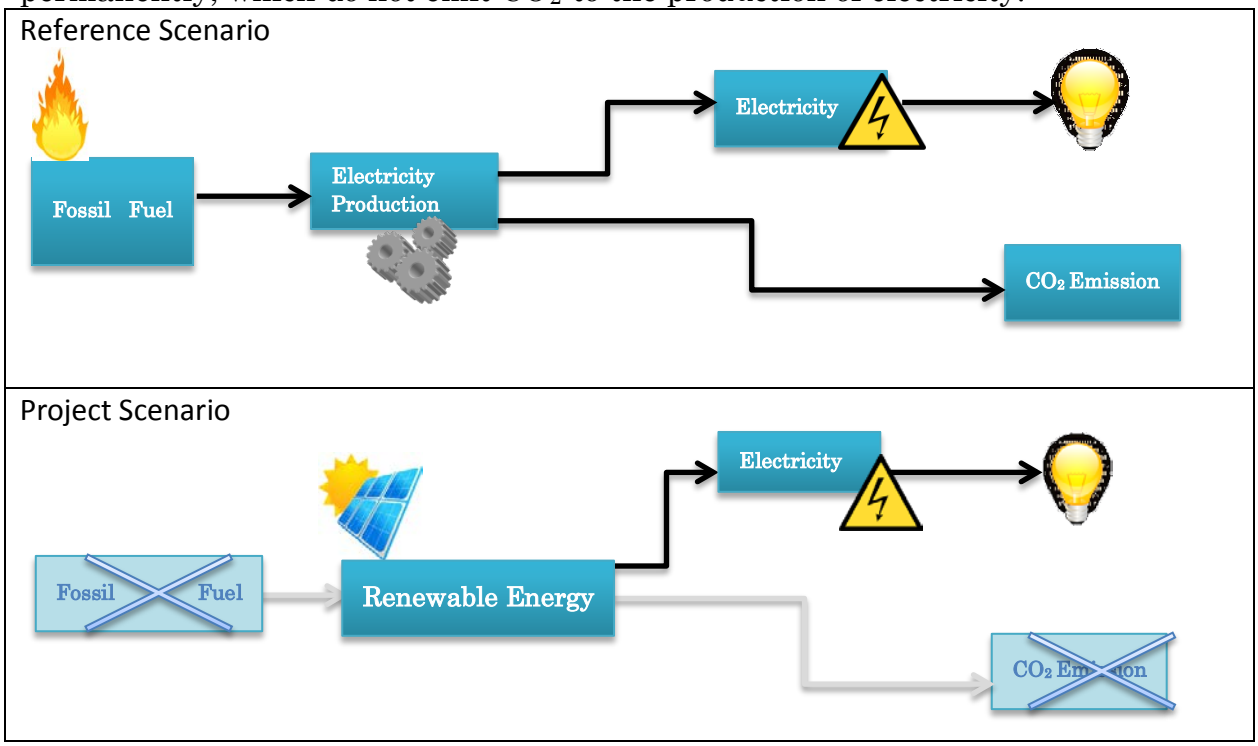

Figure 6.7.1 Image of the reference scenario and project scenario

In other words, the CO_2 emissions reduced by the introduction of renewable energy (zero CO_2 emissions) are equivalent to the CO_2 emissions produced by conventional energy without the use of renewable energy.

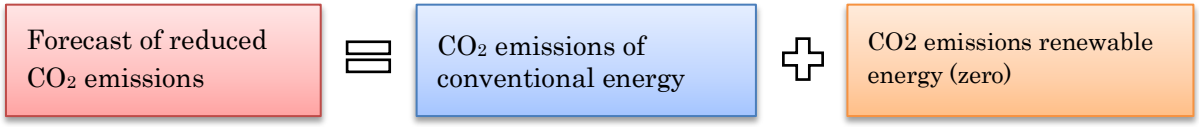

Figure 6.7.2 Relationship between projections of CO_2 emissions reduced by the proposed introduction of renewable energy and forecasts of CO_2 emissions from conventional energy

6.7.2 CDM methodologies and tools to adopt[8]

CDM methodology and tools to be adopted for the small scale photovoltaic solar pump are as follows (in September 2015).

CDM methodology	AMS-IA Electricity generation by a user (Version 16.0)
Tool methodology	Tool to calculate reference emissions, forecasts and/or leakages on the basis of electricity consumption (Version 1)

In the CDM methodology, small-scale renewable energy is defined as energy produced by a device or plant equipment less than 15 MW maximum.

6.7.3 Flow of calculation of the reduction of CO2 emissions

The figure below shows this flow.

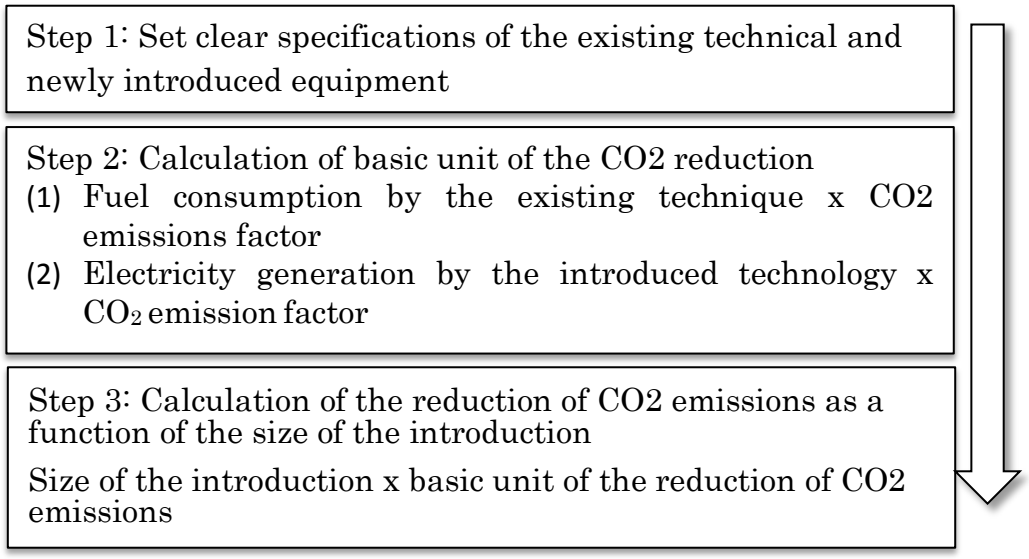

Figure 6.7.3 Flow of calculating the reduction of CO_2 emissions

In Step 1, the specifications of the existing technique which will be transformed into renewable energy (fuel consumption) and specifications of the new technique using renewable energy (electricity generation) are made clear.

In Step 2, the basic unit of the reduction of CO_2 emissions (Unit t CO_2 reduction) is calculated by multiplying the amount of gasoline, electricity, gas etc. used by the CO_2 emission factor. A standard value is given for CO_2 emission factor in the IPCC documents.

[8] https://cdm.unfccc.int/methodologies/DB/8FKZFJ7SG551TS2C4MPK78G12LSTW3, 2015.4.23

The Step 3 is to set the volume introduced by the project and calculate the total reduction in CO_2 emissions by multiplying the basic unit reduction of CO_2 obtained in Step 2.

6.7.4 Method of calculating baseline emissions using CDM methodology

3 methods for calculating baseline emissions are given in the 8th paragraph (a) - (c) and from the 10th paragraph of the CDM methodology. The calculation methods vary depending on the content of the draft introduction and the traditional technique used long before the introduction of the new technique.

Option 1: Calculation based on the electricity consumption in the mini-village network by using the introduced renewable energy
Option 2: Calculation based on the production of electricity by using the introduced renewable energy
Option 3: Calculation based on the fuel consumption of the technique used long before the introduction of renewable energy

In Option 1, the calculation is made on the basis of electricity consumption from renewable energy, in Option 2 based on electricity produced with renewable energy, and Option 3 on the basis of the fuel consumption of the traditional technique.

These calculations were based on the premise that the amount of renewable energy produced thanks to the project is equal to the fuel consumption of the traditional technique. And in the case of lighting devices for renewable energy, the same level of clarity that the traditional technique must be ensured.

Details of the CDM methodology are as follows.

Table 6.7.1 Details of the methodology

Option 1:	The estimate is based on the annual average consumer consumption. $E_{BL,y} = \sum_i \left(n_i * EC_{i,y}\right)/(1-l)$ Where $E_{BL,y}$ Annual energy baseline; kWh $\sum_i$ The sum over the group of i renewable energy technologies (e.g. renewable energy technologies for households, rural health centres, rural schools, grain milling, water pumping, irrigation, etc.) implemented as part of the project activity n_i Number of consumers supplied by installations of the renewable energy technology belonging to the group of i renewable energy technologies during the year $EC_{i,y}$ Average annual individual energy consumption observed in closest grid electricity systems among rural grid connected consumers belonging to the same group of *i* renewable energy technologies. If energy consumption is metered, *ECi,y* is the average energy consumed by consumers belonging to the group of *i* renewable energy technologies; kWh l Average technical distribution losses that would have been observed in diesel powered mini-grids installed by public programmes or distribution companies in isolated areas, expressed as a fraction

Option 2:	The estimate is done based on annual production of electricity from renewable energy technology of the project. $E_{BL,y} = \sum_i EG_{i,y}/(1-l)$ $E_{BL,y}$ Annual energy baseline; kWh $\sum_i$ The sum over the group of i renewable energy technologies (e.g. renewable energy technologies for solar home systems, solar pumps) implemented as part of the project activity $EG_{i,y}$ Annual output of the renewable energy technologies of the group of i renewable energy technologies installed; kWh L Average technical distribution losses that would have been observed in diesel powered mini-grids installed by public programmes or distribution companies in isolated areas, expressed as a fraction
Reference Emissions Options 1 and 2	above the emissions baseline is the energy baseline calculated in accordance with paragraphs 8(a) and 8(b) above times a default emission factor $BF_{CO2,y} = E_{BL,y} \times EF_{CO2}$ $BF_{CO2,y}$ Emissions in the baseline in year y; tCO_2 $E_{BL,y}$ Annual energy baseline in year y; kWh EF_{CO2} CO_2 emission factor; tCO_2/kWh

Option 3:	the emissions baseline is the historic fuel consumption calculated in accordance with paragraph 8(c) above times the CO_2 emission factor for the fuel displaced. IPCC default values for emission factors may be used. $BE_{CO2,y} = \sum_j FC_{j,y} \times NCV_j \times EF_{CO2,j}$ $BE_{CO2,y}$ Emissions in the baseline in year *y*; tCO_2 $FC_{j,y}$ Amount of fuel consumption of fuel type *j*; mass or volume unit in year *y* NCV_j Net calorific value of fuel type *j*; gigajoule per mass or volume unit $EF_{CO2,j}$ CO_2 emission factor of fuel type *j*; tCO_2/GJ J Fuel type used for combustion

6.7.5 Example of calculation of CO_2 emissions reduction

(1) In case of solar pump project introduction in off-grid

1) If the commercial power uses the traditional technique (application of Option 2)

Step 1: Development of clear specifications of devices introduced

The panels power of electricity generation is 0.5 kilowatts, the duration of use (8th paragraph (c)) of 3.5 hours, and the annual number of operating days 6 months or 180 days (from November to April).

6.7.1 Photo Small solar pumping system

Step 2: Calculation of the base unit of the CO_2 reduction

The energy produced annually by a unit is:

$E_{BL,y} = \sum_i EG_{i,y}/(1-l)$

0,5kW × 3.5 hours/day × 180 days/year/(1-0) = 315.0 (kWh /year-Unit)

The default value *is 0.0008 tCO_2 /*kWh in the same paragraph, and the project duration of 10 years, the basic emissions per unit are:

$BF_{CO2,y} = E_{BL,y} \times EF_{CO2}$

315.0 (kWh/year-Unit) × 0.0008 *(/ kWh)* × 10 (years) = **2.52 ($t\ CO_2$/10years – unit)**

Step 3: Calculation of CO2 reduction from the amount and the number introduced

The table below shows the reduction of emissions per introducing size if the project duration is 10 years.

Table 6.7.2 Reduction of CO_2 emissions per introducing size (1)

Introductory size (unit)	t CO_2/10 years
10000	25,200
1000	2,520
100	252

2) In case of traditional technique with diesel power generation (application of Option 3)

Step 1: Development of clear specifications of devices introduced

Assumption: Average annual fuel consumption is 240 L/year (average monthly fuel consumption of 120 L/month).
The heat produced by diesel (GJ/quantity or weight) is 43 TJ/Gg[9] taking into account the default IPCC or 0.036 GJ/L if we perform a conversion unit. The CO_2 emissions of diesel (t CO_2/GJ) are 74.9 t CO_2/TJ[10] or 0.074 t CO_2/GJ.

Photo 6.7.2 Diesel Power generation

Step 2: Calculation of the reduction of base unit CO_2

$$BE_{CO2,y} = \sum_j FC_{j,y} \times NCV_j \times EF_{CO2,j}$$

= 740 (L/year) × 0.036 (GJ/L) × 0,074 (tCO_2 /GJ) × 10 (years)
= 19 (t CO_2 / 10years-Unit)

Step 3: Calculation of CO2 reduction from the amount and the number introduced

The table below shows the reduction of emissions per introducing size if the project duration is 10 years.

Table 6.7.3 Reduction of CO2 emissions per introducing size (2)

Introducing size (units)	t CO_2/10 years
10000	190,000
1000	19,000
100	1,900

[9] IPCC 2006 IPCC Documents for national inventories of greenhouse gases, Volume Energy, Tables 1 and 2
[10] IPCC 2006 IPCC Documents for national inventories of greenhouse gases, Volume Energy, Tables 2 and 5

(2) In case of introduction of solar lanterns project

1) If LED lanterns with dry cell are used in the traditional technique (application of Option 2)

In case of project of replacement of LED lanterns existing dry cell with solar LED lanterns in non-electrified area, Option 1 or Option 2 is applicable because the dry cell is not defined as Fuel but as they are not connected to the mini-network of the village, Option 2 is applied. In this methodology, the reduction of emissions due to the reduction of the consumption of the dry battery is not taken into account.

Step 1: Development of clear specifications of devices introduced

The solar lantern introduced will be a lantern Panasonic of a panel power of 3.5 W (BG-BL03, after the start of electricity generation by the solar panels, charge the nickel-hydrogen battery charger battery type LR6).

Photo 6.7.3 Solar Lantern Panasonic BG-BL03

Step 2: Calculation of the base unit of the CO_2 reduction

The use time being 3.5 hours (8th paragraph (c)), the annual production of electricity per unit will be:

$E_{BL,y} = \sum_i EG_{i,y}/(1-l)$

3.5/1000 (kW) x 3.5 (h) x 365 (days)/ (1-0) = 4.47 (kWh/year-Unit)

The default value of EF_{CO2} (emission factor) is 0.0008 t CO_2/ kWh in the same paragraph, and the project duration of 10 years, the basic emissions per unit for 10 years are:

$BF_{CO2,y} = E_{BL,y} \times EF_{CO2}$

4.47 (kWh/year-Unit) × 0.0008 *(/kWh)* × 10 (years)

= 0.035 (t CO_2 / 10years-Unit)

Step 3: Calculation of CO2 reduction from the quantity and the number introduced

The table below shows the reduction of CO_2 emissions for a project period of 10 years, if the LED lanterns with dry cell are replaced with solar lanterns.

Table 6.7.4 Reduction of CO_2 emissions in the event of introduction of solar lanterns (1)

Region / Province / City	Population (2006)	1 unit for 5 people	t CO_2/10 years
Plateau-Central Region	693,137	138,627	4,852
Province Kourwéogo	136,017	27,203	952
City Boussé	41,455	8,291	290

3) <u>If the kerosene lanterns are used in the traditional technique (application of Option 3)</u>

In case of project of replacement existing kerosene lanterns with solar lanterns, Option 3 is applicable because the calculation in this option is based on the fuel consumption of the traditional technique.

Step 1: Development of clear specifications of devices introduced

Assumption: Average annual fuel consumption is 30 L/year.
The heat produced by kerosene (GJ /quantity or weight) is 43.8 TJ /Gg[11] and then, 0.035 GJ/L if we perform a unitary conversion.
The CO_2 emissions of kerosene (tCO_2 /GJ) are 71.9 t CO_2 /TJ[12] and then, 00072 t CO_2/GJ.

Photo 6.7.4 oil kerosene lantern

Step 2: Calculation of the base unit of the CO_2 reduction

The calculation is done by Option 3 with a project duration of 10-year

$$BE_{CO2,y} = \sum_j FC_{j,y} \times NCV_j \times EF_{CO2,j}$$

= 30 (L / year) × 0.035 (GJ / L) × 0,072 (t CO2 / GJ) × 10 years
= 0.76 (t CO2 / year-Unit)

The table below shows the reduction of CO_2 emissions for a project period of 10 years if kerosene lanterns are replaced with solar lanterns.

Table 6.7.5 Reduction of CO_2 emissions in the event of introduction of solar lanterns (2)

Region / Province / City	Population (2006)	1 unit for 5 people	t CO_2/10 years
Plateau-Central Region	693,137	138,627	127,537
Province Kourwéogo	136,017	27,203	25,027
City Boussé	41,455	8,291	7,628

[11] IPCC 2006 IPCC Documents for national inventories of greenhouse gases, Volume Energy, Tables 1 and 2
[12] 2006 IPCC Documents for National Greenhouse Gas Inventiories,Energy Volume 2,Table 2.5

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