Technical and economic feasibility study within the framework of the implementation of the National Determined Contribution (CDN) of Congo in the sector of land use and forestry.

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Introduction

The FAO entrusted CIRAD with the mandate to carry out three feasibility studies as part of the identification of the project "Implementation of the Contribution Determined at the National Level (CDN) of Congo in the sector of land use and the forest ”that the Congo wishes to offer to the financing of the Green Climate Fund (GCF)

The objective of the project is to develop investment projects reducing GHG emissions while generating economic and environmental benefits for local populations in three priority intervention areas (Sangha-Likouala, Pool-Plateaux, Kouilou-Niari departments). The project aims in particular to:

- Create sustainable sources of wood energy supply near major urban centers (Brazzaville, Pointe-Noire, Dolisie, Nkayi, etc.);
- Contribute to replacing shifting slash-and-burn agriculture with stabilized and sustainable agricultural practices, in particular agroforestry, which generate sustainable income;

The three feasibility studies entrusted to CIRAD are as follows:

- Technical and economic feasibility study, and development of the environmental and social management framework
- Operational and financial feasibility study
- Wood energy study

This report concerns the study of the technical and economic feasibility of the project. This study consisted of:

- Define technical itineraries of forest and agroforestry plantations adapted to the soil and climate conditions present in the various departments targeted by the project and in line with the socio-economic environment of the country.
- Define and locate the areas where this type of planting could be implemented. The location of the zones is accompanied by their environmental and socio-economic description. Studies preceding the implementation of projects must however be carried out on a case-by-case basis, the present study remaining on a relatively large scale (district) and without addressing the issue of land. Several modifications are proposed concerning the targeted departments, in particular to extend the project to the departments of Cuvette and Bouenza to the detriment of Sangha and Likouala (cf. summary note).
- Carry out an analysis of value chains concerning various major productions (cassava, cocoa, peanuts, plantains) included in the technical itineraries.

- Establish cost-benefit studies, based on value chain analyzes, to determine the economic viability of three different projects.
- Initiate the definition of an environmental and social management framework including consideration of potential risks, whether direct or indirect, for the environment and the populations concerned.

The team

The team that carried out this work consisted of:

- ✓ Francois Pinta
- ✓ Philippe Guizol
- ✓ Maurice Goma
- ✓ Vivien Rossi
- ✓ Louis mareschal

Thanks

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A. Technical routes

1) Technical itinerary for driving in eucalyptus plantation coppice

Introduction

This route offers a possible way of managing the existing eucalyptus plantations in the Republic of Congo. The main ones are located in the departments of Pointe-Noire, Kouilou and Bouenza in the Loudima area.

Twenty years ago, the eucalyptus massif located near Pointe-Noire represented approximately 42,000 hectares located on both sides of the Kouilou River, including approximately 10,000 hectares north of the river. The work carried out at the former CRDPI ten years ago showed that around 50% of the city's demand for wood energy came from logging residues (crowns) of this massif. Log wood was exported by boat, mainly after processing into chips. In the absence of adequate management of the massif, it is subject to anarchic exploitation of the plots. In addition, Pointe-Noire is the second city of the country with more than 1 million inhabitants and presents a strong demographic growth.

In addition to the share of fuelwood from eucalyptus plantations, the rest of the city's supply comes from nearby natural forests which are heavily impacted.

Reasoned management of eucalyptus plantations in the massif is becoming essential in order to ensure long-term supply to the city and would greatly limit the growing impact on the region's natural forests.

This technical route can also be applied to the Loudima forest massif. The strong demand for fuelwood for firing terracotta bricks, particularly in the Nkayi area, could be partly ensured by coppicing management of this massif, which is partly made up of eucalyptus.

Eucalyptus has the ability to reject stump after its exploitation. This characteristic can be used to regenerate stands, which requires less resources than carrying out replanting. With this type of management, the time between harvest and the growth of the new rotation is zero since the stumps immediately reject. This characteristic also has ecological advantages since the latency time between cutting and replanting is often greater than 6 months, inducing a loss of nutrients when the logging residues are mineralized. In addition, the root system already installed allows more vigorous growth of the shoots compared to new plants, which limits the problem of herbaceous management.

Soil and climate conditions:

In Congo poor savanna soils are suitable for eucalyptus. The coppiced management of this species on the poorest soils requires minimal fertilization during the recovery of stumps as well as adequate maintenance (control of herbaceous plants).

Management in coppice is possible on existing plantations (or on future plantations see note on mixed eucalyptus-acacias plantations) or in areas of deep sandy soils (e.g. Pointe-Noire region) or more clayey (e.g. region of Loudima). The more the soil is sandy, the more its depth will have to be important to ensure a maximum prospection by the roots making it possible to compensate for the decrease in the water reserve which is the case concerning the mentioned massifs.

Interview

Maintenance must be ensured as soon as competing herbaceous plants emerge. After one or more rotations of eucalyptus, a certain number of shrub plants will also have to be cut back (manual cutting or crushing) when the coppice is growing. At least one to two annual maintenance is recommended with either a simple mechanical work (superficial cutting / hoeing) accompanied or not by a herbicide treatment according to the degree of weed growth. In the case of plantations heavily invaded by grasses, the use of several passages of herbicide is essential.

Strand selection

The eucalyptus stumps will present numerous rejections (several dozen) a few months after cutting. A selection of one or two strands will be necessary between 5 and 12 months after cutting. The most developed strands will be kept which may be close but not located on the same eye. Do not keep 3 strands even if they are well developed.

Fertilization

Minimal fertilization is recommended. In the industrial plantations of Pointe-Noire, the recommended fertilization for coppicing was as follows for a production of 15 to 20 m3 of wood per hectare and per year: 40 kg N, 18 kg P and 50 kg K per ha on the first rotation of coppice (contributions at 1.5 years). In the 2nd rotation of coppice, this fertilization must increase by a third. Under this project, the needs will be lower because the expected productivity will be lower. At least 50 kg of nitrogen must be added at the end of the first year of coppice growth (after the selection of strands). This fertilization will aim to accelerate growth and boost the biological cycle, that is to say the recycling of nutrients via, in particular, the fall of litter. A minimal contribution of fertilizer,

Firewalls

The creation of firewalls around blocks of plots is essential to ensure the success of projects. Savannahs burn every year and it is certain that each plantation will be confronted with this problem. A wide firewall (6 m at least) made with a disc plow will be necessary. Regular rounds accompanied by means of fighting will also be compulsory during critical periods to limit the areas burned in the event of a fire breaking out.

Management of operating residues

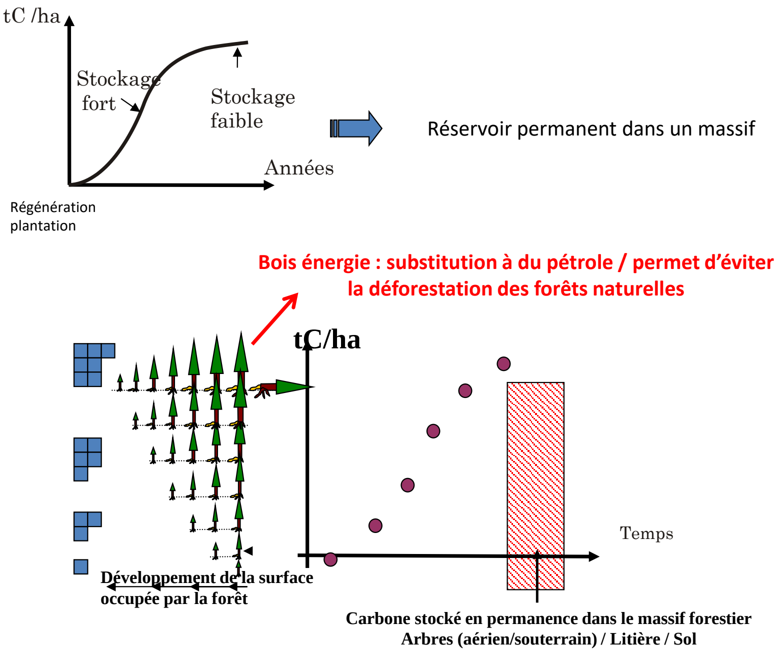
The exploitation of fuelwood or wood intended for the manufacture of charcoal must be limited to a diameter of 3 cm. All branches with a diameter of less than 3 cm must be maintained on the plot as well as all the leaf biomass. If possible the trunks can be debarked and the bark left on site if the working hand allows it. The nutrient richness of the leaves, fine tips and bark requires the application of this measure to maintain the chemical quality of the soil. The residues will be distributed relatively evenly on the plot (no swathing) and no burning will be practiced.

Expected returns

The expected yields following conversion to coppice (5-year operation) are of the order of 25-35 tonnes of wood produced per hectare (dry matter under bark).

Carbon stocks

One of the criticisms often made is that eucalyptus plantations do not store carbon in a sustainable manner because of their short rotation time (7 years on the first rotation then 5 years between each cut of coppice). This criticism is sometimes based on a poor understanding of the flows and stocks to be taken into account, as summarized in the diagram shown below.



Schematic representation of the carbon stock constituted by forest plantations with a 7-year rotation.

In the hypothesis of a balanced massif - for example on the basis of a massif of 7000 ha, 1000 ha are cut each year to be renewed in coppice (or replanted) - the carbon stock permanently present corresponds to that of 1000 ha of 1-year-old plantations + 1,000 ha of 2-year-old plantations +… + 1,000 ha of 7-year-old plantations (end of rotation in the case of a high forest). The biomass of plantations cut at 7 years replaces fossil energy (mineral coal, gas, petroleum) or coming from the exploitation of the natural forest.

Concerning soils, several examples show an increase or a stabilization of the quantity of stored carbon. In Hawaii, the conversion of pastures to eucalyptus plantations increases the C stock in the 1st meter of soil by 17.5%, to which is added the substitution of fossil C by renewable biomass (Crow et al., 2016). In Brazil, Eucalyptus afforestation does not significantly change the soil C stock (Fialho and Zinn, 2014), but here too, the production of standing biomass should also be taken into account. In Madagascar, the coppicing of E. robusta in the highlands to an increase in C stock compared to the original savannah of 38 tonnes of carbon per hectare, mainly via stumps and root system (Razakamanarivo et al., 2010). Finally in Congo D'annunzio et al., (2008) showed that an old eucalyptus plantation had carbon concentrations in the soil twice as high as in the adjacent savannah (provided that the plantation was not subjected to fires). Young plantations or old plantations having undergone fire passages did not show a significant difference in carbon concentration compared to savannas.

Risk of invasion

It is important to estimate the risk of invasion of exotic species in surrounding ecosystems. These risks are very low with eucalyptus which are, at very young stages, very little competitive compared to native vegetation (eg grasses). In general, the low invasive potential of eucalyptus is recognized (Callaham et al., 2013; da Silva et al., 2013; Larcombre et al., 2011). In Congo, whether in the region of Pointe-Noire or Loudima, which present different soil conditions, no invasion has been observed although many varieties of eucalyptus have been introduced for more than 60 years.

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2) Technical itinerary of mixed acacias-eucalyptus planting in savannah

Introduction

In Congo, on poor soils in the savannah zone, the association of acacias and eucalyptus in mixed plantations has been studied in depth. These studies show that biomass production is around 30% greater compared to a monoculture of eucalyptus (Bouillet et al., 2013). In association with acacia mangium, nitrogen transfer takes place in favor of eucalyptus trees which have a better nitrogen status (Tchichelle et al., 2017).

These studies have also shown that soils under mixed plantations have been enriched in particular with nitrogen and organic matter compared to pure eucalyptus (Koutika et al., 2014; Thichelle et al., 2017) and savannah (com. pers.).

In addition, the association of a fixing species such as acacia can increase the availability of phosphorus in soils either by the action of phosphatases which mineralize the phosphorus contained in the organic matter of the soil or by recycling via the fall of litter (Binkley et al. 2000; Houlton et al. 2008). In Congo, it has been shown that the phosphorus uptake by acacias was high and that the stocks were mostly located in the crown. Thus, restoring leaves and thin branches to the ground following the exploitation of the plots is a prerequisite to ensure optimum durability of these systems.

The principle of a mixed plantation is therefore to increase the use of the resources of the environment. This is demonstrated, for example, when a staging exists between two associated species allowing superior capture of solar radiation or even different spatial distribution of the roots allowing better prospecting of the volume of soil. These are then relations of complementarity.

Facilitation processes can also be put in place when one of the two associated species favors the other in the capture of a resource. In this case, this is what has been demonstrated in mixed plantations of eucalyptus and acacias mangium in Congo, the acacia allowing the eucalyptus to carry out higher nitrogen withdrawals than in monoculture.

Intra and inter-species competition may also exist for water, light and nutrient acquisition. The competitive relationships depend on the pedo-climatic context, the nature of the associated species and the spatial arrangement of the species. When the conditions are not met, competition can have a major impact on productivity. Planting density is a key factor allowing the manager to minimize the effects.

In addition to the inter-specific relationship aspects, the advantage of introducing acacias is that they develop a large leaf area and a thick soil litter which greatly limits the growth of herbaceous plants competing for water and nutrients. The second advantage is that this limitation of herbaceous growth reduces the risk of fires in the dry season.

Soil and climate conditions:

The work of species selection has often resulted in the choice of eucalyptus and acacia, in view of the very high adaptive capacities of these two botanical genera. This potential results from the evolutionary process which has led these species to adapt to particularly difficult environmental conditions in Australia with the alternation of droughts and fires, on very poor soils.

In Congo poor savanna soils are suitable for both species. Nevertheless, eucalyptus requires starter fertilization when planting on the poorest soils. In association with acacia mangium or acacia auriculiformis this fertilization can be reduced or suppressed.

These plantations are possible in areas of deep sandy to clayey soils. The more the soil is sandy, the more its depth will have to be important to ensure a maximum prospection by the roots making it possible to compensate for the decrease in the water reserve. The land should be relatively flat to facilitate planting, maintenance and operations.

An annual rainfall of 1200 mm, or more, is suitable even with a marked dry season of 3 to 4 months.

Types of associations:

Several arrangements of the two species are possible in the plots with planting densities ranging from 800 to 1200 plants per hectare. These planting densities appear to be adapted to the ecological conditions of the Congo savannas. A higher density can induce a significant mortality (by competition between the stems) in the driest places (very sandy and / or shallow soils with low water retention capacity, no groundwater or very deep water table out of access for trees).

Two planting methods are possible:

- Method 1: base of 1000 plants per hectare with 50% acacias and 50% eucalyptus. This design requires replanting after each rotation, as the acacia does not shed a stump. Two types of mixing are possible:
  - Acacias and eucalyptus planted alternately on the row
  - A row of acacias planted alternately with a row of eucalyptus

In this configuration, the stand must be replanted at the end of the first rotation. To do this, the eucalyptus strains will have to be devitalized (see results of ex CRDPI work on devitalization). Food crops (particularly cassava) could possibly be installed at the start of the second rotation benefiting from the enrichment of the soil produced by acacias.

- Method 2: on a basis of 1200 plants per hectare including 800 eucalyptus and 400 acacias. After the first harvest, the eucalyptus trees are grown in coppice which prevents the plot from being replanted. On row 2 eucalyptus are planted alternately with an acacia. In the second rotation, the stand is grown in eucalyptus coppices with one or two sprigs selected per stump of eucalyptus rejecting (cf.Technical itinerary for driving in eucalyptus plantation coppice).

Plant production:

The technical itinerary for the production of seedlings in the nursery can be found here:
http://sngf-madagascar.mg/wp2/

Preparation of the ground:

Three methods of preparing the ground are possible:

- Plowing can be done (40 cm deep) which will decompact the soil if they are compact. This decompactions will allow an optimal installation of the root system. The strong initial growth of the root system will ensure rapid colonization of deep horizons allowing trees to satisfy their water intake during dry seasons. Plowing in the open also makes it possible to remove very competitive herbaceous plants from the savannah, in particular for eucalyptus, and thus favor trees during the first year of growth.
- Plowing can be replaced by a subsoil which decompacts the soil to a greater depth but does not allow the elimination of savannah vegetation. This practice limits the mineralization of organic matter in the soil compared to full plowing. Subsoiling requires high horsepower

tractors and the use of higher rate herbicides to control weeds. After the burning of the savannah in the dry season, a herbicide spraying will be carried out during the run with doses of 2.5 l to 4.5 l of glyphosate per hectare depending on the density of the vegetation. The diluted product will be applied with a micronizer then the subsoiling carried out. Planting will be carried out at the start of the rainy season after the soil has been re-moistened.

- This last method of preparing the ground and the simplest to implement since it does not require any tillage. The plants are planted directly after burning the savannah and herbicide treatment (see above). This technique will be carried out on light soils that do not present any physical constraint to root growth, in particular on sandy soils. It is the most economical planting method that will be applied as a priority in the case of a small community project.

Planting

The plants should be well formed and vigorous. They should be at least 30 cm high from the collar. The plants will have been copiously watered just before the planting operation. If the plants were produced in plastic bags, these should be removed when planting. Planting holes will need to be adjusted to the size of the root ball which may differ depending on the plant supplier. The most important thing is that the root ball of the plant is properly buried in the soil, a slight depression can be formed around the plant in order to collect rainwater. The filling soil should be sufficiently packed around the plant. Poorly buried clods will not allow good development of the tree and will increase the risk of mortality.

Relining

One or more relining should be done within a few months of planting. Mortality can occur in the event of an exceptional dry period and / or by insect attacks (stem cut crickets, for example). Trees replanted 4 months after planting cannot catch up and will remain stunted and dominated for the remainder of the rotation. After this period, relining becomes unnecessary.

Interviews

Maintenance (weeding) should be carried out regularly in order to eliminate competition from weeds for water and mineral elements, and particularly grasses. A lack of maintenance of the plantations also increases the risk and the force of the fires which occur regularly causing a decrease in the growth and a loss of nutrient in particular nitrogen by volatilization.

Weeding can be carried out by surface hoeing to limit as much as possible the deterioration of the roots of eucalyptus trees growing in shallow horizons or by the use of herbicides. In this case, the doses will be between 2.5 l and 4 l of glyphosate per hectare depending on the vigor of the recruit. The diluted product will be applied by sprayer. This operation requires dry and windless weather. Protection of the young plants will be necessary to prevent the herbicide from reaching them.

Firewalls

The creation of firewalls around plots is essential to ensure the success of projects. Savannahs burn every year and it is certain that each plantation will be confronted with this problem. A wide firewall (at least 6 m) made with a disc plow will be made between blocks of plots. Regular rounds will also be necessary during critical periods to limit the areas burned in the event of a fire breaking out.

Duration of rotations

The stands will be exploited after a standard duration of 7 years. Depending on the land, this period may be reduced (fertile soil) or lengthened (poor soils). A very short rotation period (3 or 4 years) can jeopardize the fertility of the plot by excessive export of mineral elements in the biomass. In the case of replanting, the plots should be exploited if possible during the dry season and then replanted as soon as the rains resume, once the soil has been re-moistened. A prolonged wait between exploitation and replanting is harmful because on the one hand a part of the organic matter mineralizes inducing a loss of nutrient and on the other hand this delay is favorable to the development of a significant herbaceous regrowth that it will have to be removed again before planting. Technical itinerary for driving in plantation coppice

Management of operating residues

The exploitation of fuelwood or wood intended for the manufacture of charcoal must be limited to a diameter of 3 cm. All branches with a diameter of less than 3 cm must be maintained on the plot as well as all the leaf biomass. If possible the trunks can be debarked and the bark left on site if the working hand allows it. The nutrient richness of the leaves, fine tips and bark requires the application of this measure to maintain the chemical quality of the soil. The residues will be distributed relatively evenly on the plot (no swathing) and no burning will be practiced.

Expected returns

The expected yields in the first rotation (7 years) are of the order of 30 to 40 tonnes of wood (dry matter under bark) produced per hectare in the two proposed planting systems. Regarding option 1, this production will be made up of around 2/3 of eucalyptus wood and 1/3 of acacia wood and 3/4 of eucalyptus and 1/4 of acacia in option 2. Coppicing in the second rotation (option 2) will generally give lower yields (25-35 tonnes per hectare) compared to the first rotation combining eucalyptus and acacias, but the additional costs associated with replanting will be reduced.

Carbon stocks

A study was carried out in Congo concerning, among other things, the carbon content of the soil in mixed eucalyptus-acacias plantations (Koutika et al., 2014). This study shows that after a mixed plantation rotation of 7 years (on an initial soil of savannah afforested in eucalyptus for 20 years) that the carbon stock increased by 2.1 tonnes per hectare compared to the monoculture of eucalyptus over a depth of between 0 and 25 cm. No study has been carried out in Congo to directly compare the effects of a mixed plantation compared to savanna soils since these plantations were installed on plots previously afforested with eucalyptus. Other studies show a carbon enrichment of soils of mixed plantations associating a legume (kaye et al., 2000;Forrester et al., 2010) after previous crops such as pastures or sugar cane plantations. In general, afforestations appear to increase soil carbon stocks after a more or less long period of afforestation (Li et al., 2012; Fialho and Zinn, 2014; Razakamanarivo et al., 2010).

The carbon stocks contained in the standing biomass of forest plantations are significantly greater than in the savannah (see technical note on eucalyptus coppice). For a mature plot of eucalyptus (6 years old), a stock of 74.5 tonnes per hectare of above-ground biomass (dry mass) was measured in Congo, including 61.7 tonnes of trunk wood and 15.1 tonnes of root biomass while the values in savannah are 3.5 and 8.3 tonnes per hectare for the above-ground and below-ground dry biomass respectively.

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3) Technical itinerary of teak planting

Introduction

Teak (tectona grandis) is a species native to Asia that is planted in about 70 tropical countries for the production of timber and service timber (including poles) when it is managed in coppice or during harvesting operations. depressing. The estimated global area of teak plantations varies between 4.3 and 6.9 million hectares (IUFRO, 2017). The reputation for quality linked to teak wood initially comes from wood exploited in natural stands (eg Burma). The supply of teak from natural forests is currently severely limited. Under these conditions, the production of teak wood to supply the growing world demand will be mainly carried out in plantations. Teak plantations in tropical areas are developing an increasingly marked interest for private sector investors with in particular a significant boom in clonal teak plantations (Monteuuis and Goh 2017). In the market, teak wood from plantations has a reputation of lower quality except for stands aged 50 years and over (eg Thailand, India and Indonesia). The widely practiced short rotation management (± 20 years) does not allow the production of high quality timber. The production of high quality teak in plantation is nevertheless possible by respecting certain conditions in particular with regard to the genetic material and the management of the plots (including the duration of the rotations). teak wood from plantations has a reputation for lower quality except for stands aged 50 and over (eg Thailand, India and Indonesia). The widely practiced short rotation management (± 20 years) does not allow the production of high quality timber. The production of high quality teak in plantation is nevertheless possible by respecting certain conditions in particular with regard to the genetic material and the management of the plots (including the duration of the rotations). teak wood from plantations has a reputation for lower quality except for stands aged 50 and over (eg Thailand, India and Indonesia). The widely practiced short rotation management (± 20 years) does not allow the production of high quality timber. The production of high quality teak in plantation is nevertheless possible by respecting certain conditions in particular with regard to the genetic material and the management of the plots (including the duration of the rotations).

This forest species can develop in variable climatic conditions ranging from low rainfall (600 mm per year) to very high rainfall (<3000 mm per year). Teak also tolerates extended dry seasons and a wide range of soils. However, for the objective of producing quality timber, the optimal pedoclimatic conditions are much more restricted. Particular attention must be paid to the choice of plant material which will largely determine the quality of the wood (eg natural durability, percentage of heartwood, infradensity, etc.) but also the formation of rectilinear barrels with limited branching. Other criteria will be decisive for a quality production such as the vitality of the plants when they leave the nursery, the duration of rotation and the management of plots, teak being sensitive to competition. Teak is a species that can be planted by smallholders with good financial return if the above conditions are met. The association with food crops at the start of the cycle is also interesting. An incentive system to ensure the use of appropriate plant material and adequate management is necessary. This type of planting can be a promising opportunity for the timber industry, allowing diversification of the income of small planters. However, from a lumber production perspective, the relatively long rotation duration implies setting up on state land by state services or by specialized private investors. teak being sensitive to competition. Teak is a species that can be planted by smallholders with good financial return if the above conditions are met. The association with food crops at the start of the cycle is also interesting. An incentive system to ensure the use of appropriate plant material and adequate management is necessary. This type of planting can be a promising opportunity for the timber industry, allowing diversification of the income of small planters. 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Soil and climate conditions:

Teak is a relatively demanding species in terms of soil quality. Moderate acidity (pH> 5.5), relatively high cation exchange capacity (> 4 cmolc. Kg-1) and a balanced textured soil will be appropriate. Compact, very clayey soils as well as hydromorphic soils, temporarily flooded are to be avoided.

The precipitation regime is an important factor in the growth of teak. A very marked dry season will favor the formation of lateral branches. In fact, water stress causes the bud break on the sides, favoring the growth of branches to the detriment of log wood. Additional pruning work will be necessary to reduce the presence of large knots that degrade the quality of the wood. Eventually, the appearance of a fork will stop the growth in length of the barrels. While the recommended optimum varies from 1200 to 2500 mm of annual precipitation, a well distributed rainfall over the year and exceeding 1800 mm per year will be recommended, in particular for highly productive clones. In all cases, the introduced genetic material must be adapted to local pedo-climatic conditions and, to do this,

Genetic material

Teak improvement programs exist in many countries with the objective of improving the quality of the wood. Most of the genetic material currently used in teak plantations is of uncertain origin and does not allow for quality production. Plantings can be made from seeds or clones (cuttings) obtained from selected lines. Significant progress has been made in recent years in the production of improved seeds but also in clonal production. Currently, some high productivity clones allow the production of quality wood. The genetic material must therefore imperatively come from a certified origin, whether for seeds or clones. Several methods of seedling production are possible in the nursery which are not detailed here. A trial with efficient clones (Goh and Monteuuis 2012) was recently set up in Gabon, the results will have to be analyzed to confirm their adaptation to Central African conditions. A supply of efficient clones is possible in Malaysia:http://www.ysgbioscape.com/

The nursery teak plant production protocol is available here:*http://www.cnra.ci/email.php?idfich=39*

Preparation of the ground:

Three methods of preparing the ground are possible:

- Plowing can be done (40 cm deep) which will decompact the soil if they are compact. This decompactions will allow an optimal installation of the root system. The strong initial growth of the root system will ensure rapid colonization of the deep horizons allowing the trees to satisfy their water withdrawal during the dry seasons. Plowing in the open also makes it possible to remove very competitive savannah herbaceous plants, in particular for teak, and thus favor the trees during the first year of growth.
- Plowing can be replaced by a subsoil which decompacts the soil to a greater depth but does not allow the elimination of savannah vegetation. This practice limits the mineralization of organic matter in the soil compared to full plowing. Subsoiling requires high horsepower tractors and the use of higher rate herbicides to control weeds. After the burning of the savannah in the dry season, a herbicide spraying will be carried out during the run with doses of 2.5 l to 4.5 l of glyphosate per hectare depending on the density of the vegetation. The diluted product will be applied with a micronizer then the subsoiling carried out. Planting will be carried out at the start of the rainy season after the soil has been re-moistened.
- This last method of preparing the ground and the simplest to implement since it does not require any tillage. The plants are planted directly after burning the savannah with or without herbicide treatment. This technique will be carried out on light soils that do not present any physical constraint to root growth, in particular on relatively sandy soils. It is the most economical planting method that will be applied as a priority in the case of a small community project.

Planting density and thinning

Planting densities vary depending on the context and production objectives ranging from wide spaces (4 mx 4 or 5 mx 5) to higher densities (2.35 mx 2.35). This choice will impact stand management operations. High densities can be used with genetic material of uncertified provenance or if management operations will be limited in the first years (control of grass cover, etc.). The density will then make it possible to partially compensate for these effects but will require a first significant thinning before the trees come into strong competition, between 3 and 8 years depending on the site. The depressing operation will be carried out according to the type of production envisaged (volume and quality of barrels at the end of the rotation). It will reduce competition and eliminate dominated / poorly shaped trees. This should be done quickly after closing the canopy. The objective is to concentrate resources (water, nutrients, light) on the most beautiful subjects. A prolonged wait without depressing will lead to increased mortality and produce very low growth in diameter.

Low density planting will be preferred if maintenance work can be properly carried out, in particular the fight against weeds. In low planting density longer rotations will generally be considered for the production of large individual volumes. Rather early pruning will also be necessary to ensure good conformation of the barrels.

At low density (from 3 x 3 m spacings) intercrops can be planted (peanuts, corn) more than 1 meter from the teak line for 2 to 3 years depending on the development of the trees. The maintenance of crops will promote the fight against herbaceous plants.

Table 1: schedule of thinning work to be carried out on a plot planted with an initial density of 1600 plants per hectare (source: from CNRA, 2012).

Caractéristiques des peuplements	Eclaircie 1	Eclaircie 2	Eclaircie 3	Eclaircie 4	Eclaircies 5 et 6
Age (ans) en fonction de la fertilité	3 à 9	6 à 20	11 à 13	16 à 19	20-47
Densité après éclaircie (tiges/ha)	800	450	300	210	100 - 125
Diamètre moyen (cm)	11	15	26	33	38 et plus
Hauteur totale (m)	10 à 11	13 à 14	17 à 18	25 à 26	> 26
Produits d'éclaircies	Perches – piquets – poteaux – bois de chauffe			Bois d'œuvre	

When planting, the plants should be well formed and vigorous. The plants will have been copiously watered just before the planting operation. If the plants were produced in plastic bags, these should be removed when planting. Planting holes will need to be adjusted to the size of the root ball which may differ depending on the plant supplier. The most important thing is that the root ball of the plant is properly buried in the soil, a slight depression can be formed around the plant in order to collect rainwater. The filling soil should be sufficiently packed around the plant. Poorly buried clods will not allow good development of the tree and will increase the risk of mortality. To facilitate the transport of "stumps" can be prepared from nursery plants.

Fertilization

Fertilization gives disparate results depending on the pedoclimatic context. In the poorest soils, suitable fertilization can increase yields by 30 to 50%. This operation is carried out at planting and possibly following the first depressing In acidic soil pH <5.5, the application of an amendment (limestone, gyspe, dolomite) is recommended.

Interviews

Maintenance (weeding) should be carried out regularly in order to eliminate competition from weeds (particularly grasses) for water and mineral elements. A lack of maintenance of the plantations increases the risk and the force of the fires which occur regularly causing a decrease in the growth and a loss of nutrients including nitrogen by volatilization.

Weeding can be carried out by surface hoeing to limit as much as possible the deterioration of roots growing in the superficial horizons or by the use of herbicides. The diluted product will be applied by sprayer. This operation requires dry and windless weather. Protection of the young plants will be necessary to prevent the herbicide from reaching them. Interviews should be carried out during the 5 years following planting.

Firewalls

The creation of firewalls around plots is essential to ensure the success of projects. Savannahs burn every year and it is certain that each plantation will be confronted with this problem. A wide firewall (at least 6 m) made with a disc plow will be made between blocks of plots. Regular rounds will also be necessary during critical periods to limit the areas burned in the event of a fire breaking out.

Pruning

This operation is essential for obtaining quality wood. This operation also depends on the density of plantation and the genetic material introduced. In general, the first pruning is carried out up to heights between 4 and 6 m (tree of 10-11 m) and a second will intervene thereafter up to 6 meters in height. Higher prunings can be continued afterwards depending on the production objectives. The operator will take care not to "climb" too high at the risk of reducing the crown too much and reducing tree growth. This operation will preferably be carried out in the dry season.

Duration of rotations

The rotation period is very variable, ranging on average from about twenty years to 80 years and more depending on the type of production envisaged.

Expected returns

Teak is considered a fast growing species, but less so than eucalyptus and acacia trees. Growth in height is very strong the first years. The yield of teak is subject to debate for several reasons, the introduction of this species has been carried out in areas for which no retreat exists and management techniques have been very variable. In suitable sites and under proper management the height growth of plants reaches 3 to 6 meters per year (Jerez M and Coutinho S, 2017). An annual increase in volume reaching 15 to 20 m3 per hectare is very strong. For an increase below 6 m3.ha-1.year-1, planting is not profitable (Jerez M and Coutinho S, 2017).

Carbon stocks

Knowledge about the effect of teak plantations on carbon storage in soils is very limited. However, teak plantation projects on sites occupied by savannah and / or highly degraded forest allow an increase in carbon storage in above-ground and underground biomass as well as in ground litter. In this context, the diagram presented above in the context of eucalyptus plantation remains valid for all forest plantations including teak. One consequence of the protection of plots against fire is the presence of an important layer of litter on the ground allowing the incorporation of carbon into the soils, a very limited process in savannah ecosystems generally subject to annual fires. In this context,

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4) Agroforestry technical itinerary based on acacias

Introduction

The cities of Brazzaville, Dolisie and to a lesser extent the city of Pointe-Noire are located in areas of savannah developed on poor soils. As a result, food crops (especially cassava and maize) established on these impoverished soils show low yields and the use of inputs remains in the minority. In the savannah zone, the soils under more fertile forests (forest islands, lowland areas, riverine forests) are primarily exploited by farmers after burning causing severe degradation of these ecosystems. Beyond self-consumption, agricultural production is exported to cities in a variable manner depending on the possibilities of delivery. Charcoal, a by-product of slash-and-burn agriculture, is mainly consumed in urban centers. Faced with this observation (low yields in savannah areas and slash-and-burn cultivation in forest islets), the implementation of agroforestry practices based on nitrogen-fixing trees offers, to a certain extent, environmental benefits on issues of 'soil depletion, deforestation and carbon storage in agroecosystems. At the same time, this alternative makes it possible to meet the needs of the populations by producing fuelwood and foodstuffs, partly consumed for themselves, or exported to urban centers. This technical note presents, on the basis of scientific work and experiences of development projects, the establishment of an agroforestry system based on nitrogen fixing trees (acacias) in order to enrich the soils with nitrogen and organic matter allowing an increase in crop yield and the production of fuel wood in a renewable. On the subject, the emblematic example conducted in the Democratic Republic of Congo (Mampu agroforestry project) has shown that an economic profitability of such a project is possible subject to certain conditions being met. It is not a question of reproducing the same project in the Republic of Congo but of adapting it according to local specificities. the emblematic example carried out in the Democratic Republic of Congo (Mampu agroforestry project) has shown that an economic profitability of such a project is possible subject to compliance with certain conditions. It is not a question of reproducing the same project in the Republic of Congo but of adapting it according to local specificities. the emblematic example carried out in the Democratic Republic of Congo (Mampu agroforestry project) has shown that an economic profitability of such a project is possible subject to compliance with certain conditions. It is not a question of reproducing the same project in the Republic of Congo but of adapting it according to local specificities.

The interest of acacias consists mainly in their strong atmospheric nitrogen fixation capacity which has been quantified in particular in Congo in the region of Pointe-Noire (60% of the nitrogen present in the biomass of acacia mangium comes from the 'Atmosphere, Tchichelle et al., 2017a). This fixing capacity is expressed in particular in soils initially poor in nitrogen. The cumulative amounts of nitrogen mineralized in the soil (horizon 0-20 cm) under acacia stands reached 340 kilos of nitrogen per hectare 2 years after their planting (Tchichelle et al., 2017b) which is incomparably higher than in a savannah. At the age of 7, the nitrogen in the soil, mainly contained in organic matter (horizon 0-25 cm) and the nitrogen present in acacia residues (thin branches and leaves), represents a quantity of 1 , 74 tonnes per hectare (Tchichelle et al., 2017b). These characteristics clearly show the agronomic potential that this species can represent in the Congo. In this note, the aim is to show how to convert this potential into services dedicated to agroforestry production (wood and agricultural products) and environmental conservation (soil fertility and carbon storage).

Soil and climate conditions:

The various experiments carried out in the Congo show that poor savanna soils are perfectly suited to acacias mangium and auriculiformis. Agroforestry plantations are possible in areas of deep, sandy or clay-sandy soils. The more sandy the soil, the greater its depth to ensure maximum prospecting by acacia roots to compensate for the decrease in water reserves, especially in the dry season. The land should be relatively flat to facilitate planting, maintenance and operations. The average annual rainfall should be at least 1200 mm and the presence of a marked dry season of 3 or 4 months will not be a limit. The relative humidity of the atmosphere must be high (> 80%), a favorable criterion for the growth of acacias.

Production of acacia plants:

The establishment of a village nursery for the production of acacia plants is described here:

http://makala.cirad.fr/les_produits/guides_pratiques

Preparation of the ground

The preparation of the land in the savannah can be carried out manually or mechanically depending on the size of the project and the means implemented. The savannah shrubs will be cut first before removing the herbaceous vegetation. Three possibilities are possible for the preparation of the ground:

- Plowing can be done (30 to 40 cm deep) which will decompact the soil if the latter are compact. The savannah will first be burnt or cut back with a roller. An additional herbicide treatment may possibly be applied before plowing in full. Decompactions will allow an optimal installation of the root system ensuring good start of trees and crops. The strong initial growth of the root system will ensure the trees a rapid colonization of the deep horizons allowing them to satisfy their water withdrawal during the dry seasons.

- Plowing can be replaced by a subsoil which decompacts the soil to a greater depth but does not allow the elimination of savannah vegetation. This practice limits the mineralization of organic matter in the soil compared to full plowing. The subsoiling requires high power tractors. Depending on the scope of the project, herbaceous plants can be controlled by the use of herbicide before subsoiling or by manual work. If a herbicide is used, spraying will be carried out following the burning during the shoot with doses of 2.5 l to 4.5 l of glyphosate per hectare depending on the density of the vegetation. The diluted product will be applied with a micronizer then the subsoiling carried out.

- This method of site preparation requires manual labor only. Acacia plants and food crops are planted directly after burning or manual clearing of the savannah. This technique will be carried out on light soils that do not present any physical constraint to root growth, in particular on sandy soils. This is the most economical planting method that will be applied by small farmers who do not have the possibility of mechanization (eg tractor and driver rental).

Planting

Planting will take place at the start of the rainy season after the soil has been sufficiently re-moistened. Acacias are planted at a density of 1111 plants per hectare with a spacing of 3 meters between rows and 3 meters on the row. The planting holes will have been opened beforehand with a dimension of 30 cm deep by 30 cm on the side. These dimensions can be adapted according to the size of the root ball of the plants from the nursery. A good initial rooting requires that the collar of the plant is positioned at the limit of the soil surface (possibly in a depression arranged for the collection of rainwater) and that the filling soil is sufficiently compacted. The container (plastic bag) of the plant's root ball will be removed just before planting,

In the inter-rows, cassava and maize will be planted mainly, either as pure crops or as a mixture. Other plants can also be combined according to local habits (tomato, okra, pepper, etc.). Improved varieties of cassava will be essential to optimize yield.

Interviews

The initial maintenance of the acacia plants will be carried out in the same way, and at the same time, as the maintenance of food crops positioned in the interlines, that is to say mainly by superficial hoeing. The crops can be cultivated over two years, then the acacia canopy will become too dense.

Duration of rotations, operation and second cycle

The period of rotation of the acacia stand will depend on the area available to a farmer and his annual planting capacity. The rotation period will be between 7 and 12 years. A farmer, supported by manpower, exploiting 1 hectare per year must have a minimum of 7 hectares of land to set up rotations of 7 years. In this configuration, the farmer will have to plant each year and for 7 years, 1 hectare of land with acacias and food crops. Seven years later, the second rotation can begin after exploitation of the first hectare planted. These areas are given for information only and depend on the ability of the operators to organize teamwork, to benefit from labor and / or mechanization. It should be noted that, on the savannah, an agroforestry plantation of acacia and cassava in the first cycle cannot produce yields equivalent to those of a cassava plantation carried out after an acacia cycle. For this reason, farmers will have to receive aid from the project until the exploitation / replanting of the first acacia parcel so that the benefits, particularly in terms of soil fertility, are perceptible. However, it would be ideal for acacia plantations to be initially established on large areas so that at the end of the rotation, the land is ceded to farmers who could benefit from the wood and the fertility induced by the trees. For this reason, farmers will have to receive aid from the project until the exploitation /

replanting of the first acacia parcel so that the benefits, particularly in terms of soil fertility, are perceptible. However, it would be ideal for acacia plantations to be initially established on large areas so that at the end of the rotation, the land is ceded to farmers who could benefit from the wood and the fertility induced by the trees. For this reason, farmers will have to receive aid from the project until the exploitation / replanting of the first acacia parcel so that the benefits, particularly in terms of soil fertility, are perceptible. However, it would be ideal for acacia plantations to be initially established on large areas so that at the end of the rotation, the land is ceded to farmers who could benefit from the wood and the fertility induced by the trees.

At the end of the rotation, the trees are exploited and transformed into charcoal directly in the plots, preferably in the dry season. The charcoal residues can be distributed throughout the plot in order to increase the fertility of the land. The residues (leaves, branches) will then be destroyed by the use of a controlled fire. This controlled burn will clean the plots, facilitating the establishment of the next crop cycle and lifting the dormancy of the acacia seed stock present in the soil. Post-harvest burning will cause significant volatilization of nitrogen present in residues and litter on the soil surface. According to data published in Congo on very poor soils (Tchichelle et al., 2017b), soil nitrogen will remain in the system at a level of 1.2 tonnes per hectare (horizon 0-25 cm).

In the second rotation and beyond, an addition of amendment will be necessary to guard against soil acidification (Dubiez et al., 2018). The quantity supplied will be 2 tonnes per hectare in the form of crushed limestone.

Expected returns

Acacia wood: 40 to 50 tonnes per hectare for a 7-year rotation on the Batékés plateaus and 60 to 75 tonnes on the more fertile soils of the Niari valley. The carbonization yield varies between 10-15%.

Cassava: 5 to 10 tonnes on the Batékés Plateaux for an 18-month cultivation cycle depending on the varieties and any phytopathological damage and between 7.5 and 15 tonnes on the soils of the Niari valley. Yields will be about 20% higher in the second rotation after a cycle of acacia cultivation.

Maize: 0.5 to 1.5 tonnes per hectare depending on the site, optional crop, maize is planted in the first year only.

Carbon storage

It has been shown that the introduction of nitrogen-fixing trees, and in particular acacias, makes it possible to increase the carbon stock of the soils compared to previous uses (pastures, savannah, sugar cane, etc.). Regarding agroforestry practice, it has been shown in the Democratic Republic of Congo (Mampu massif, based on acacias auriculiformis, cassava and maize) an increase in carbon and nitrogen contents in the soils after one, two and three rotations (Dubiez et al., 2018) including when the technical itineraries included a burning of the residues at the end of the rotation. This increase is on average 16% under plantations compared to the surrounding savannas. It was noted that the sandy nature of the soils at the Mampu site is a limit to the increase in the carbon content of the soils. Additional information concerning carbon storage is also summarized in the technical note mixed eucalyptus-acacias plantations. In particular in Congo, the work of Koutika et al. (2014) show an increase in carbon stocks in the surface horizon of the soil under acacia plantation (800 plants per hectare) of 2.1 tonnes per hectare compared to a eucalyptus plantation on savannah.

With regard to storage in the biomass of forest plantations, the principles of storage are explained in the technical note "eucalyptus coppice".

Overall, a study on carbon sequestration was carried out as part of the evaluation of the Mampu agroforestry project and estimates indicate that this agroforestry system sequesters 113,000 tonnes of CO2 annually over an area of 7,500 hectares. Beyond sequestration, this system allows the production of wood energy which promotes the preservation of natural wooded areas. It is estimated that this Mampu agroforestry system prevents the annual destruction of 500 ha of savannas and gallery forests (data taken from the Mampu Vol. I project synthesis report).

Reference:

Dubiez E, Freycon V, Marien JN, Peltier R, Harmand JM. 2018. Long term impact ofAcacia auriculiformis woodlots growing in rotation with cassava and maize on the carbon and nutrient contents of savannah sandy soils in the humid tropics (Democratic Republic of Congo). Agroforest Syst.,https://doi.org/10.1007/s10457-018-0222-x

Koutika LS, Epron D., Bouillet JP, Mareschal L. 2014. Changes in N and C concentrations, soil acidity and P availability in tropical mixed acacia and eucalypt plantations on a nutrient-poor sandy soil. Plant and soil, 379: 205-216.

Tchichelle S., Mareschal L., Koutika LS, Epron D. 2017a. Biomass production, nitrogen accumulation and symbiotic nitrogen fixation in a mixed-species plantation of eucalypt and acacia on a nutrient-poor tropical soil. Forest Ecology and Management, 403: 103-111.

Tchichelle S. Epron D. Mialoundama F. Koutika LS. Harmand JM. Bouillet JP. Mareschal L. 2017b. Differences in nitrogen cycling and soil mineralization between a eucalypt plantation and a mixed eucalypt and Acacia mangium plantation on a sandy tropical soil. Southern Forests, 79: 1-8

5) Technical itinerary of agroforestry plantation based on cocoa in the savannah

Introduction:

Recent work carried out in Cameroon in particular shows that the installation of agroforestry plantations associating cocoa in forest-savanna transition zones is a production method whose yields can be equivalent to those obtained in traditional agroforestry in forest zones (Jagoret et al. , 2012; Jagoret et al., 2017). The success of agroforestry plantations in these savannah zones is possible but subject to several conditions. In fact, particular constraints arise for this type of project and, in particular, the eradication of herbaceous plants which exhibit a strong persistence (eg Imperata cylindica, Hyparrhenia diplandra). The fertility of savannah soils, often mediocre, must be progressively improved, in particular by the establishment of tree cover to achieve the yields obtained in forest areas. The association of various species of fruit and forest trees makes it possible both to control herbaceous plants and to enrich the soil. Faced with these constraints, technical and / or logistical support to be defined will have to be granted to growers. Only motivated and experienced entrepreneurs (or failing that who can benefit from training and support) will be able to carry out this type of project. Food crops installed at the start of the cycle allow, on the one hand, maintenance of the plots and, on the other hand, to economically enhance the clearing work. The diversification of income, in particular with food crops and fruit trees, contributes significantly to the functioning of households and reduces risks in a context of fluctuating world cocoa prices. This type of plantation limits dependence on chemical inputs, including in marginal areas, that is to say with a rainfall of between 1300 and 1500 mm on poor and relatively sandy soils.

It has been shown that the establishment of cocoa trees in forests is a very important driver of deforestation in tropical zones. The will of the Republic of Congo to revitalize the cocoa sector must be accompanied by strict framework measures to reduce the potential impacts on the natural forest and to respect the country's commitments, particularly with regard to its National REDD + Strategy.

In this context, and to support the Republic of Congo in the development of the cocoa sector while minimizing environmental impacts, this technical sheet presents an operating procedure for installing cocoa trees in the savannah. It is important to point out that there is no single operating mode and many variants could be implemented which will depend on the social, economic and environmental context of the project area. Multi-year technical support carried out by qualified personnel will be necessary to ensure the sustainability of the projects.

Soil and climate conditions:

This type of agroforestry plantation is possible on relatively deep (> 2m) sandy-clay soils (proportion of sand <60) ensuring a large volume for root prospecting, especially in areas with poorly distributed rainfall throughout the year. A precise pedological characterization will be necessary given the sometimes significant variability of the soils, in particular depending on the relief (hydromorphic lowland zone, impoverished ridge zone, etc.). The plots must not have been exhausted beforehand by several cycles of food crops (eg cassava) but installation on fallow land is possible. Installation and maintenance will be facilitated in relatively flat areas which will be preferred. Rainfall must be at least 1300 mm per year with a dry season not to exceed 3 months. In this context, the soil-climate interaction is important, a pluviometry at the limit of acceptability for cocoa can be compensated by soils having a good water retention capacity or located on a shallow water table.

Procedure:

Preparation of the ground:

Several land preparation techniques are possible. The cocoa trees will be planted i) after one or two food planting cycles or ii) after mechanized work and herbicide control by herbicide treatment. The first method of preparing the land is intended for growers with little financial means, which is generally the case in Africa. The second method of preparing the ground will allow a larger-scale establishment for entrepreneurs with greater investment resources.

1. Control of savanna herbaceous plants by annual crops

    This method of installing cocoa trees under shade has proved its worth in Cameroon in marginal savanna areas for cocoa production (Jagoret et al., 2012). This strategy consists of cultivating food crops for two years (groundnuts, maize, squash, etc.). Two interviews (weeding) will be necessary before the soil is covered by the plants. After 2 years of cultivation and manual elimination of savannah herbaceous plants, the cocoa trees are planted in association with fruit trees. Forest trees are also introduced or those naturally established are preserved. Bananas (plantain) are installed beforehand to ensure the initial shade. Food crops continue for the next 2-3 years and their maintenance allows efficient control of herbaceous plants.

2. Herbaceous control by mechanized work and chemical treatment

    This alternative is based on mechanized and chemical control of herbaceous plants and therefore requires greater financial investment. The areas planted can therefore be larger. The savannah is mown beforehand then burnt (or rolled back) to allow plowing of the plot. The plot can possibly be is cultivated (groundnuts) one year. In this case, planting is carried out mechanically with a seeder allowing the sowing of 80 kg of peanut seed per hectare. The planting of trees and cocoa trees can also be done in the year of plowing at the start of the rainy season. Bananas (plantains) are planted to provide initial shade. The total elimination of herbaceous plants will be ensured by a herbicide treatment on the regrowth.

Production of banana and cocoa plants:

The protocol for the production of banana plants is available here:

https://agritrop.cirad.fr/576537/1/La_multiplication_de_materiel_de_plantation_de_qualite_pour_ameliorer_1895.pdf

https://publications.cta.int/media/publications/downloads/1650_PDF.pdf

The protocol for the production of cocoa seedlings is available here:

http://www.worldagroforestry.org/downloads/Publications/PDFS/MN17369.pdf

https://www.biologievegetale.be/plant-ch/cacaoyer/techniqu/pepincacao.htm

Installation of temporary shading

This shade is important for the subsequent establishment of the cocoa plants. The density of bananas will gradually decrease with the closure of the canopy around the fourth year.
Bananas will be planted at the very beginning of the rainy season with a spacing of 4 m by 4 m.

Planting the tree layer

The spacing between tree species is an important point because it makes it possible to control in particular the shade and the air circulation in the plantation. A closed canopy in the upper stratum can promote the development of pathogenic fungi. Three layers of vegetation can be distinguished in these agroforestry systems. Stratum 1 which contains cocoa trees and possibly small fruit trees (0-7 m), stratum 2, medium (10-20 m) which mainly comprises fruit trees and the upper stratum (<20 m) mainly comprises forest species. The density of planting of the different strata and, in particular of strata 2 and 3, are interdependent, that is to say that according to the production objectives one stratum can be favored in terms of density of plantation compared to another.

- **Low stratum 0-5m**

Composed mainly of cocoa trees (1,100 plants / ha) this stratum may also include other species of small size depending on the local context (guava, safoutier, soursop, citrus fruit, etc.)

- ***Low stratum 10-20m***

This stratum is made up of fruit trees and palm trees (safoutier, avocado, colatier, palm etc.). The mango tree appears to be competitive with cocoa trees and will therefore be avoided.
The fruit tree species chosen will depend on local contexts, promising markets and consumption habits. The planting density will be between 30 and 100 plants per hectare.

- ***High stratum> 20m***

This layer is composed of forest trees which have a role of recycling nutrients and provide part of the shade. Their density will be between 25 and 50 trees / ha. The species will be adapted to the area and the wishes of the planters, for example: cheese maker, Limba, Iroko, Njansang, ayous.

Picketing

Staking is an essential operation which will allow planting distances to be respected. Too high a density will limit growth due to competition and too large spacings will cause problems in controlling weediness. Staking will be carried out according to the densities chosen for the different strata according to the projects. Stakes of different heights will be used to mark the holes for the plants in each stratum. For a base of 1100 cocoa trees / ha, a spacing of 3 x 3 m will be used.

Trouble and establishment of plants

The hole must be carried out to ensure a good recovery of the plants before the start of the rainy season. Holes 30cm wide and 30cm deep will be opened for the bananas.
Holes 40 cm on the side and 40 cm deep will be opened for woody trees. On sloping ground a terrace will be formed for each plant.
The black surface soil will be set aside. Plants will be planted at the start of the rainy season when the soil has been suitably re-moistened. When planting the black earth will be used for filling and sufficiently compacted. A basin will be formed around the plant which will collect a maximum of rainwater ensuring a good recovery of the plants.
In order to limit evapotranspiration and the growth of weeds, mulching will be carried out with the residues of food crops or weeds around the plants.

Fertilization

Fertilization can be practiced for cocoa trees, the latter is generally very little practiced, in particular due to lack of access to inputs from small planters. For the fertilization to be effective it is important that the cocoa trees are in optimal conditions. For example, insufficient exposure to light accompanied by fertilization will not improve yield. When the trees in strata 2 and 3 are sufficiently developed and a forest atmosphere is created, the biological cycle (nutrient uplift via aerial litter falls and root mortality) will enrich the soil with carbon and nutrients.

Starter fertilization in year 1 will be carried out at a rate of 50 g of NPK per cocoa tree plants and limestone amendment at a rate of 2 tonnes per hectare. Fertilization at the start of the cycle will allow good establishment of the cocoa trees.

Fertilization is an important expense item. Careful attention must be paid to compliance with the application conditions.

Interviews

Firewalls

The creation of firewalls around plots is essential to ensure the success of projects. Savannahs burn every year and it is certain that each plantation will be confronted with this problem. A firewall at least 6 m wide, ideally made with a disc plow, will limit the risks.

Weeding

The elimination of herbaceous plants is essential from the first months following the installation of the plants in order to minimize competition for water and nutrients. Maintaining food crops for the first 2 years will enable a significant part of these operations to be carried out. Residues of weeds and crops will serve as mulch which will limit the growth of grasses around the plants, limit evaporation and their decomposition will bring a certain amount of nutrients and organic matter to the soil. These residues will be placed on a radius of 1 m around the plants.

In the event that the control of grass cover cannot be ensured manually, a targeted use of herbicides will be possible (4 liters of glyphosate per hectare or 130 ml for a 15-liter sprayer).

Relining

The replacement of dead or dying plants will be carried out at the start of the following rainy season, once the soil has been properly re-moistened. In a well-kept plantation the mortality rate does not exceed 10% but mortalities of up to 25% are often observed. A second relining can also be done the second year after planting.

Shading adjustment

The shade provided by associated species (banana, trees, palms) is beneficial to cocoa plants by regulating the microclimate and avoiding direct exposure of young plants to radiation. Direct exposure to solar radiation can increase physiological stress, evapotranspiration and vulnerability to certain pests (mirids). Shading makes it possible to greatly limit grass cover. However, too much shade could have harmful effects on cocoa trees, in particular by promoting the development of conditions conducive to disease (increased incidence of pathogenic fungi and bacteria, for example brown rot). The level of shading must therefore be balanced in order to increase the favorable effects while limiting the unfavorable effects. Shading allowing 50 to 70% of the incident light to pass through is recommended. When trees associated with cocoa trees will grow, shade management will be done either by pruning and / or tree elimination on a case-by-case basis (felling, mortality caused by barking). Shading adjustment will vary in frequency and intensity depending on growth rate and will require plot-by-plot diagnostic monitoring. It is better to favor light and frequent interventions rather than heavy interventions more spaced out in time. Shading adjustment will vary in frequency and intensity depending on growth rate and will require plot-by-plot diagnostic monitoring. It is better to favor light and frequent interventions rather than heavy interventions more spaced out in time. Shading adjustment will vary in frequency and intensity depending on growth rate and will require plot-by-plot diagnostic monitoring. It is better to favor light and frequent interventions rather than heavy interventions more spaced out in time.

Expected yield:

The examples taken from the literature make it possible to quantify the productions in this type of system. Jagoret et al., 2014 reports: “In Cameroon for example, the yield of agroforestry cocoa trees can exceed 900 kilos per hectare after about twenty years. This annual yield is similar to, or even greater than, that obtained in a good number of cocoa farms conducted in monoculture when farmers are struggling to apply the recommended technical package. It was reached in plots where cocoa trees are planted at a density of 1000 plants per hectare, in association with around one hundred trees (70% fruit and 30% forest). This performance is confirmed in Central America. The evaluation of cocoa trees in a complex agroforestry environment reveals yields which, despite their variability,

In this type of system, yields are progressive, the first cocoa harvest occurs 3 or 4 years after the cocoa trees are planted with around one hundred kg per hectare, then increases to 500 kg per hectare around 8 years to stabilize around 800-900 kg per hectare after a dozen years.

Effect on carbon stocks:

Several studies show that the establishment of agroforestry systems in a savannah significantly increases the carbon stock in the biomass and increases the carbon levels in the soil. The primary objective of this route is to ensure the growth of cocoa trees which requires soils rich in organic matter. From savannas whose soils are low in carbon, it has been shown in Cameroon that the carbon content increased from 1.70% in savannah in the 0-20 cm horizon to 2.25% under 10-year-old agroforestry systems and 3.12% under 40-year-old agroforestry systems (Jagoret et al., 2012). These results confirm what had been measured by Glatard et al. (2007) in the same country. A more recent study carried out in Cameroon (Nijmeijer et al., 2018) shows that the increase in carbon content in soils between 0 and 15 cm deep is 7.3 ‰ per year in low clay soils and 9.5 ‰ per year in more clay soils after conversion of savannas. The same authors show that the amount of carbon stored in aboveground biomass is on average 8.2 tonnes per hectare in savannah and increases to reach 50.5 tonnes in aged agroforestry systems.

These examples show that this type of cultural practice allows a significant increase in the quantity of carbon stored. Additional studies will have to be carried out to quantify the variations in stocks at the level of the root biomass not taken into account in the various studies. In terms of carbon stored in the soil, the finding also shows a significant increase in concentrations between savannas and agroforestry systems installed on savannas. Additional studies would make it possible to quantify, beyond the contents, the variations in stock.

In unfavorable conditions for cocoa cultivation, these agroforestry systems allow, on the one hand, the restoration of degraded savannah soils and, on the other hand, the production, without inputs or with low inputs, as much marketable cocoa as the cocoa trees of forest.

References

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6) Assisted natural regeneration in degraded forest areas

Introduction

The degradation of forests and soils in the Republic of the Congo is an important issue that concerns more and more sectors, in particular along traffic axes and in peri-urban and peri-village areas. The main causes of this degradation are the exploitation of forest soils for the establishment of slash-and-burn agriculture and the exploitation of fuelwood. Forest islands in savannahs, lowland forests and large forest areas are affected by these practices to varying degrees depending on their location. The practice consists of almost total cutting down of forest stands to establish crops after burning. Following the harvests, the soils of the plots which have become less productive are left fallow to allow a reconstitution of fertility. Several factors can compromise the restoration of fertility, in particular the repeated passage of fires, erosion on sloping land and the reduction of fallow periods which lead to soil impoverishment. These practices risk ultimately causing the disappearance of forest areas with the gradual establishment of less demanding species, ultimately leading to the establishment of the savannah. The pressure on forest soils is set to increase in the coming decades because of the growing food needs linked to the increase in the country's population. In this context, reasoned management of forest plots, exploited in slash-and-burn cultivation, becomes a priority. Assisted natural regeneration (ANR), with a possibility of enrichment in woody (plantation) is a route which makes it possible to favor the forest regrowth and to minimize the negative impacts on the grounds. As part of the European Makala project, this alternative has been tested and the results obtained significant (Peltier et al., 2014). Nevertheless, two important obstacles have been identified that may limit the large-scale extension of this type of management. It is about social acceptance of these practices and securing access to land. Two important brakes were identified that could limit the large-scale extension of this type of management. It is about social acceptance of these practices and securing access to land. Two important brakes were identified that could limit the large-scale extension of this type of management. It is about social acceptance of these practices and securing access to land.

Exploitation of the plot

An agricultural plantation project in a wooded area (on forests or woody fallows) will begin with the identification of a certain number of trees to be kept standing. These targeted trees will be identified by a marking visible at breast height (paint, tape). The marked tree density will be low to leave most of the space for crops. For large trees (C130> 60cm), their number will vary from 15 to 30 per hectare distributed evenly. The conserved species will, as far as possible, have a useful role for the operator (medicinal properties, fruit production, fertilizing property, timber, etc.). The conservation of these standing trees will essentially ensure part of the regeneration (role of seed tree) following the exploitation of the plot. The trees will be preserved from fire by cleaning a perimeter of a few meters at their foot. The fire should be started in relatively humid conditions so that it can be of low intensity. Failure to comply with these conditions will cause high mortality among the selected trees. The trees at the edge of the plot will also be preserved. The rest of the stand is then felled for making charcoal or left on the ground before burning.

Installation of crops and regeneration operations

Following the burning and / or the transformation of wood into charcoal, short-cycle food crops (± 3 months) are installed as well as cassava. Before the harvest of short-cycle crops (corn, peanuts, etc.), certain shoots, suckers or natural seedlings of forest trees will be identified. At this stage it is important that various species be selected in order to accelerate the growth of the recruits and to increase the goods and services provided by the future fallow. After harvesting the short-cycle crops and during weeding of the cassava, the selected woody regrowth will be favored by the farmer. Depending on the needs, the regrowth or seedlings of woody plants can be weeded, untied and some stump shoots selected. This operation will be repeated until the final cassava harvest. According to the operator's needs,

Expected

The maintenance of the forest regrowth will allow a substantial saving of time for the regeneration of the forest cover. The growth of stems thus favored (instead of being cut back systematically) will allow young trees to quickly dominate invasive, bushy or herbaceous species. With ANR management, the gain in growth is significant. Peltier et al., (2014) show in DRC that, 31 months after the initial burning, the number of woody regrowth stems greater than 2.5 m in height is 638 per hectare in RSA compared to 202 stems per hectare on plots that have not been managed in RSA. Consequently, the faster reconstitution of the forest cover makes it possible to reduce the colonization by herbaceous plants limiting the risk of savannah and to preserve soil fertility.

In order to promote and disclose this efficient management method, the farmer must be able to re-exploit the fallow that he has helped to regenerate. Consequently, this system must be encouraged by securing access to land for farmers.

Reference

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B. Characterization of potential areas for project implementation

1) Department of KOUILOU

No.	Zoning	Pedoclimatic characteristics	Human densities, product evacuation	Main drivers of degradation	Possible changes in the drivers of degradation and deforestation in the targeted areas	Mitigation measures against degradation and deforestation (Cf. technical itineraries)
1	**Department of Kouilou:** **Zone 1**: Right of way for Eucalyptus plantations (formerly EFC company) on the northern part beyond the Kouilou river. Project: management in coppice of existing eucalyptus plantations. **Zone 2** : Locality of Hinda, Loémé basin and axis of the National road 1. Project: Simple	**<u>Geographical location</u>** **<u>Relief</u>**: Flat to slightly hilly to the west (zone 1) varying between 50 and 120m altitude. Hilly to strongly hilly to the east (zone 2, pre-Mayombe and Mayombe massif) varying from 120m to 500m in altitude. **<u>Weather :</u>** Subequatorial climate zone. Dry season marked between June and September. Cumulative rainfall: between 1200-1300 mm / year in zone 1 to 1200-1500 mm / year in zone 2. Average annual temperature: 25 ° C.	**<u>Population densities:</u>** Low on average in Kouilou (6.1 inhabitants / km2), with 10,200 inhabitants in Madingo-Kayes district (zone 1) and 60,000 in Hinda (zone 2). The proximity of Pointe-Noire is an asset for the supply of equipment and for the export of products. **<u>Agriculture</u>** Cropping system: shifting slash-and-burn agriculture, mixed farming and fallows. Almost non-existent breeding mainly represented by poultry farming and fish farming.	<u>Zone 1</u>: Eucalyptus massif in the process of exploitation not controlled by the populations for the production of charcoal and service wood (poles etc.) with a very high demand from the city of Pointe-Noire (± 1 million inhabitants) . The management of the massif was handed over by the state to the SNR after liquidation of the company EFC. The current area reduced to 35,000 hectares out of the 45,000 initially present, including 10,000 hectares located north of the Kouilou River. The massif has lost nearly 7,000	**<u>Subsistence agriculture</u>** 1)Continuation of the demographic increase and immigration in Kouilou. Develop in Pointe-Noire. Increased pressure on forest areas by slash-and-burn cultivation and carbonization with the risk of reduction in fallow periods and soil impoverishment. 2)Lack of alternative to slash-and-burn cultivation, retreat of the forest front in the Mayombe massif (zone 2) and degradation of lowland forests in savannah zone (zone 1) **<u>Lumbering</u>**:	Zone 1: Application of the management in coppice of eucalyptus plantations in the northern part of the eucalyptus massif. A specific study must be carried out to determine with precision the areas to be converted into coppice. It is probable that a certain area (to be defined by the study) will have to be replanted due to excessive degradation of the current plantations. Approximate target area: 5,000 ha dedicated to the production of fuelwood with improved ovens and

	management plans (PSG).	**Natural vegetation**: pseudo-steppe savannas with light to absent shrub stratum (Annona arenaria) in zone 1 and dense semi-deciduous and evergreen transition rainforests in zone 2. **Soils:** Yellow ferralitic soils depleted on sandy deposits in the savannah (zone 1) with red soils reworked on metamorphic and schisto-limestone rocks (zone 2). Very limited agricultural potential in sandy coastal areas (zone 1) due to the chemical poverty of the soils. Higher potential in the forest zone (Mayombe) with more clayey and locally fertile soils.	**Evacuation of products to Pointe-Noire**: Via the RN5 (paved between Madingo-Kayes and Pointe-Noire) for zone 1. Kouilou crossing bridge under construction, accessible only to light vehicles, passage by ferry for trucks. Via the RN1 from zone 2 and secondarily by the Brazzaville-Pointe-Noire railway line Substantial network of secondary tracks in the Loémé basin but evacuation dependent on weather conditions (unmaintained tracks).	hectares during the last decade due to the extension of the city of Pointe-Noire to fires and illegal logging. Zone 2: Shifting agriculture on burns (cassava, corn, plantain, pineapple) mainly to supply the city of Pointe-Noire. Production of charcoal before cultivation to feed the city of Pointe-Noire and secondarily artisanal sawing. Concerning the two targeted areas: lack of governance, control system of the authorities not very effective.	3) Steady increase in demand for timber on domestic and export markets. 4) Continued weakness of administrative control systems.	an industrial carbonization unit. Zone 2: Establishment of PSG including restoration and conservation measures at the level of customary territories. Assisted Natural Regeneration (ANR) is a technique that can be tested in this still heavily wooded area. Improvement of carbonization yields in zone 1 (installation of improved furnaces) and in zone 2 (improvement of traditional carbonization practices).

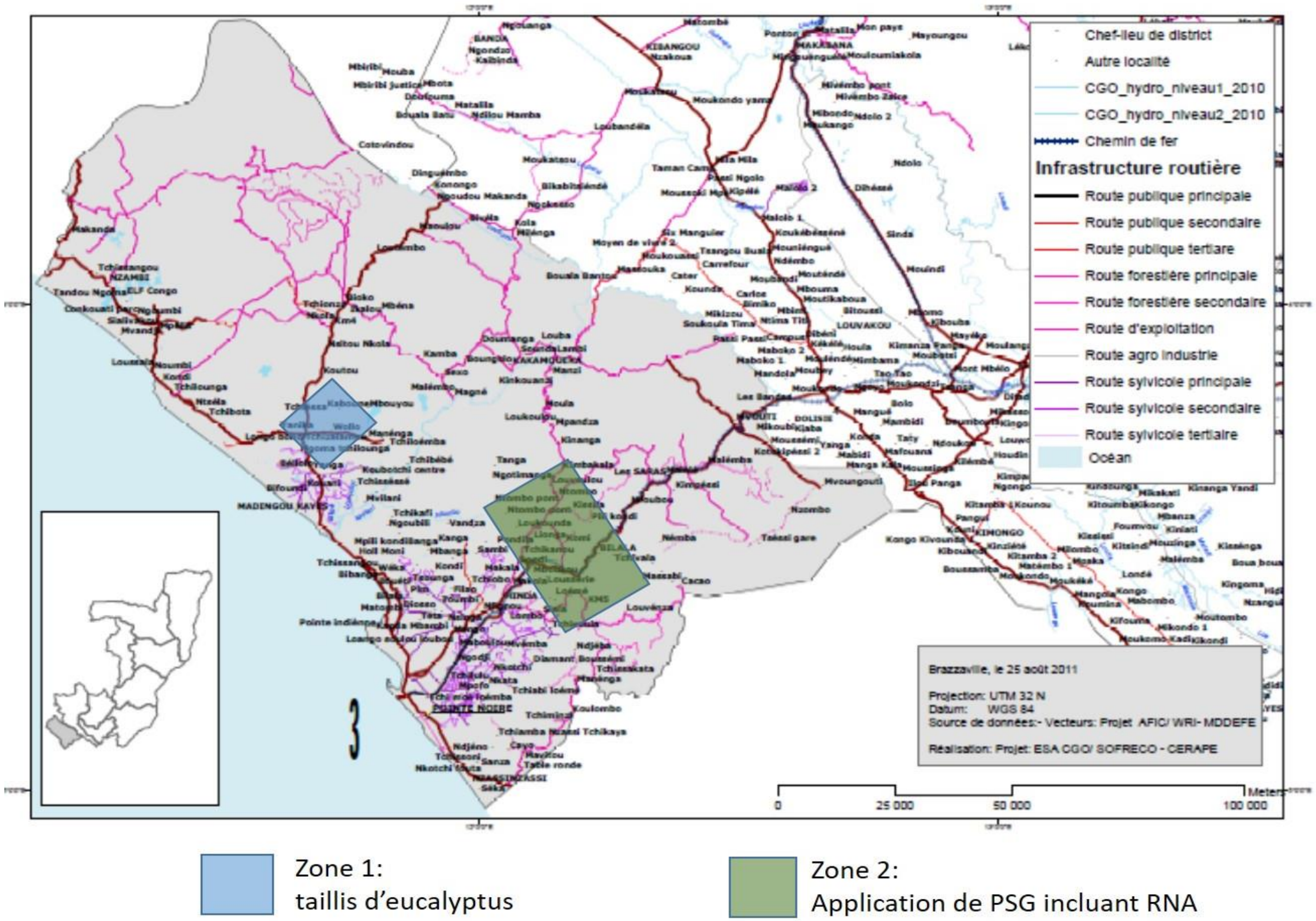


Figure 1: Location map of the Kouilou department and approximate locations of areas of interest to the project.

(Modified from: AFIC / WRI-MDDEFE project)

2) Department of NIARI and BOUENZA

No.	Zoning	Pedoclimatic characteristics	Human densities, product evacuation	Main drivers of degradation	Possible changes in the drivers of degradation and deforestation in the targeted areas	Mitigation measures against degradation and deforestation (Cf. technical itineraries)
2	**Department of Niari and Bouenza:** **Zoned**1: East of Dolisie, capital of the Niari department, ideally near the RN1. Project: Acacias-cassava agroforestry. **Zone 2** : Loudima eucalyptus massif (Bouenza) located about fifty km from zone 1. Project: management in coppice existing	**Geographical location** **Relief**: Flat to hilly east of Dolisie, varying between 150 and 400m. Presence of mounds and lowlands and flat areas suitable for different types of agricultural and agroforestry plantations (Zone1). In zone 2 the relief is not very accentuated, the zone is located on the plateau overhanging the Niari river. **Weather :** For both zones, subequatorial climate of the low Congolese type. Dry season marked between June and September. Cumulated rainfall: between	**Population densities:** The average inhabitant density in Niari is 8.3 inhabitants / km2, with 80,000 inhabitants in Dolisie (third city of the country). La Bouenza (Nkayi capital, fourth city of the country with 70,000 inhabitants) is the most populous department of the Congo (20% of the national population) with the population density significantly higher than in the rest of the country with 26 inhabitants / km2 (for comparison, Niari is the second department of the Congo in terms of population density).	Shifting agriculture on burns (cassava, plantain, peanuts, corn) mainly for local consumption (Dolisie) and to supply the city of Pointe-Noire and even Brazzaville. Significant degradation of lowland forest areas and forest islands in savannah with enriched soils. Strong degradation of the Mayombe forest near Dolisie on the RN1 axis. More than 95% of forest degradation is due to agricultural clearing	**Subsistence agriculture** 1) Demographic increase in these two most populous departments of the country which will eventually lead to an increasingly intensive exploitation of forest areas for the establishment of slash-and-burn, charcoal and fuelwood production. Risk of reduction in fallow periods and soil impoverishment. Risk of increased demand for fuelwood for firing building bricks in these departments. 2)Lack of alternative to slash-and-burn cultivation, retreat of the forest front in the Mayombe massif near	Zone 1: Installation of an acacia-based agroforestry system with cassava and maize cultivation interspersed at the start of the rotation (see acacia-cassava agroforestry technical route). Approximate target area: 2,500 ha. The exploitation of acacias will be accompanied by an improvement in carbonization yields (installation of improved ovens) and / or improvement of traditional

	eucalyptus plantations.	1200-1300 mm / year Average annual temperature: 25 ° C. **Natural vegetation:** In both zones, shrub savannas with grasses (Hypparrhenia diplandra, panicum maximum, Imperata cylindrica), light to dense shrub layer (Hymenocardia acida, Annona arenaria, Bridelia ferruginea, Nauclea latifolia) and the presence of degraded forest islands. **Soils:**In both zones, the soils are of the desaturated yellow ferralitic type of varying depths developed on clayey-silty materials from the medium schisto-limestone substrate. Rejuvenated and possibly hydromorphic soils depending on the relief. Interesting agricultural potential for food crops and forest plantations. Soils of heavy texture (clay)	**Agriculture** Traditional family-type cropping system with low use of inputs. The most important productions are: cassava, peanuts and bananas. The Niari valley is one of the most cultivated areas of the Congo, suitable for the development of agricultural and agro-industrial activities. Livestock is mainly represented by cattle and pigs. **Product evacuation**: Mainly via the RN1 towards Dolisie, Pointe-Noire and Nkayi, Brazzaville, Possibility of evacuation by rail (CFCO) in priority for non-perishable products and more anecdotally by Dolisie	in these 2 departments. Strong demand for firewood for baking clay bricks in Bouenza, the main building material for homes (eg Nkayi district). The lack of governance and ineffective control mechanisms are aggravating factors.	Dolisie and degradation of lowland forests and forest islands in savanna areas. **Lumbering**: 3) Steady increase in demand for timber on domestic and export markets. 4) Continued weakness of administrative control systems.	carbonization practices. Zone 2: Application of coppice management of eucalyptus plantations in the Loudima massif. A specific study must be carried out to determine with precision the areas to be converted into coppice. It is probable that a certain area (to be defined by the study) will have to be replanted due to excessive degradation of the current plantations. Approximate target area: 2000 ha dedicated to the production of wood energy. The energy wood produced will aim to meet the demand for fuel for

		relatively well structured but sensitive to settlement.	airport (a few tens of tonnes of cassava transit annually to Pointe-Noire and Brazzaville).			firing bricks in the district of Kayes and Madingou.

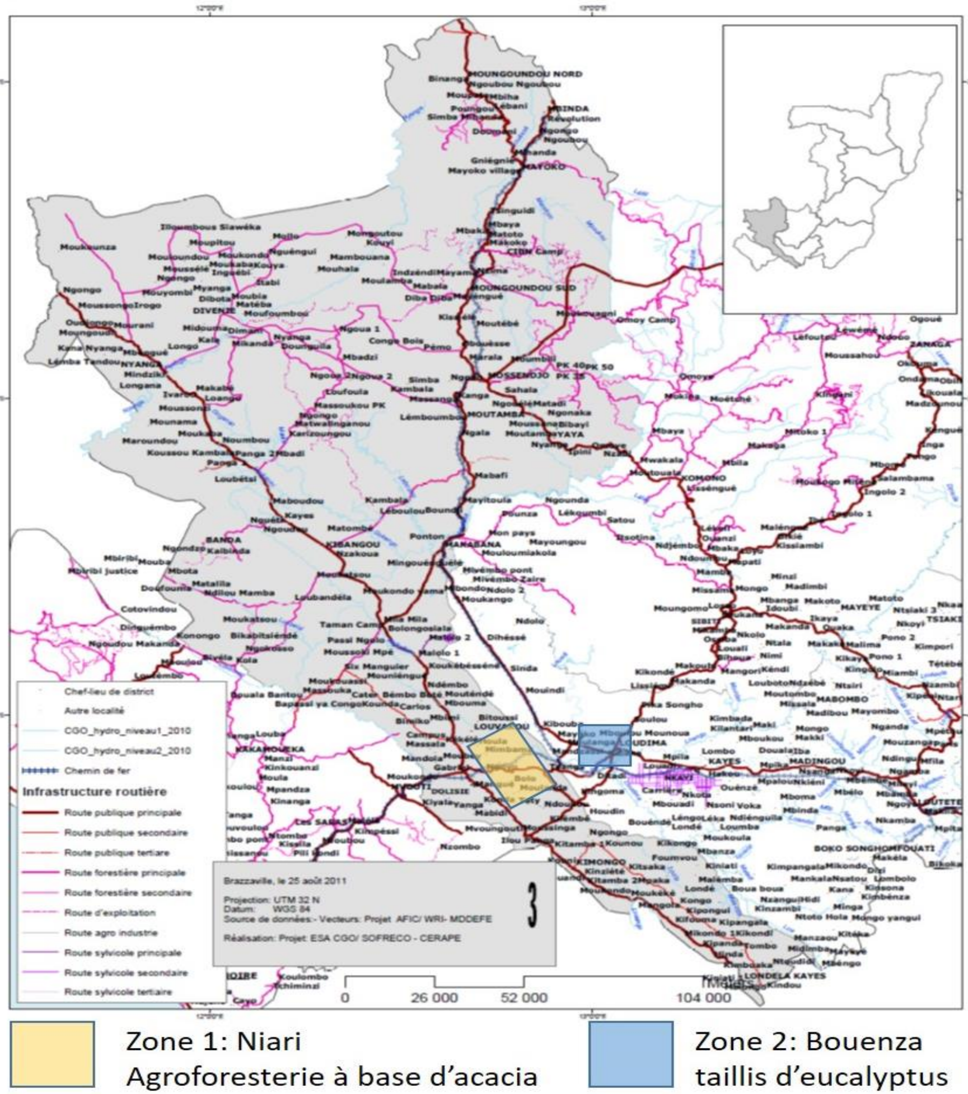


Figure 2: Location map of the Niari department and approximate locations of areas of interest to the project.

Zone 1: Niari, Zone 2: Bouenza. (Modified from: AFIC / WRI-MDDEFE project)

3) POOL Department

No.	Zoning	Pedoclimatic characteristics	Human densities, product evacuation	Main drivers of degradation	Possible changes in the drivers of degradation and deforestation in the targeted areas	Mitigation measures against degradation and deforestation (Cf. technical itineraries)
3	**Pool Department:** **Zone 1** : Ignié and Ngabé district north of Brazzaville in / or near the areas selected by the Pronar (block B). Project: mixed forest plantations. **Zone 2** : Between Ngoma-Tsétsé and Kinkala, ex. RN1.	**<u>Relief</u>**: Plateau with moderate relief interspersed with dry valleys at an altitude of between 450 and 650 m in zone 1. Zone 2 is hilly with an altitude varying between 350 and 550 m. **<u>Weather :</u>** Low Congolese subequatorial climate zone. Dry season marked between June and September. Cumulated rainfall: between 1350-1650 mm / year in zone 1 and between 1300 and 1400 mm in zone 2. Average annual temperature: 25 ° C. **<u>Natural vegetation</u>**:In zone 1, savannas with Trachypogon thollonii and Hyparrhenia diplandra and savannas with	**<u>Population densities:</u>** Low on average in the Pool (7.3 inhabitants / km2). In zone 1, densities range from 3 to 7 inhabitants / km2 with 29 and 30,000 inhabitants in the districts of Ignié and Ngabé respectively. In zone 2, the average densities range from 5 to 24 inhabitants / km2 with 35,000 and 16,000 inhabitants for the districts of Kinkala and Ngoma-Tsétsé respectively. The proximity of Brazzaville is an asset for the supply of equipment and for the export of products with	<u>Zone 1 and 2</u>: Shifting agriculture on burns (cassava, corn, plantain, peanuts) mainly for local consumption and food for the city of Brazzaville. Production de charbon avant mise en culture de zones forestières pour alimentation de la ville de Brazzaville. Concerning the two targeted areas: lack of governance, control system of	**<u>Subsistence agriculture</u>** 1) Population increase. Increased pressure on forest areas by slash-and-burn cultivation and carbonization with the risk of reduction in fallow periods and soil impoverishment. 2)Lack of alternative to slash-and-burn cultivation, retreat of forest fronts in the massifs of the southern pool (zone 2 and beyond) and degradation of lowland forests in savannah zone (zone 1). **<u>Lumbering</u>**:	Zone 1: 164,500 ha have been allocated to Pronar in this department, with large areas in the Ignié and Ngabé district (block B). In this zone, the objective is to set up mixed acacias / eucalyptus plantations (see technical itinerary for mixed forest planting) for the production of fuelwood with evacuation in Brazzaville. Surface area envisaged for the project: 2,500 ha.

	Project: Acacias-cassava agroforestry.	Loudetia with a shrub layer reduced to absent composed of Hymenocardia acida, Annona arenaria and Vitex madiensis. Presence of mesophilic forest islands located on the edge of plateaus and lowlands. In zone 2, dense to moderately dense shrub savanna composed of Hymenocardia acida, Annona arenaria and degraded gallery forests. **Soils:** Impoverished yellow ferralitic soils, sandy to sandy clay developed on sandstone and sandy loam (Batékés plateau series) in zone 1. Very limited agricultural potential in sandy areas (zone 1) due to the chemical poverty of the soils which are nevertheless suitable for forest plantations. In zone 2, the soils are also formed from schisto-sandstone series and polymorphic sandstone. The soils are generally sandy, acidic and poor in exchangeable bases.	its ± 2 million inhabitants. **Agriculture** Traditional cropping system: shifting slash-and-burn agriculture, mixed farming and fallow land. Stronger grip dedicated to agriculture in zone 2 than in zone 1. In zone access to water limits agricultural development. Cattle, goat / sheep breeding and poultry farming are predominant. **Evacuation of products to Brazzaville**: Via the RN2 for zone 1. Via the ex. RN1 from zone 2 and secondarily by the Brazzaville-Pointe-Noire railway line for zone 2. Substantial network of secondary tracks in zone 2 but evacuation	the authorities not very effective locally, aggravated by post conflict situation.	1) Steady increase in demand for wood on the domestic market (artisanal sawing) and poles for construction. 2)Continued weakness of administrative control systems. 3)Zone 2: post-conflict situation, possibly insecure area.	Zone 2: Installation of an acacia-based agroforestry system with cassava and maize cultivation interspersed at the start of the rotation (see acacia-cassava agroforestry technical itinerary). Approximate target area: 3000 ha of community plantations and 1500 ha of private plantations. Improvement of carbonization yields in zone 1 (installation of improved furnaces) and in zone 2 (improvement of traditional carbonization practices).

			dependent on weather conditions (unmaintained tracks).			

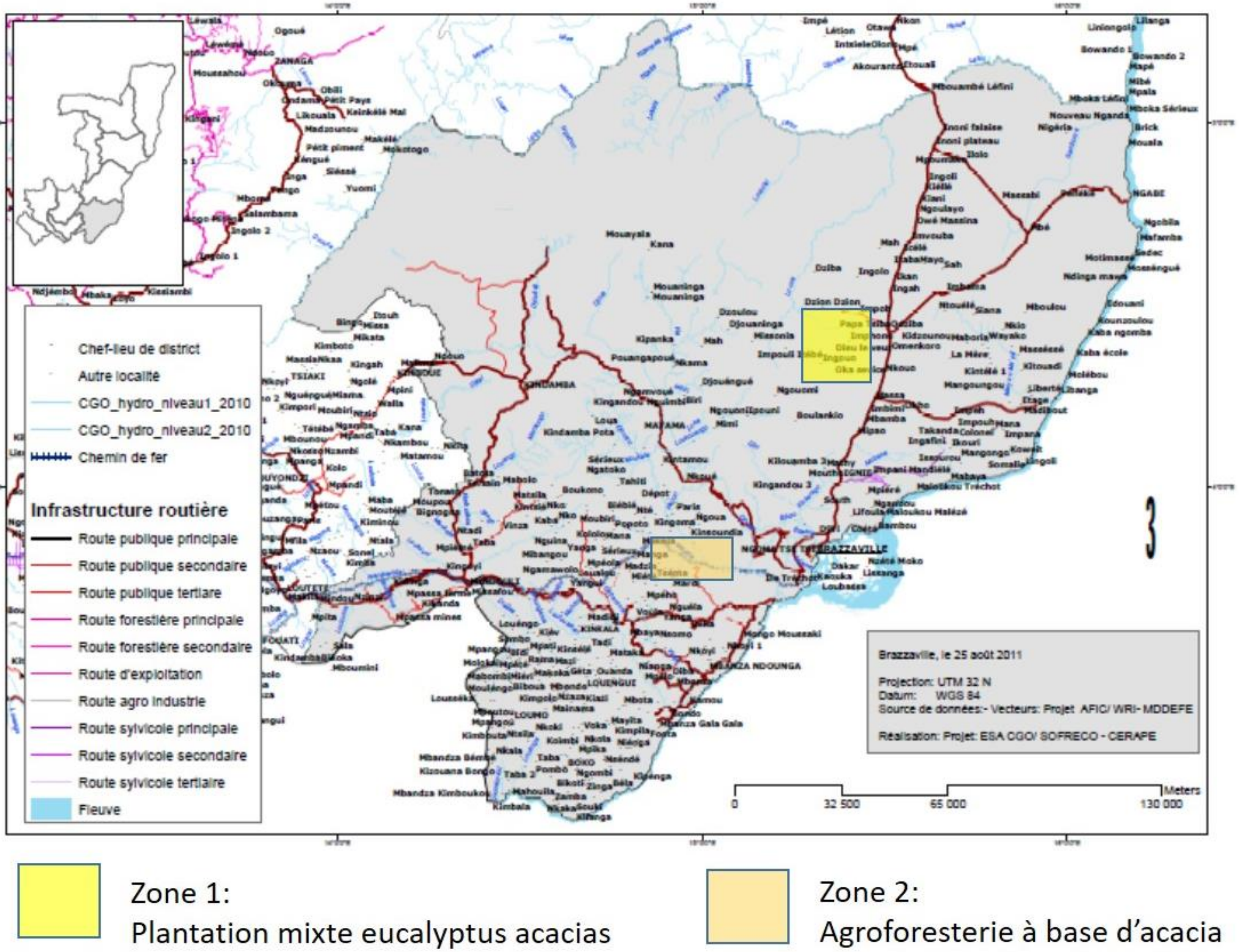


Figure 3: Location map of the department of Pool and approximate locations of areas of interest to the project. (Modified from: AFIC / WRI-MDDEFE project)

4) PLATEAUX Department

No.	Zoning	Pedoclimatic characteristics	Human densities, product evacuation	Main drivers of degradation	Possible changes in the drivers of degradation and deforestation in the targeted areas	Mitigation measures against degradation and deforestation (Cf. technical itineraries)
4	**Department of Trays:** **Zones** : Districts of Ngo, Mpouya and Gambona in which are located the main afforestation blocks of Pronar (in particular blocks G, H, J, KE). Project: mixed forest plantations.	**<u>Relief</u>**: Plateau area in the region of Ngo (550-500 m above sea level, block G of Pronar) cut into dry or active valleys. The slope is slightly oriented to the north and the east with an average altitude of 300 m at the bottom of the valley and along the Congo River. **<u>Weather :</u>** Subequatorial climate zone of transition between the Bas-Congolese and subequatorial climate. Dry season marked between June and September. Cumulated rainfall: between 1500 and 1800 mm / year and between 1200 and 1400 mm along the Congo River. The	**<u>Population densities:</u>** Low on average in the department (4.5 inhabitants / km2). The districts of Ngo and Mpouya are the least populated with 16,700 and 9,200 inhabitants respectively. Gamboma district is the most populous with 43,200 inhabitants. **<u>Agriculture</u>** Traditional cropping system oriented towards low-yield food production: shifting slash-and-	Shifting agriculture on slash and burn (cassava, maize, bananas, peanuts) is the main driver of degradation of forest areas. Production mainly for local consumption, exports to Brazzaville being limited. Bush fires (burning of savannah and cleared areas) are also a major threat that hinders the reconstitution of degraded forest cover and the reconstitution of the	1)Continuation of the demographic increase even if the population densities are still low to this day in this department. Extension of the area of influence of the capital to provide for its supply. Increased pressure on forest areas by slash-and-burn cultivation and carbonization with the risk of reduction in fallow periods and soil impoverishment. 2)Lack of alternative to slash-and-burn cultivation implying the retreat of forest fronts in the different massifs of the area	A total of 279,000 ha have been allocated to Pronar in this department, with large areas in the districts of Ngo, Mpouya and Gambona in the east of the department. In this zone the objective is to set up mixed acacias / eucalyptus plantations (see technical itinerary of mixed forest plantations) for the production of fuelwood with evacuation to Brazzaville by land and / or river.

		annual average temperature is 25 ° C. **<u>Natural vegetation</u>:**All the blocks are located in areas of savannah with islands of mesophilic forest and gallery forests bordering the rivers. Savannas are of two types; savannah with Trachypogon thollonii and Hyparrhenia diplandra, Ctenium newtonii with reduced shrub layer (Hymenocardia acida and Annona arenaria); savanna with Hyparrhenia acida and Loudetia demeusi with light carpet and thin shrub layer dominated by Hymenocardia acida. **<u>Soils:</u>**The soils are developed from 2 tertiary geological formations: the series of Batékés plateaus made up of sandstone and sandy silt and the Stanley Pool series made up of sandstone and argillites (valley bottoms and along the Congo River). The soils of the high plateaus are of the yellow ferralitic type, impoverished on sandy clay and sandy material on the lowlands and slopes of	burn agriculture, mixed cropping and fallow land. The main productions are cassava, yams and peanuts and bananas in the district of Ngo. Small cattle, goats and sheep herds. The use of fertilizers and phytosanitary products is anecdotal. **<u>Evacuation of products to Brazzaville</u>**: Mainly via the RN2, secondarily via the port of Mpouya which is however in poor condition. Network of secondary roads and tracks mostly not or poorly maintained (silting up, eg Ngo-Mpouya link).	soil fertility potential in fallow areas. The lack of governance and the authorities' control mechanisms are ineffective despite the proximity of the Lefini wildlife reserve.	and accentuation of the impacts in the Lefini wildlife reserve. 3)Continued weakness of administrative control systems.	Surface area envisaged for the project: 2500ha. The eucalyptus and acacia plants could be produced by the nursery under development in Ngo. The Pronar and the SNR could be the actors of this valuation of the less productive savannah soils. An improvement in carbonization yields by installing improved ovens will be necessary.

		the plateaus. Along the Congo River are found podzolic soils on sands and / or hydromorphic locally along the rivers.				

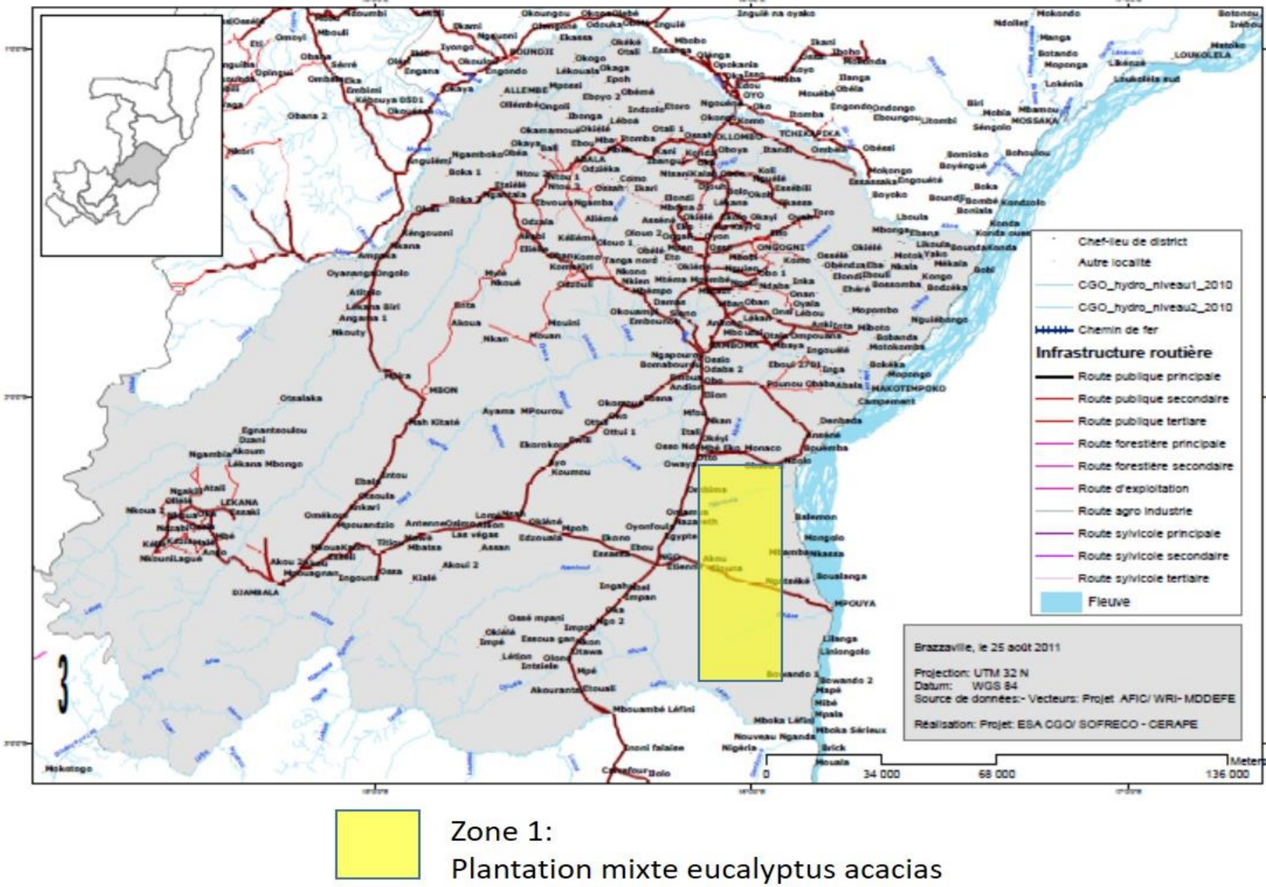


Figure 4: Location map of the Plateaux department and approximate location of the area of interest to the project. (Modified from: AFIC / WRI-MDDEFE project)

5) Department of SANGHA

No.	Zoning	Pedoclimatic characteristics	Human densities, product evacuation	Main drivers of degradation	Possible changes in the drivers of degradation and deforestation in the targeted areas	Mitigation measures against degradation and deforestation (Cf. technical itineraries)
5	**Sangha Department:** **Zones:** The areas targeted in this department by the project are located in the community development series (eg Pokola, Kabo for CIB-Olam, Ngombé for IFO, Souanké for SEFYD and in the SDCs of SIFCO) as well as in degraded areas of production series. Projects: Implementation of Simple Management Plans (PSG),	**Relief** : the relief consists of a horst base (600-800m above sea level) interspersed with ditches and valleys (300-400m above sea level) with a dense hydrographic network. **Weather :** Equatorial climate zone. Annual precipitation varies between 1600 and 1800 mm with a dry season between June and August and between December and February. In the dry season, the monthly accumulations do not drop below 50 mm. The annual average temperature is 25 ° C.	**Population densities:** Very low on average at the level of the department (0.8 inhabitants / km2), with a population concentrated along the roads, rivers and in forest sites. The largest urban center is Ouesso (Chef-Lieu) with 49,000 inhabitants followed by Sembé, Souanké and Pokola (between 10 and 15,000 inhabitants in these towns). The main roads are: Mambili-Ouesso and Keta-Sembe. Forest tracks are dense in the north and northeast of the department. The other means of communication are	The main cause of degradation is linked to logging in this department. Failure to comply with regulations in terms of forest management and exploitation (illegal logging) aggravates damage. Shifting agriculture on burns (cassava, corn, plantain, peanuts) mainly for self-consumption and to supply the city of Ouesso. Low impact compared to logging.	1) Large-scale development of agro-industry, mainly oil palm. 2)Uncontrolled development of cocoa plantations in forests in the event of a strong revival of the cocoa sector. 3)Population increase leading to increased pressure on forest areas through slash-and-burn cultivation, carbonization and artisanal logging. 4)Lack of alternative to slash-and-burn agriculture with the risk of reducing fallow periods and soil impoverishment.	1) Implementation of Simple Management Plan (PSG) including restoration and conservation measures in the series of community development. Assisted Natural Regeneration (ANR) is a technique that can be tested in this still heavily wooded area. **2)** Plantation of timber (local species and teak) in degraded forest areas within FMUs.

	plantations of local species and cocoa production in agroforestry systems.	**Natural vegetation:** Dense rainforests partially deciduous with Ulmaceae and Sterculiaceae, evergreen forests of dry land with Gilbertiodendron dewevrei; evergreen swampy flooded forests with Uapaca heudelotii, Entandrophragma and Sterculia subviolacea. Raphiales in permanent flooded area. **Soils:**Three main types of soil: undifferentiated red ferralitic or reworked on schist and quartzite; brown to reddish brown, sandy clay ferralitic soils; alluvial hydromorphic ferralitic soils.	river and airport (Ouesso). Significant trade with neighboring Cameroon (import of various products and foodstuffs and export of wood and marginally coffee / cocoa). **Agriculture** Cropping system: shifting slash-and-burn agriculture, mixed farming and fallow land without the use of inputs. The majority of products on the markets come from Cameroon. Almost non-existent breeding mainly represented by poultry farming and fish farming. Agro-industry: takeover of ex Sangha palm by Eco-Oil Energie (40,000ha) for replanting of palm groves. Other projects of this type are in the	Concerning the two targeted areas: lack of governance, control system of the authorities not very effective. Proximity to the border allowing uncontrolled export of forest products.	**Lumbering**: 1) Steady increase in demand for timber on domestic and export markets leading to increased illegal logging. 2)Non-existence of a development plan in some concessions. 3)Continued weakness of administrative control systems.	

			process of being put together.			

6) LIKOUALA Department

No.	Zoning	Pedoclimatic characteristics	Human densities, product evacuation	Main drivers of degradation	Possible changes in the drivers of degradation and deforestation in the targeted areas	Mitigation measures against degradation and deforestation (Cf. technical itineraries)
6	**Department of Likouala:** The areas targeted in this department cover all or part of the community development series of Enyellé for Cib-Olam, Ipendja for Thanry, Lopola for BPL, Lola, Moualé for Mokabi SA and SDC for SIFCO and Likouala timber.	**Relief**: the relief consists in the north and northeast of the department of a horst base (400-600 m altitude) interspersed with valleys (200-300 m altitude) with a dense hydrographic network. The southern half is made up of a basin with low drop-offs and a complex hydrographic network on Quaternary formations. **Weather :** Equatorial climate zone. Annual precipitation varies between 1,600 and	**Population densities:** Very low on average at the level of the department (2.5 inhabitants / km2), with a population concentrated along the roads, rivers and in forest sites. The largest urban center is Impfondo (Chef-Lieu) with approximately 45 to 50 thousand inhabitants. Large population of Rwandan refugees (120,000 people). The main roads are: Epena, Imfondo and	The main cause of degradation is linked to logging in this department. Failure to comply with regulations in terms of forest management and exploitation (illegal logging) aggravates damage. Shifting agriculture on burns (cassava, bananas, etc.) mainly for self-consumption but low impact	1) Large-scale development of agro-industry, mainly oil palm. 2)Uncontrolled development of cocoa plantations in forests if the revival of the sector and the price of cocoa allow it. 3)Population increase leading to increased pressure on forest areas through slash-and-burn cultivation, carbonization and artisanal logging. 4)Lack of alternative to slash-and-burn cultivation. with risk of reduction in fallow	1) Implementation of a Simple Management Plan (PSG) including restoration and conservation measures in the series of community development. Assisted Natural Regeneration (ANR) is a technique that can be tested in this still heavily wooded area. 2) Plantation of timber (local species and teak) in degraded forest

		1,800 mm with a decrease in precipitation in July and a short dry season between December and February. In the dry season, the monthly accumulations do not drop below 50 mm. The annual average temperature is 25 ° C. **Natural vegetation**: Mixed forests with Gilbertiodendron dewevrei; dense partially deciduous rainforests with Ulmaceae and Sterculiaceae, inundated swamp forests with Uapaca heudelotii, Entandrophragma palustre; forests in Guibourtia demeusei and Raphiales in permanent flooded areas. **Soils:** Red-brown, clay-sandy ferralitic soils on the Carnot and Bambio sandstones series,	Dongou. An important network of secondary roads and forest tracks in the north and west of the department. Road link between this department, Sangha Cameroon and the Republic of Central Africa. **Agriculture** Cropping system: shifting slash-and-burn agriculture, mixed farming and fallow land without the use of inputs, very weak agricultural influence at the level of the department, most of which is located along the communication routes. Production essentially dedicated to self-consumption (3% of production is exported outside the department) with	compared to logging. Concerning the two targeted areas: lack of governance, control system of the authorities not very effective. Proximity to the border allowing uncontrolled export of forest products.	periods and soil impoverishment. **Lumbering**: 1) Steady increase in demand for timber on domestic and export markets leading to increased illegal logging. 2)Non-existence of a development plan in some concessions. 3)Continued weakness of administrative control systems.	areas within FMUs.

		alluvial ferralitic and hydromorphic soils on alluvial terraces and peaty hydromorphic soils in flooded areas.	mainly cassava, bananas and taro. Almost non-existent breeding mainly represented by poultry farming. Fishing is one of the main artisanal activities of the department			

C. Cassava, Cocoa, Peanut, Banana Value Chains

ABBREVIATIONS, ACRONYMS AND ACRONYMS

AgriCongo	Congolese Development Support Institute
CEMA	Agricultural machinery operation center
CEMAC	Central African Economic and Monetary Community
CERAG	Plant genetic improvement research center
CDV	Value chain
CNSA	National Center for Improved Seeds
Congo SAN	Congo Food and Nutrition Security Project
CRAL	Loudima Agronomic Research Center
DGRST	General Delegation for Scientific and Technological Research
PRSP	Poverty Reduction Strategy Paper (2008-2012)
ENSAF	National Higher School of Agronomy and Forestry
ENSP	National Polytechnic School
FAO	Food and Agriculture Organization of the United Nations
MET	Traditional micro enterprises
MEFB	Ministry of Economy, Finance and Budget
NG Enterprise	NGUESSO Company
OCV	Food Crops Office
SME	Small and medium enterprises
PMI	Small medium industries
PND	National development plan
UNDP	United Nations Development Program
RC	Republic of Congo
PRODER South	Rural development project in Niari, Bouenza, Lékoumou and Kouilou.
PRODER 3	Likouala, Pool, Sangha Rural Development Project
PNSA	National program for food security
RGPH	General census of population and housing, 2007
SPS	Sanitary and Phytosanitary Safety
TPE	Very small businesses
EU	European Union

General context of this study

This study was carried out as part of the implementation of the Congo's National Determined Contribution (CDN) in the land use and forestry sector and more specifically as part of a "technical feasibility study and economic, and development of the environmental and social management framework ”.

This report includes analysis of four value chains: cassava, bananas, cocoa, and peanuts.

The analysis of the value chains made it possible to carry out cost / benefit studies which appear in the report. All of these studies aim to develop projects intended to implement the Congo's National Determined Contribution (CDN).

General Value Chains

1. The objectives of the value chain studies

It was requested "a brief analysis of the value chains of some agricultural and forestry products (wood and non-wood)" value chains as defined during the workshop to launch the study.

Also, we present here the non-timber value chains selected during the workshop: cassava, plantains, peanuts and cocoa. The departments concerned are: in the south of the country the Kouilou and the Niari, more in the center the Pool and the Plateau, finally in the north the departments of Sangha and Likouala. Given the time available and the need to search for local bibliographic references, we were unable to travel to the different departments.

2. Method used

The purpose of value chain analysis (VCT) here is to understand the interactions between the actors that make it possible to deliver products to end consumers and the links between the activities in these VDCs. The interest here is to identify the bottlenecks, the risks in order to prevent them, the solutions to mitigate them and finally, in this context, the new opportunities to define the priority intervention points for this MV project.

Of course, market mechanisms regulate an important part of these interactions between actors, however the CDV approach that we use aims to also highlight other mechanisms of interaction and coordination between actors. There may thus exist modes of coordination, for example through power relations, institutional arrangements, which influence the relations between actors and which regulation by prices alone could not explain. For example, climate change creates new modes of coordination.

Given the time available we adopted a pragmatic approach, which consisted in analyzing the available literature while making a number of observations on the markets in Brazzaville and Pointe Noire.

The general objective was therefore to identify the mechanisms and organization of value chains, bottlenecks and risks. We have tried each time to highlight the following points:

- An analysis of the economic, social and environmental context of the CDV
- An analysis of the actors, the central actors, the facilitating actors
- The geography of production and its regional specificities
- A functional analysis (Links between actors, mapping of these links, the different stages of product transformation, bottlenecks)

- An analysis of cost structures
- An analysis of the Environmental and Social risks linked to the studied CDV.

The value chain approach differs from the value chain approach. The value chain approach aims to understand the economic, production and distribution processes. She is interested in the different stages that the raw material undergoes, here from the field to the final consumer, through the processing, transport and marketing circuits. The value chain approach takes into account a greater number of actors and institutions that influence the sector, in particular non-market stakeholders, such as non-governmental organizations (NGOs). It also takes into account the broader institutional environment which influences the actors directly involved, up to the institutions linked to the issue of climate change. Geibler observes that in current production and consumption patterns, value chains are important causal links between human activity and environmental change; it identifies indicators from the value chain to the interaction between human and ecological systems (Geibler, 2010).

We have tried, in each CDV analysis, to distinguish the central CDV actors who often correspond to those of the sector, facilitating actors and associated channels who can influence the CDV that we summarize in a diagram as presented in the figure 1 below:

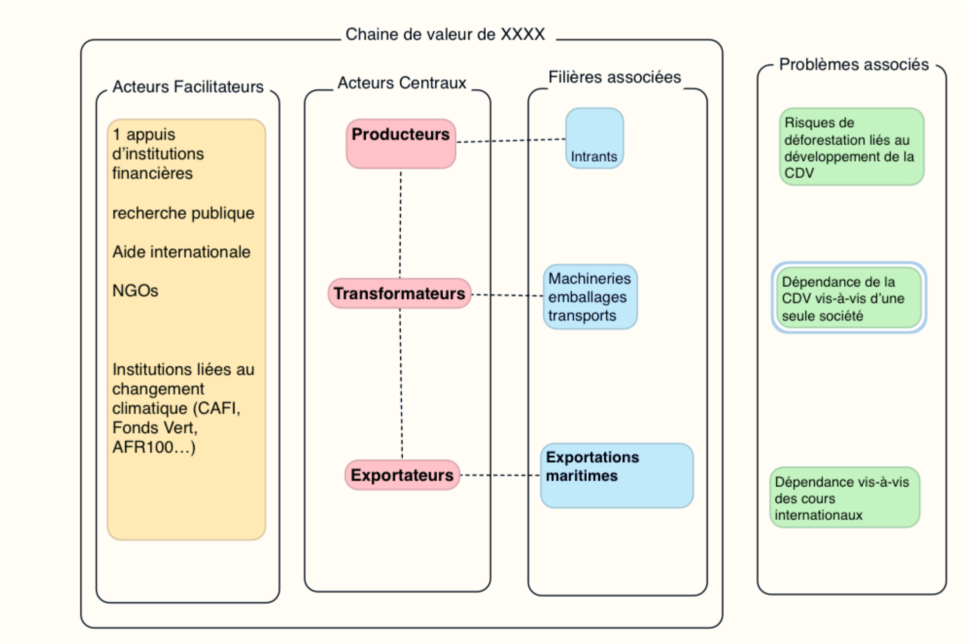


Figure 1: Schematic representations of the organization of a CDV.

3. General observations on the mission

This mission had three objectives: to meet the various stakeholders (public and private institutions, NGOs and direct actors), the collection of data on the value chains of the selected products, and documentary research. The practical working method used was that of direct interviews with institutional actors and a role play at the level of field actors in the markets where we actually bought the products.

Having observed a form of confusion between sectors and value chains, we often started these interviews by redefining these terms to finally state the objectives of our work.

It should be noted and pointed out that the number of field days dedicated to this work was very insufficient, which meant that we focused our work on the cities of Brazzaville and Pointe-Noire, considering that the value chains for the products considered end. almost all in these large centers.

4. The historical context and its consequences for the agricultural sector

With the cEconomic and financial rise in 1986, due to the fall in crude oil prices and the fall in oil revenues, structural adjustments were put in place through agreements with the IMF for a rescheduling of the external debt. As a result, the state companies and farms which ensured the supply of inputs, the processing, the supply and the marketing of agricultural products disappeared.

Then successive civil wars (1993, 1997, 1998) affected the Congo. The war resumed again in2002 then after a lull a new crisis, mainly confined to the department of Pool, emerged from 2014 until today.

Consequently the agricultural sector, already underdeveloped, was seriously disorganized, this was further accentuated with the weakening of agricultural services such as AgriCongo whose means of intervention have diminished. These political crises and wars, which shook the Congo, had the effect of disrupting the supply chains of cities; in these periods producer prices plunged while prices in town increased.

Also there has been very little investment in the agricultural sector in Congo. Agriculture is based on very small farms of the order of 1 to 2 ha, little mechanized which produce 90% of food production. In this context, 70% of agricultural workers are women. Slash-and-burn cultivation and low productivity, both in terms of work and per area, are the rule. Finally, under these conditions the Congo does not produce enough and is therefore dependent on imports to feed its population. Today, one of the government's priorities is to improve the country's food autonomy to meet the needs of the population while reducing imports.

Thus, the Congo, in the past, did not sufficiently create support structures, which could have enabled the development of sustainable and resilient agriculture. The oil manna made it possible to feed the urbanites via imported products. Such a policy has made the country vulnerable, for example if the CFA franc were to be devalued, the urban population would be hit hard by the sudden increase in foodstuffs, without it being possible to be sure that the Congolese peasantry could survive. '' adapt and respond quickly enough to this urban demand.

Cassava and Derivatives TDC Chapter

1. Context

Agriculture in the Congo is very poorly developed. Only 2% of the 10 million hectares of arable land is cultivated. It is essentially based on very small, mixed, subsistence farms. This agriculture is often associated with small livestock. Food crops represent 80% of cultivated land. Cassava is one of the main food crops in the Congo. While the Congo imports around 70% of the agricultural products it needs, it is almost self-sufficient in cassava. Cassava, with a production of around 1.2 million tonnes per year, represents 75 to 80% of food production, which is around 1.5 million tonnes per year (ADF, 2018; World Bank 2017). The average cassava crop yield is 6 to 8 t / ha / year in Congo (ADF, 2018) while elite IITA clones can reach 50 t per hectare. Doubling production would be a reasonable goal.

However, very gradually, a new class of agricultural producers appeared capable of investing in private farms using the services of agricultural technicians and workers, mechanization and soil amendments. Mechanization may be in the fields but above all in the processing of cassava. This class of producers is made up of local elites (businessmen, well-to-do officials, retirees). This phenomenon is still largely marginal. Eco-oil is looking for this type of actor in Bouenza, with whom they wish to associate. It would be necessary to identify in the departments of Plateau, Pool, Niari or Kouilou if this type of actor exists.

Cassava undergoes many transformation processes that generate added value. These processes still make very little use of mechanization.

Economic

In Congo, the cassava value chains (chikwangue, foufou, etc.) are very probably the main sources of income in the countryside.

90% of the Congolese population consumes cassava or cassava products (World Bank, 2017). Although the urban population consumes less cassava (175 kg / year) than the rural population (425 kg / year), urban demand constitutes an important and growing market. This domestic market is valued at $ 174 million (World Bank, 2017).

Congo imports tubers and processed cassava products mainly from DRC (Ntsouanva et al, 2013). Cassava is a real economic sub-sector in Congo, the first of the agricultural sector, it is made up of a set of distinct, labor-intensive value chains involving a variety of businesses, the vast majority of which are informal.

At farm level. Cassava yields in Congo are very low. While they are of the order of 7 t / ha / year, they would have a potential of 25 to 30 t / ha / year. The margins for progress are therefore enormous. However, the average size of the farms (0.6 ha) and their location in dense forest in mountainous areas make it difficult to move to very advanced mechanization. The low agricultural yields are also explained by a lack of renewal of plant material and bad practices which favor the spread of cassava diseases and finally the lack of use of fertilizers. This is largely due to the lack of an effective extension service.

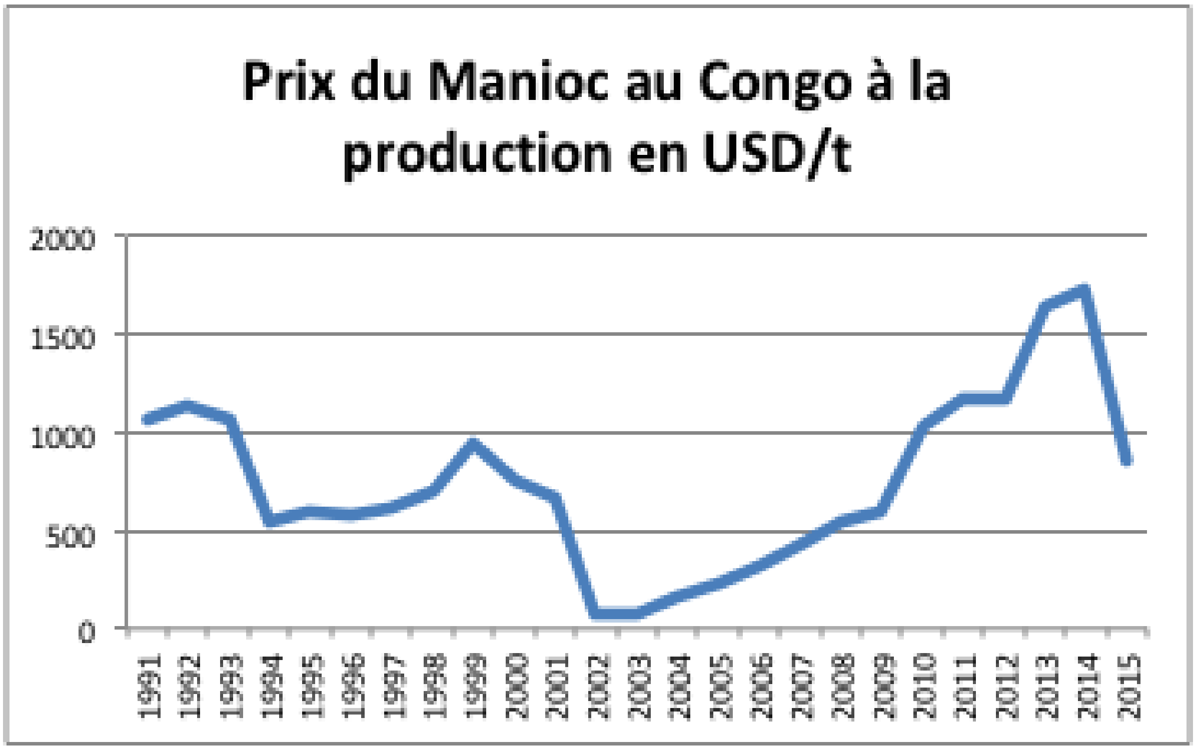


Figure 2: Evolution of cassava price (Source: FAO stat)

The Congo has suffered, in its recent history, successively three major crises:

- A first crisis of 1993-1994 was political at first, then took an ethnic turn.
- The Congo-Brazzaville civil war started from June 1997 to December 1999 but it was prolonged until 2002.
- Finally a third crisis from 2014

Producer prices reflect these periods of political crises during which the country is disorganized, the purchasing power of consumers decreases, the risks of intermediaries increase, so the main level of adjustment is the producer price which falls.

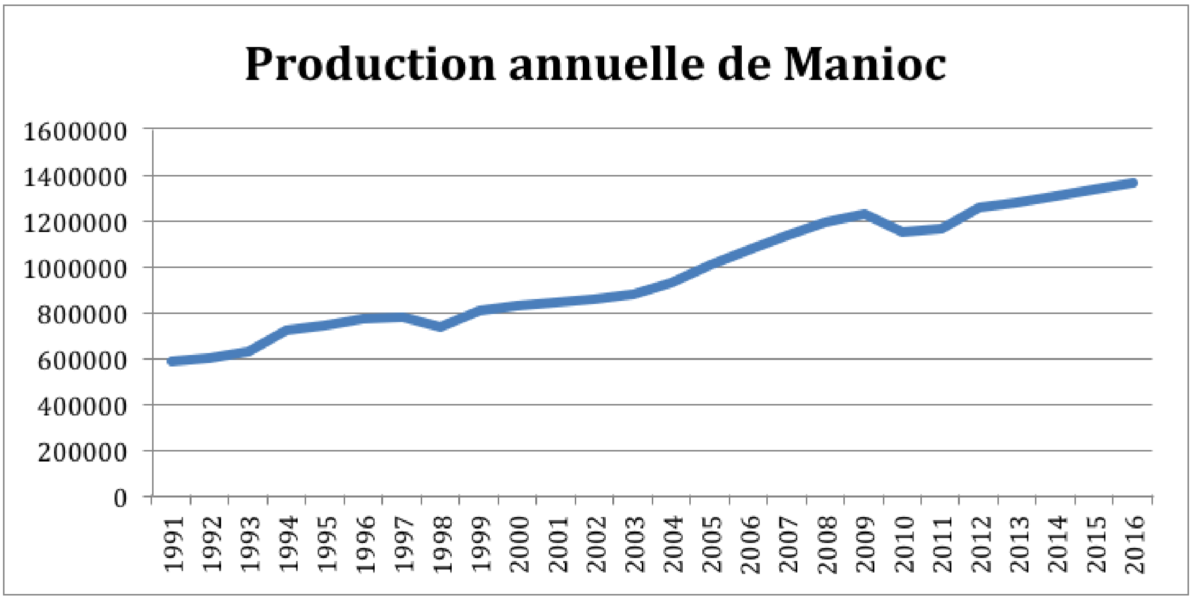


Figure 3: Evolution of cassava production over the period 1991-2016 (Source: FAO stat)

Social

Agriculture in Congo employs around 0.5 million people, of which 70% are women (World Bank, 2017). Women are very much involved all along the cassava value chains.

In rural areas, they are in charge of many agricultural works and the first transformations of cassava.

In town, they take care of cassava processing and marketing. Agricultural tasks such as cassava processing are very tedious as, at the moment, little mechanization is used along these value chains. On average, the weekly working time of women is 60 hours while that of men is only 30 hours, according to a survey in the plateau region cited by (ADF, 2008). The usual division of labor between men and women assigned women to food production, while men were responsible for logging activities in dense forest, cash crops, hunting and fishing. The collapse of cash crops has forced men to invest in food crops as well.

The arduous nature of the work is one of the main problems in the value chain, whether at the level of traditional farms or at the processing level.

There are gender differentiations between value chains. For example, the chikwangue value chain is largely controlled by women while gari is mostly produced by men but marketed by women.

There is still a marginalization of indigenous peoples by the Bantus who systematically refuse to buy the products of these former, under the pretext of lack of hygiene. This creates tensions between these communities.

Environmental

The agricultural sector produces 79% of greenhouse gas (GHG) emissions (World Bank, 2017). In particular, slash-and-burn agriculture by small farmers is a factor of deforestation, reinforced by the use of chainsaws, the main form of mechanization observed. Farmers are already experiencing the effects of climate change, particularly in the Plateau department, they observe the need to advance planting dates and lengthen agricultural cycles, and they also observe an increase in the frequency of floods (World Bank, 2017).

In pure culture, on slopes, without mulching, cassava also causes soil erosion.

2. Actors

The cassava value chain is probably the one that involves the greatest number of direct and indirect actors, due to the variety of products it generates and the still very manual nature of the various transformations to obtain these products in Congo.

Facilitating actors

Rural development projects (PRODER) improve the capacities of farmers, introduce new and more efficient varieties and promote grouping and the farmer. The Loudima Agricultural Research Center (CRAL[1]), although located in Bouenza, has a national mandate. He does varietal improvement, in particular on food crops and cassava. This Center has been supported by numerous projects and research actions carried out during the 1980s and 1990s were able to limit the effects of certain cassava diseases (bacteriosis, cochineal, mites, etc.), but we do not know what its capacities are. current.

The genetic research center on the improvement of tropical plants (CERAG) ensures the production of vitro cassava plants, in particular for the Plateaux.

The National Center for Improved Seeds (CNSA) improves and distributes seeds and for cassava healthy cuttings.

The FAO, the World Bank, the European Union, IFAD are financially and technically helping the Congo cassava value chain.

Central Actors

The central actors are tuber producers, collectors, transporters, producers of semi-finished or finished products, equipment suppliers, service providers, wholesalers, warehouse rental companies, retailers and finally consumers. Most of these actors are in informal type enterprises, traditional microenterprises (METs) whether rural or urban, very small enterprises and very rarely medium enterprises.

There are three types of agricultural production systems. Most of the production (90%) is produced by small farms of 1 to 2 ha; urban and peri-urban agriculture, forms the second type, they are made up of very small producers (less than 0.5 ha per agricultural worker) or more modern semi-commercial farms, which produce specifically for urban consumption; finally, the last type is that of agro-industrial production systems, which, except for NG Entreprise (see below), no longer exists in the case of cassava in Congo (World Bank, 2017). Three industrial production and processing units were created by the Congolese State in the 1970s. One was created in Bouenza in Mantsoumba (1600 ha) with an industrial production of 12,000

[1] The CRAL is under the supervision of the IRA (National Institute for Agricultural Research)

t of foufou. Two others were created in the Pool, one in Mbe (4,800 ha) the other in Makoua (900 ha). In 1986, the state withdrew from these activities and the three farms were closed (SOFRECO b, 2012).

The elderly or indigenous populations have very small farms where self-consumption is the rule and agricultural work is carried out manually with rudimentary tools. More generally in Congo self-consumption absorbs about half of production.

The only real big cassava company in Congo is “NG Entreprise”, which supplies its cassava processing plant with flour and starch, from its plantations and tubers from individual producers with whom it has developed contractual arrangements. But this factory is located in the department of Cuvette. Apart from this enterprise there are some large farms of over 100 ha which use the mechanization of tractors and amendments; they are few in number (Ntsouanva et al, 2013).

Small cassava farmers in Congo do not use mechanization, pesticides or fertilizers. Unfortunately, these farmers often practice slash-and-burn agriculture.

AgriCongo had launched, several years ago, in the mechanization of cassava processing in Kombe (Pool), it produced cassava bread wrapped in plastic film, but with the war the equipment was vandalized then it There was no relaunch of the project and this activity has stopped. Finally, the company NG enterprise, took over a farm and a cassava processing unit producing foufou in Oyo (Cuvette department).

Women play a very large role in production and primary processing, but also in secondary processing located in cities and all along the marketing chain. The mechanization of repetitive tasks at the processing level is encouraged in municipalities with an energy source.

Associated value chains

Several other value chains are directly associated with cassava value chains. For example the manufacture of tools for the mechanization of production, packaging manufacturing sectors, transport, the supply of agricultural inputs, and finally the wood energy CDV. The manufacture of packaging involves the use of non-wood forest products such as the amarantaceae leaves necessary for packaging and cooking the Chikwangue, or the threads to tie the Chikwangue. The use of mobile telephony is also increasing and transforming CDV. The collectors lose power because information circulates better and sometimes direct orders are put in place, on the basis of family relationships of trust, for example between women wholesalers in the city and producers in the countryside.

Agricultural instrument manufacturing sectors such as small forges to make hoes, mills for crushing foufou cossettes are also associated with the cassava value chain.

Cassava could be associated with livestock value chains, which are very deficient in Congo in providing feed for livestock. Cassava may also be associated with the CDV of fungal production. But for the moment these value chains are little developed there.

3. Geography of cassava production and regional specificities

Most cassava production is located on the outskirts of large towns in the departments of Pool (27% of production) and Plateaux (11%) near Brazzaville and the departments of Bouenza (18%), Lékoumou (10 %) located between Pointe-Noire and Brazzaville and the departments of Kouilou (8%) and Niari (13%) close to Pointe Noire. The Cuvette department (9%) also supplies Brazzaville (SOFRECOa, 2012). In the other departments, cassava production is low and mainly for subsistence.

In the forest departments of Sangha and Likouala, where cassava production is low, this Green Climate Fund project will mainly focus on the production of cassava family farming, in order to provide good cultural practices that will reduce the impact on deforestation while increasing production. All the more so since these northern departments import cassava from Cameroon and the CAR.

In the other peri-urban departments (Plateau, Pool, Niari, Kouilou), efforts will have to be focused all along the cassava value chains, in particular in the processing sector.

Specificities of the Plateaux department

In 2010, the estimated cassava area was 20,000 ha. These are small farms. (SOFRECOa). 59% of the production of these small farmers is self-consumed.

20% of the Brazzaville city's cassava supply is provided by these small farmers in the plateaux. They produce about 10% of national production. Most of the cassava is processed at the production sites either into foufou (30%) or chikwangue (65%).

Djambala, Lékana, Ollombo and Ongogni are the localities of the Plateaux where cassava production is the highest. The agricultural workforce is paid there or the producers have small agricultural machinery. The areas cultivated per agricultural worker exceed one hectare. Then come the districts of Abala, Ngo and Allembé where production is lower and the areas per agricultural worker are between 0.5 ha and 1 ha.

Specificities of the Pool department

Ignié and Ngabé are the areas in Pool where cassava production is the highest (1 ha / asset). The districts of Mindouli and Kindamba are less productive with smaller areas per farm worker between 0.5 and 1 ha. The areas per agricultural worker are less than 0.5 ha and production is mainly intended for self-consumption in the districts of Kinkala, Louingui, Loumou (Ntsouanva et al, 2013).

Specificities of the Niari department

53% of production is self-consumed (Ntsouanva et al, 2013). Divénié, Ngoua2, Passi Passi are the localities of Niari where cassava production is the highest. Production is lower in the Kimongo district. Mechanized equipment is more developed than in other departments due to the presence of electrical energy.

Specificities of the Kouilou department

65% of production is self-consumed there (Ntsouanva et al, 2013), in particular in the following districts where the areas per farm worker are less than 0.5 ha: Hinda, Tchamba- Nzassi.

Specificities of the Sangha department

Cassava cultivation remains widespread in the department; in the forest, cassava cultivation is associated with slash-and-burn cultivation. However, the Sangha department is often in deficit and imports cassava from Cameroon or the CAR.

The only form of mechanization for agriculture, in forest regions, is the introduction of the chainsaw. It is at field level the main instrument for reducing the arduousness of field opening work, which mainly consists of cutting down trees and clearing land. The cost of labor in forest areas is very expensive, it limits the ability to open large fields. But owning a field guarantees food security.

Variety improvement programs by various projects financed by the government and by donors have been developed in the past: the World Bank (PDARP), IFAD (PRODER) and FAO (Congo San).

Specificity of the Likouala department

66% of production is self-consumed (Ntsouanva et al, 2013). As in the department of Sangha, the machines run on thermal energy, which is very expensive and therefore limits the development of mechanization.

4. Functional analysis

Links between actors

The facilitating actors at the level of primary production are rural development projects (Ex PRODER), the Loudima Agronomic Research Center (CRAL), the genetic research center on the improvement of tropical plants (CERAG), the national center of improved seeds (CNSA), AgriCongo.

The central actors of the cassava value chain are first of all mainly women who form three categories.

A first category of actors is at the level of primary production. It is the households of small farmers who produce the cassava tubers and carry out the first transformations, in particular the retting. Also in this category there are rural households who specialize in a little more extensive processing. At this level, a large part of the production is self-consumed (around 50%).

A second category of players is located in major markets and in towns. They are processors and wholesalers. This category also includes material handlers, transporters, custodians who maintain stocks and various tax officials.

The towns are supplied by road, rail and waterway. The poor condition of the roads in some departments is a factor limiting cassava production. The availability of means of transport and the parafiscal system along the roads affect consumer prices.

Small quantities of cassava-based products are exported to the European Union by air (less than 50 t per year).

Due to the spread of information through mobile telephony, a certain number of players are tending to disappear: between category one and category two, rural collectors no longer do business and as information circulates better. stocks are also being reduced, affecting depositaries. The risks are particularly located at the level of transport and storage.

Finally, the third category is made up of retailers and consumers. They are located in rural or urban markets. In this category, still dominated by women, we also find partners of men who are carriers, handlers and tax officials.

At the market there are at least two types of taxes, the market tax for cleaning and the municipal tax for the municipality.

5. Mapping the CDV

We will distinguish:

- The flour and Foufou value chain
- The Chikwangue value chain
- The Gari value chain

But there are many variations (Yiniké, Mbobolo, Mbenzé, Mossombo…). Each variant implements very precise operations which are illustrated, for three of them, in the following diagram. These operations are for the moment mainly manual, but could to a certain extent be mechanized (see the experiences of AgriCongo). Cassava, beyond being the main food base of the Congolese has many other uses: starch for clothes, flour for pastries as a substitute for wheat, glue, etc.… but in Congo cassava mainly used to produce foufou and Chikwangue.

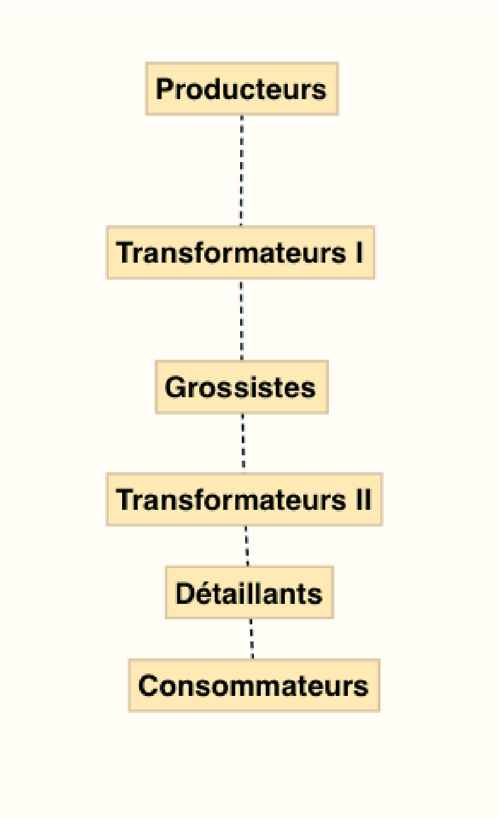


Figure 4: The central actors of the cassava value chain

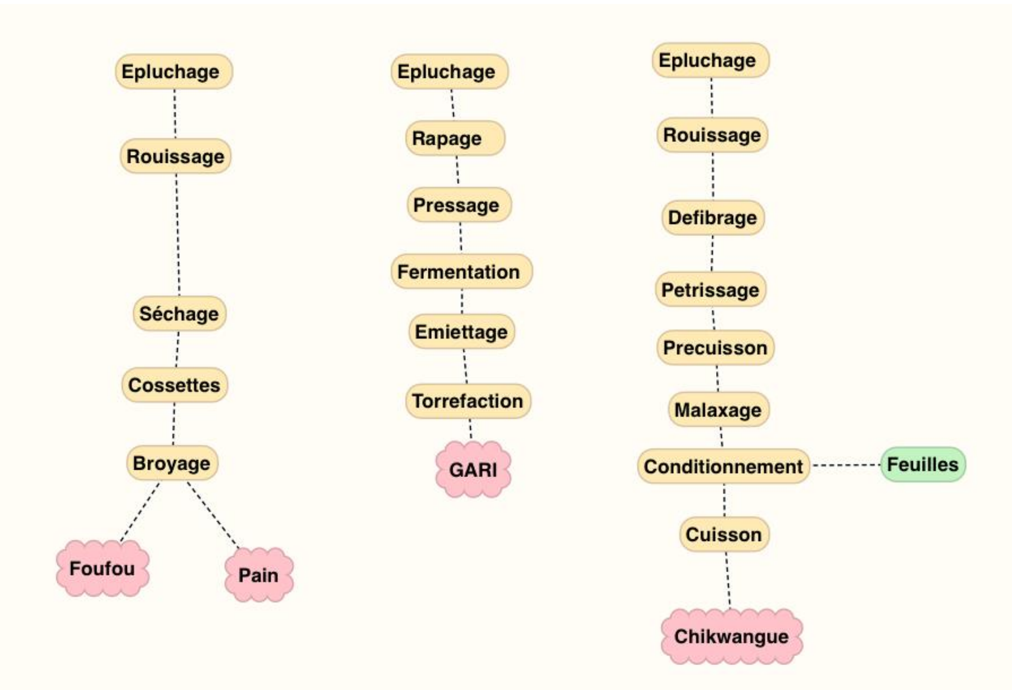


Figure 5: Diagram of processing operations for three cassava value chains

Cassava processing is still largely manual; However, mechanization is developing in certain departments and this makes it possible to change the scale of production, in particular for dried products. Chikwangue production includes rather painful kneading operations, which should be more mechanized. The machines used are often cobbled together from scrap materials, which can cause hygiene problems.

Cassava in dry form of chips or flour keeps better. At the moment, the production of bread from cassava flour is negligible.

Yields vary depending on the product: 32% for Gari, 48% for Chikwangue.

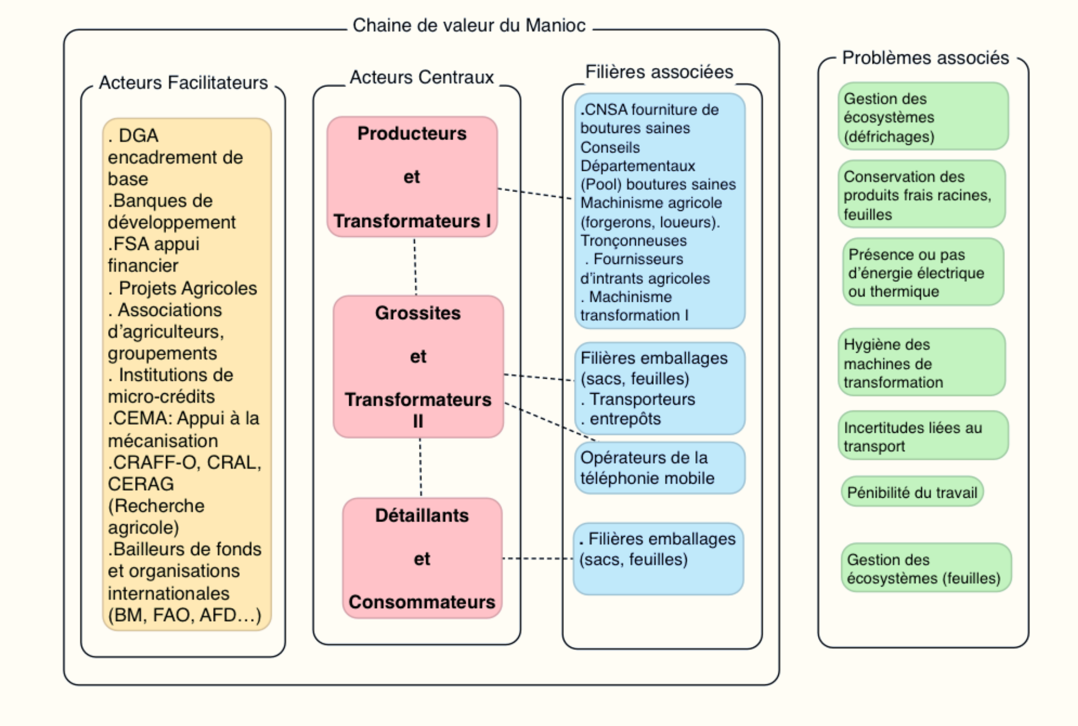


Figure 6: Cartography of the Cassava Value Chain

6. Bottlenecks

There are health risks with processed products, for example on the trays, there is no laboratory for the control of food and pesticide residues. Various studies have shown that the existing equipment for cassava processing does not take into account technical and health standards.

The spread of cassava diseases is a major problem. Cassava is propagated by cuttings rather than seeds. This has many advantages because farmers can produce their own cuttings or buy or acquire them directly from other farmers. For 10,000 cuttings / ha it takes 50,000 FCFA (according to data from CRAL Loudima). However, farmers tend to use their own cuttings even when they are already infected with diseases.

The agronomic and phytosanitary constraints are accentuated for problems of capacities and sociological beliefs. Cultivation techniques are poorly developed; they are reduced to shifting cultivation and due to the remoteness of the fields from the homes associated with the arduousness of the work, the cultivated areas per farmer are very low (0.5 ha / farmers, 2013).

The weak mechanization at the processing level is a bottleneck. Indeed, as cassava is very perishable in the raw state and its tubers rot in four days, it is important to quickly carry out treatments which require a lot of labor. These transformations are also a means of creating added value at the farm level, while primary cassava production is not very profitable. However, it requires painful and repetitive work that only mechanization could mitigate.

Poor infrastructure, lack of access to credit, and lack of agricultural advice are factors that prevent large numbers of smallholder farmers from engaging in these commercial value chains. In particular, farms located in peri-urban areas could benefit from the removal of its bottlenecks.

There are also very few cooperatives or effective farmers' associations capable of providing agricultural services (inputs, mechanization, advice) due to a lack of associative culture. Those that exist are the result of a project and not necessarily a perennial character or they are micro mutual aid systems to share the work in a rotating way and free themselves from the excessive blow of the workforce.

In particular, women have limited access to agricultural inputs, credit, land ownership and labor power (World Bank, 2017). In addition, impacts on women's employment can emerge with the spread of the mechanization of cassava processing operations, which is often accompanied by a masculinization of the value chain.

Land pressure is relative and is distributed very differently between the departments. It is more pronounced in the departments of Kouilou, Pool and Plateaux where it can be considered important. On the contrary, land pressure is low in the departments of Sangha and Likouala which are almost, in terms of human presence, desert (Ntsouanva et al, 2013).

Mechanization in the savannah zone is very limited due to the lack of private service companies for agricultural mechanization and the lack of support from the CEMA (Centers for the Exploitation of Agricultural Machines of the Ministry of Agriculture and Livestock). There are also sociological obstacles to mechanization, such as pressure groups of agricultural workers who have inalienable rights, which allow them to fix the prices of agricultural tasks, which leads to high costs of manual agricultural operations (Ntsouanva et al. al, 2013).

In general, the very significant drop in yields observed after 1984, from 36 t per hectare to less than 10 t per hectare, while the State structures intended to support family farming were dismantled, clearly shows that the one of the bottlenecks is the lack of agricultural services.

We will retain the following brakes:

- At the level of primary tuber production: access to healthy and productive plant material and the fight against phytosanitary diseases.
- At the processing level, mechanization accessible to women
- Transportation

The bottleneck is the lack of agricultural support services.

7. Cost structures

The cost of cassava production varies according to the regions, the ecological zone and the mechanized or traditional system (Unit: FCFA / ha):

	Savannah		**Forest**	
	System traditional	**System mechanized**	**System traditional**	**System mechanized**

Kouilou	626,000	-	720,000	500,000
Niari	720,000	500,000	569,000	343,000
Trays	BORN	390,000	-	-
Pool	390,000	331,000	-	470000
Sangha	-	-	1,350,000	-
Likouala	-	-	525,000	-

Board 1: Cassava production cost per hectare (source[2])

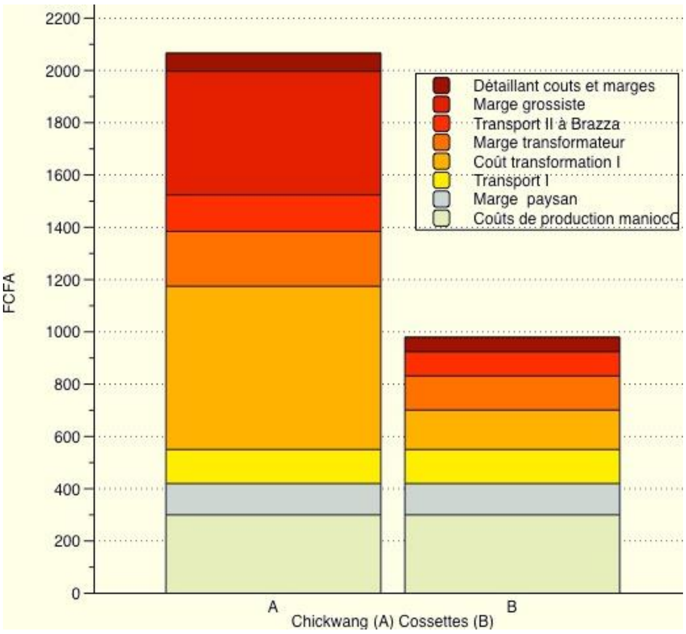
The added value in relation to turnover is greater for alcohol (73%), then chikwangue (68%), gari (65%) and finally cossettes (36%) (Ntsouanva et al, 2013).

A traditional chikwangue processing unit can reach 200 kg per week, or 110 chikwangues of 1.8 kg. Production is generally irregular and on order.

Cassava is marketed in various forms along the value chain and according to uses: tubers, retted dough, defibrated or not, chikwangue, cooked tubers, chips, gari, flour, etc.

The yields of processed products vary according to these products: thus, the mass of the retted paste is 65% of the mass of fresh tubers required for its manufacture. For chikwangue it represents more than 50% and 25% for dry products such as cossettes. The chikwangue value chain is the most profitable.

The prices of chikwangue are lower in areas where self-consumption is higher, in forest areas (Niari, Pool Sud); they are higher in areas close to cities.



[2]Table taken from: NTSOUANVA, B., Michel, MJ, Richard, B., Heliodore, M., Armand, M., Maurice, E., & Brice, P. (2013). Support for the Development of a Cassava Sector Development Strategy in Congo, 1–178.

Figure 7: Comparative structures of the costs of processing 10 kg of tubers to produce either Chikwangue (about 5 kg) or Cossettes (foufou) (about 7 kg) in A (authors' analysis using data from Bienvenu, N., Michel, MJ, Richard, B., Heliodore, M., Armand, M., Maurice, E., & Brice, P. (2018). Support for the development of a development strategy for the cassava sector in Congo, 1–178).

8. Analysis of the environmental and social risks linked to the cassava chain.

Although for the moment the Congo is 80% self-sufficient in cassava, the projections of the SOFRECO study indicate that it should be possible to increase production from 1.2 million tonnes to nearly 4 million tonnes in 2035, this is simply to cope with the increase in the population and the new needs linked to the increase in purchasing power (flour for bread-making and animal feed in particular) (SOFRECOa, 2012). The way in which this increase in production will take place will or will not generate environmental and social impacts.

Risks	***Reduction measures***
Environment	
Pollution linked to agricultural inputs, pesticides and fertilizers (Industrial agriculture) The introduction into forest areas of the chainsaw associated with cassava cultivation is a risk of accentuating deforestation The risk of spreading cassava dise	• The government is investing in research and extension for second generation agriculture with reasoned use of inputs, thrifty and agroforestry. • Intensifying production through green agriculture can reconcile increased production with reduced deforestation. • Support to producers by introducing improved cuttings resista diseases.
Social	
Political instabilities that affect producer prices and the CDV as a whole Marginalization of women and indigenous peoples through the introduction of mechanization	• Bringing back social peace is a priority and promoting indigenous peoples in development policies • Include women and indigenous peoples in all processes of dissemination of agricultural intensification and agricultural mechanization techniques.
Economic	

Fall in production due to insufficient technical supervision.	• Support research and extension to support farmers.
Distrust of local products because of health problems with processed products.	• Improvement of processing equipment, development • Creation of laboratories for the control of food and pesticide residues.
Difficulties in transport and storage	• Policy for improving transport and (road network) and st infrastructure through public policies.
Difficulty accessing credit	• Facilitate access to credit (eg as part of a development project)
Land dispute	• Facilitate the recognition of land rights

5. Main bibliographic sources

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Cocoa CDV Chapter

1. Context

Historical

For three decades, between 1960 and 1980, cocoa was one of the flagship productions of Congolese agriculture. Cocoa cultivation, at that time, was supported by the State (research, popularization, supply of inputs); the OCC, the Congolese office for coffee and cocoa, thus supported the farmers until the marketing of cocoa.

Cocoa production was concentrated in the departments of Sangha, Likouala and Nord de la Cuvette. Experiments have also been set up in the departments of Niari, Lékoumou and Kouilou, but cocoa cultivation has disappeared in these departments (ADF, 2008).

Since then, the farmers have come face to face with themselves. Many plantations have simply been abandoned. The official production collapsed, however at the Cameroonian border still passes cocoa which is exported via Cameroon.

More recently, the government of Congo has decided to revive the cultivation of cocoa. It developed a National Development Program (PND) for cocoa production (2014 2018) which aimed to regenerate and create 23,000 ha with a yield of 1 ton per ha in year 7 (Congo, 2014). For this, he wanted to rely on private companies known worldwide, so he made agreements with the company CIB-Olam (Congo-MAE OLAM, 2014).

Olam had bought the CIB forestry concession, so he was on the ground while being a major global player in the agro-food sector. Olam served as a service provider to the government between 2012 and 2016, for the creation of nurseries, the distribution of cocoa plants and inputs to farmers. The objective was to plant 15,000 ha by 2023. Olam also had the right to export cocoa; Olam exported small quantities of cocoa between 2013 and 2015, these were tests to assess its quality. However, Olam's cocoa activities came to a halt in early 2018 due to the government's financial problems.

Small farmers still remember the support of the State, guaranteed prices, it is this revival they expect. Olam, an international agro-industrial company, had the scale and experience to make a strong contribution to this revival with the State. Its withdrawal is a strong indicator of the high risks of the relaunch of cocoa in the Congo.

Another company governed by Congolese law, smaller than Olam, Diamon Cacao, also provides inputs and markets some of the cocoa beans harvested. This company has been in operation since 2011. To help farmers maintain their old plantations, this company makes loans of around 20% on the basis of previous productions. It also provides agricultural tools. Diamon thus bought 600 t of beans in 2017, then 1200 t including 700 t for Likouala and 500 t for Sangha. This cocoa is sold mainly in Italy.

The purchase price from producers is negotiated according to the international price with the assistance of the Departmental Directorate of Agriculture. Until now, it has varied between 500 and 750 FCFA per kilo. Transport between the production points and the Pointe-Noire port which is the place of export is done either by boat or by vehicle. The price per tonne transported is around 1.2 million FCFA. Diamon provides financial and logistical support in the packaging of the beans, which is carried out with the assistance of agents from the Department of Agriculture.

The revival of cocoa activity seems for the moment suspended due to the financial constraints of the government. A better knowledge of the Diamon company could be one avenue, however we fear that it is not the size enough for a lasting recovery.

Economic

The Congolese government observes that the cocoa market is growing and that 70% of production comes from sub-Saharan Africa. He hopes that the Congo can capture a share of this market in order to diversify the national economy (PNIASAN: RC, 2017).

Indeed, Sub-Saharan Africa exported 10.1 billion dollars of cocoa in 2016 while the Republic of Congo only exported 7.1 million dollars the same year. As Diamon hopes, the Congo should take advantage of the revival of this activity by working for an organic quality sector to take advantage of the cocoa market niches and again to embark on a semi-processing before exporting.

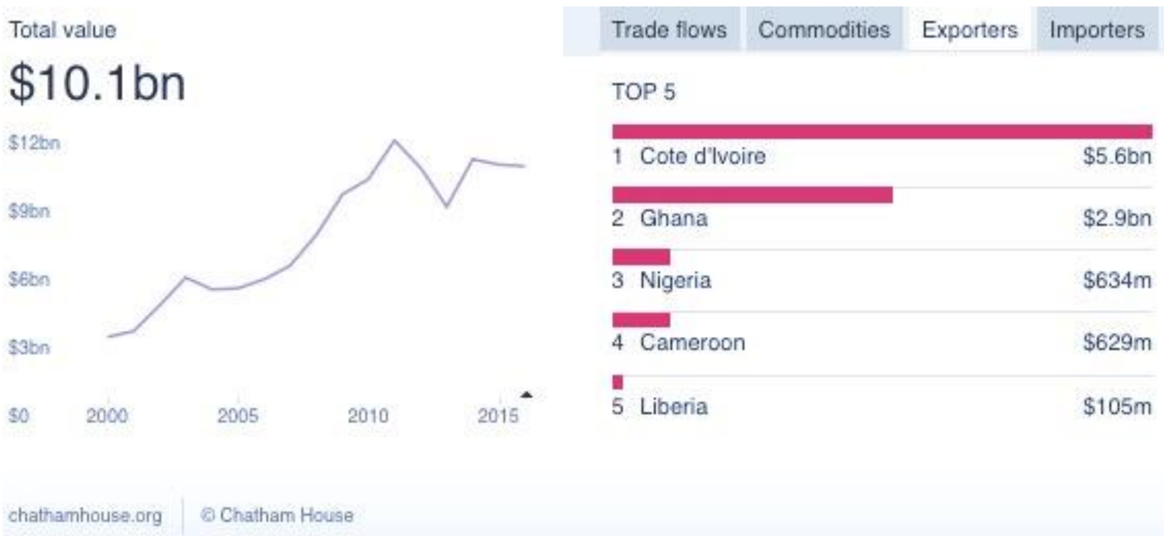

Figure 8: Sub-Saharan Africa, cocoa export (Source: chathamhouse)

There would be 2,500 t of cocoa beans which would be exported to Cameroon from Sangha via informal channels, while the cocoa does not go out to Cameroon from Likouala. Indeed, the port of Douala is much closer than that of Pointe Noire when you are located in the Sangha.

Social

The government's ambition is to revive cocoa production by relying on farmers who already own old plantations. It also wishes to support other actors in the cocoa value chain such as approved local buyers, transporters and exporters.

In the cocoa-growing regions concerned, farmers have very few opportunities to sell their production due to the distance from the main domestic markets. So they are waiting for the relaunch of cocoa. They have small farms but some have been able to adapt to the lack of technical support. However, these small farms employ outside labor. Young people and women are very active there. Indigenous populations do not benefit from support (source Olam-CIB report).

Studies carried out with local populations by CIB-Olam have shown that local populations prefer the development of cocoa to any other speculation (cassava, pineapple, etc.). Although the cultivation of cocoa in this region has not been developed since the 1980s, it seems that the population keeps a "culture" of cocoa and also the memory that the OCC ensured the marketing of cocoa. Olam has considered marketing cocoa in the Sangha region and purchased small quantities of cocoa but this activity does not seem to develop.

This region is very sparsely populated, around 2 inhab / km2, there are some settled refugee migrants who come from the DRC and CAR and even from Rwanda. With the exception of Rwandans, who market gardening, these populations are not farmers.

The establishment of plantations in the dense forest requires the felling of trees which is a difficult activity. Currently it is facilitated by the use of chainsaws which explains the presence of other economic operators for the sale of this material and their repair. Cultivation of cocoa requires phytosanitary monitoring, which would require qualified personnel and pesticides.

Environmental

The areas of predilection for cocoa cultivation are areas of dense forests. Shifting slash-and-burn agriculture is the dominant type of crop, as everywhere in the Congo and specifically in the area, this agriculture has the effect of cutting down forests to take advantage of the richness of their soils. At the present stage, the establishment of new plantations means deforestation and / or forest degradation.

The increase in deforested areas will also have an impact on hunting because the populations will have access to previously inaccessible areas and this will contribute to the erosion of biodiversity. The anti-poaching system, which already exists, will need more attention.

With the felling of the forest, it is also likely that the development of coal mining and fuelwood activities will contribute to the release of CO2.

Deforestation is a potential risk in the event of a strong recovery in CDV. Areas dedicated to cocoa must be mastered and regulated within the framework of the various cocoa projects (eg: national register of producers, etc.). Regeneration of existing plantations would be a means of mitigating this effect, but this requires strong supervision of producers and the development of incentives.

2. Actors

Facilitating actors

The main facilitating actors are currently the private companies OLAM and DIAMON.

Central Actors

According to CIB-Olam, in 2012 there were around 1,600 active cocoa producers in the three main cocoa departments (Sangha, Likouala and Cuvette).

Cocoa producers are farmers, they produced around 2,300 tonnes of cocoa beans in 2012. These are family farms that together owned around 4,700 ha of cocoa trees on a median area of 2 ha each. However the average yield was very low (300 kg / ha) and the production of poor quality. The lack of support from the State to the farmers has resulted in the degradation of the quality of maintenance, a lack of access to inputs, the non-rejuvenation of the plantations, the non-respect of fermentation, drying and drying techniques. storage. The production collapsed in quality and in quantity and with, the resources of the peasants.

Alongside the official buyers (Olam Diamon), there are informal purchasing networks that export cocoa via Cameroon. They are close to the communities and have their trust (Olam).

Most of the peasants would like the State to provide them with the same services as in the past years (60 to 80): access to inputs, good seeds and the guarantee of selling their production (according to Olam-CIB).

3. Functional analysis

Links between actors

CDV is poorly developed in Congo today. Producers have either given up cocoa or are dependent on collectors from Cameroon and Diamon today is the only official buyer.

The main actor was CIB / OLAM, which supported producers up to export and had a training and research laboratory. Unfortunately, this actor is retiring. We also know that Diamon also plays a similar role.

However, there are informal value chains to Cameroon organized by traders.

Mapping the value chain

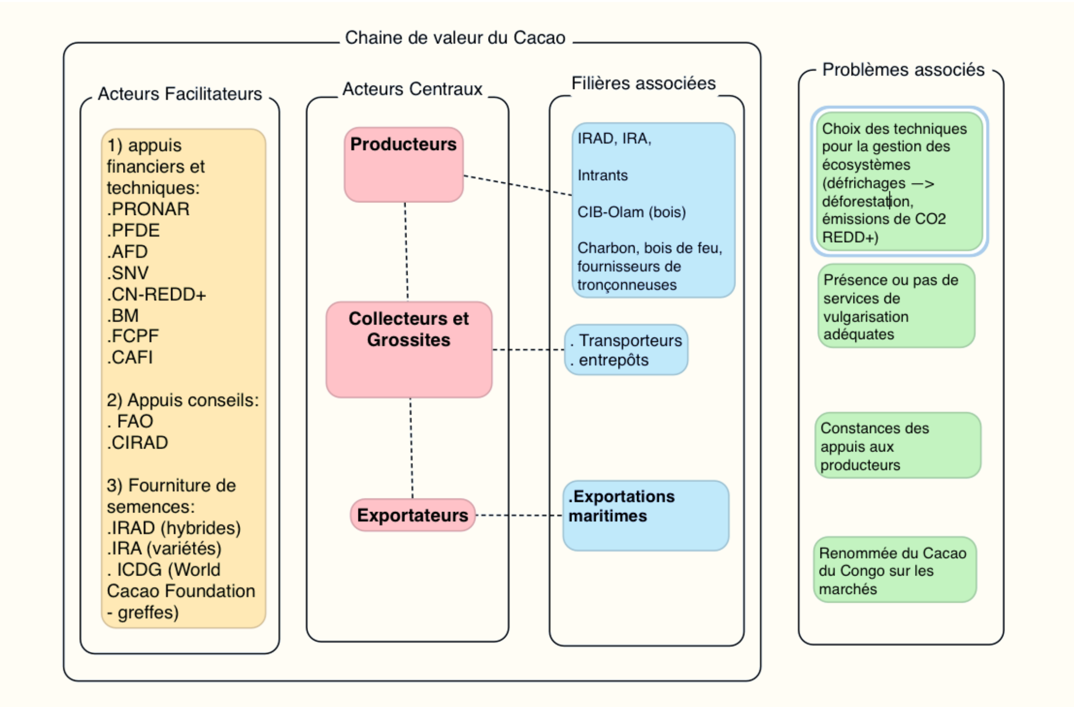

Figure 9: Mapping of cocoa CoS in Congo

Bottlenecks

The lack of State investment in research during the past decades is a major constraint to the dissemination of efficient cocoa hybrids (in quality and quantity). Also in the short and medium term, the State will find it difficult to revive quality plantations.
The actors of the cocoa value chain have become informal due to the absence of the state for several decades; thus, most of the production is evacuated to Cameroon and does not enter into national statistics. The state should put in place incentive policies to regain their confidence.
The relaunch of cocoa requires consistency in government efforts outside, the latter's financial means are currently very limited.
The major obstacles are:

- The availability of quality plant material to replace the mostly old or very old cocoa trees. (Seed fields, adapted varieties etc.); Difficulty for farmers to obtain plant material from the Pokola nursery.
- High transport cost for export from the port of Pointe-Noire
- Lack of a formal framework for the export of cocoa via Cameroon (lack of traceability, no quality control, usurious interest rates).
- Insufficient supervision of the departmental agricultural directorates.
- Lack of national cocoa processing capacity.

4. Cost structures

At the moment we have little information on the costs along the value chain, which hardly exists in Congo. The purchase prices paid to producers by Diamon are between 500 and 750 FCFA per kilo. These are prices that do not reflect the average which must be much lower now:

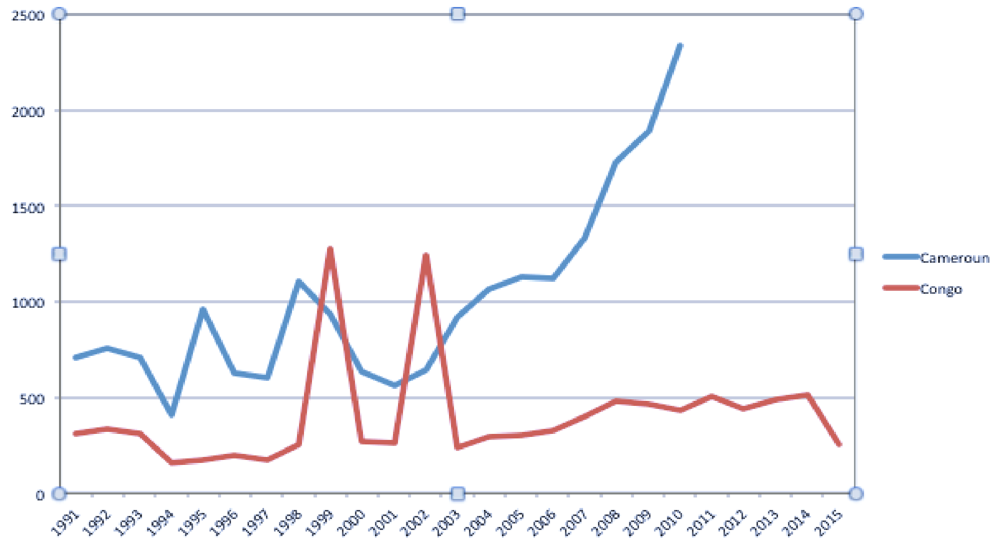

Figure 10: Producer prices of cocoa in USD / tonne are significantly lower in Congo than in Cameroon, because it is a product intended for export and the value chain is disorganized. Source:http://www.fao.org/faostat/en/#compare

In 2010, producer prices were five times higher in Cameroon (1170 FCFA / kg) than in Congo (218 FCFA / kg) (FAO Stat). In 2015, the ton of beans produced by producers in the Congo was 256.4 USD (FAO Stat) or 154 FCFA / kg. However, it seems that purchases by OLAM / CIB were better paid to producers between 650 and 850 FCFA / kg and those by Cameroonian buyers even more between 750 and 1000 FCFA / kg (PDCE, 2018).

Producer prices for cocoa are therefore very low in Congo, while the consumer price index for agricultural products is rising faster than in Cameroon. The price of cocoa to the producer remains low probably due to the disorganization of the cocoa value chain in Congo. This is a major disincentive to relaunch the cocoa CDV in Congo.

Headings	Price FCFA / kg	%
Producer price	750	32
Transport fee	600	26
Pointe Noire rendering price	1350	59
Pointe Noire Handling Fees	405	17
Storage costs	540	24
FOB Pointe Noire price	2 295	100

Table 2: Cost structure of the cocoa CDV of Sangha outlet Pointe Noire in 2014 - Source: (PDCE, 2017)

Headings	Price FCFA /	%
Producer price	875	32
Transport fee	300	26

Various fees (customs, chamber of commerce, se etc.)	68	
Cameroon border delivery price	1,243	

Table 3: Cost structure of the cocoa CDV from Sangha outlet Cameroon in 2014 - Source: (PDCE, 2017)

The previous cost structure analyzes explain why a substantial part of cocoa is exported by Cameroon (PDCE, 2017). They also show that the government will have to consider incentives for the cocoa to leave via Pointe Noire (tax free for carriers to Pointe Noire, subsidized loans for CDv actors to Pointe Noire).

5. Environmental and Social Risk Analysis

The main beneficiaries must be the peasants according to the official texts. However, the development of the cocoa value chain requires constant and combined financial efforts from the State and private companies, which have been lacking in the past.

The revival of cocoa cultivation presents a risk of deforestation and degradation which could be mitigated by new agroforestry techniques for forest reconstruction. However, these will require significant technical support because the main model known for the moment is, on the contrary, to clear the forest. Cocoa cultivation has been the engine of deforestation in Côte d'Ivoire and to a lesser extent in Cameroon for example.

Establishing cocoa plantations has land implications that can generate conflict. Legal and land analyzes are necessary.

Risks	***Reduction measures***
Environment	
Deforestation linked to the cocoa cultivati method	• Regeneration of old cocoa farms in forest areas • Development of a cocoa-culture agroforestry in savannah zones
Social	
Exclusion of indigenous peoples	• People's information processes indigenous people before the development of project: indeed the development of cocoa cultivation can have the effect of arrival of migrants which makes the indigenous peoples associated with transfers land which subsequently generates conflicts.
Political instabilities that affect producer prices and the whole CDV	• Cocoa VCTs in regions far from ports are very vulnerable to crises policies, guarantee cohesion and national unity
Economic	
Lack of access to the market by producers to the distances to the ports and the	• Purchase contracts by private parties or the State • Farmers have adapted by selling to Cameroon, but this does not benefit the

vulnerability of the CDV to crises which di transport.	Congo.
Problem of lack of access to the internatic market due to quality	• Establish long-term policies in quality standards. • Supervision of the CDV to defend cocoa qualities of controlled origins for take advantage of these new markets and labels (organic…) • Develop the transformation of the product on square
Fall in production due to the absence of technical supervision.	• Support private companies like Diamon or CIB / Olam who invest and provide technical support for the production to marketing. • Regeneration of existing orchards and densification

6. Conclusions

The cocoa development model as practiced in Côte d'Ivoire and Ghana is no longer suited to the most profitable markets which require zero deforestation cocoa. Agroforestry models are therefore an opportunity to position ourselves strategically in this changing market and has new quality requirements.

The history of the CIB shows that the development of cocoa in this region is very fragile. Purchases of cocoa by Olam are not growing, probably in part because the current production is insufficient, the company without public aid is not investing in the regeneration of cocoa trees either. In addition, the population is low in these forest regions and therefore the available labor force will be so except to consider more migrations which may be undesirable, if we want to avoid deforestation. At the moment, there has not been a well-structured cocoa value chain for several decades. The reconstruction of these value chains would require significant and sustained efforts over time. One can doubt that the current actors (States and private companies) are able to provide this effort in a sustainable way.

The World Bank is considering this relaunch via actions to promote CDV, for example by developing the production of certified plants and providing technical support, structured health monitoring, etc.

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Peanut TDC Chapter

1. Context

Groundnut production in Congo is in the order of 20,000 to 30,000 t per year, for comparison, that of Cameroon is in the order of 750,000 t and world production in the order of 40 million. tons.

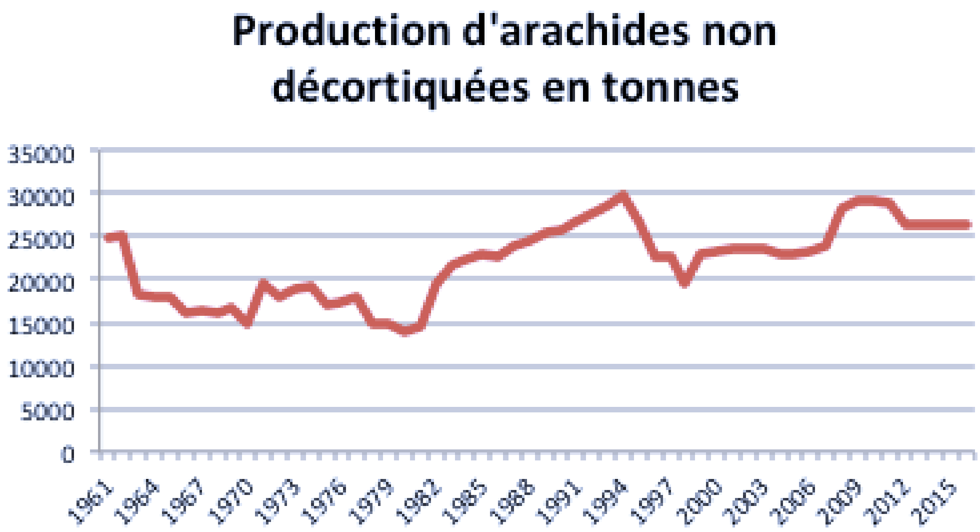


Figure 11: Production of unshelled peanuts in tonnes (source http://www.fao.org/faostat/en/#compare)

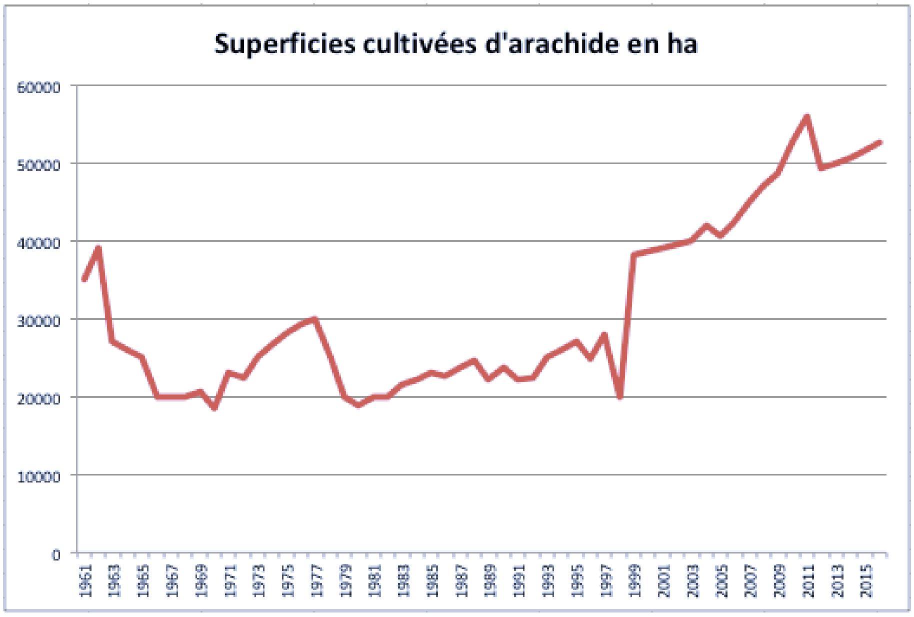


Figure 12: Groundnut area in ha (source http://www.fao.org/faostat/en/#compare)

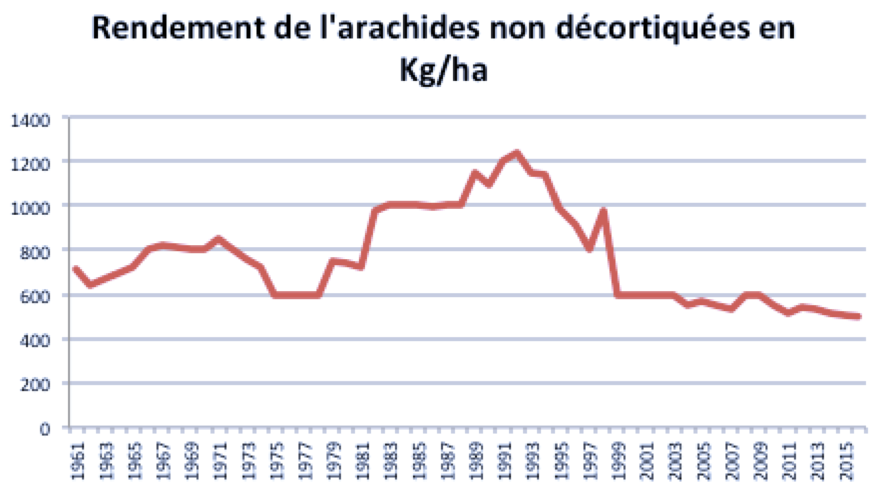


Figure 13: Yields of unshelled groundnuts in kg / ha (source http://www.fao.org/faostat/en/#compare)

In Congo, we can distinguish two types of peanut agriculture, subsistence agriculture for human and animal consumption managed largely by women and industrial agriculture for the production of oil or other industrial products. such as spread.

Subsistence farming is carried out on very small farms where groundnut cultivation often occurs in combination crops. During the last 20 years, groundnut cultivation has almost doubled (see figure 12), while production has tended to stagnate (figure 11) and yields have fallen below the 600 kg / ha mark afterwards. have reached 1.2 tonnes / ha in the early 1990s (Figure 13). These very low yields represent those of subsistence farming and indicate that in the 2000s the industrial cultivation of groundnuts had almost disappeared.

Industrial agriculture fell sharply with structural adjustments, the closure of the Nkayi oil mill which produced 25,000 t and more generally with successive crises. It is this factory that Eco-Oil is rehabilitating in the department of Bouenza. This type of industrial peanut value chain requires mechanized agricultural production using fertilizers and phytosanitary products.

Eco-Oil or large farms run by foreign entrepreneurs[3]are, for the moment, the only ones capable of developing this industrial peanut agriculture in Congo. Eco-Oil's objective is to have, to supply its plant, a production of 160,000 t of unshelled peanuts, from 80,000 ha. Groundnut yields with the use of inputs could potentially reach 2.5 t / ha, Eco-0il is targeting 2 t / ha. Production, for its part, peaked in the mid-1990s at 30,000 t then it fell to around 26,000 t in 2015 (see figure 11 FAO data).

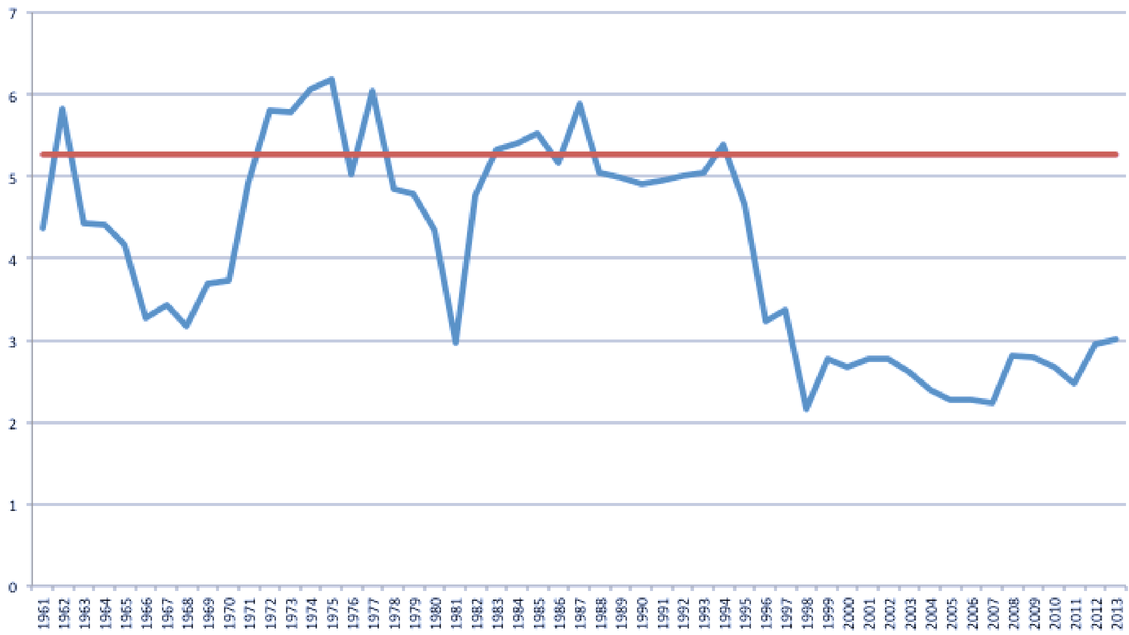
Groundnuts are cultivated most of the time in the savannah, in particular groundnuts in industrial cultivation; it is also cultivated on forest fallows less than 4 years old, which makes it possible to have better yields for small farms that do not use fertilizers (ADF, 2008).

For the departments that interest us, groundnuts are grown mainly in Niari, the Plateaux and in the Pool. The main other production departments are Bouenza and Lékoumou, where industrial groundnut crops are grown (ADF, 2008). For this study we will focus more on groundnuts from small farms in associated crops.

Economic context

Groundnut production poorly covers the country's food needs. Consumption is estimated at 7.9 kg / person / year (PDCE, 2017) of shelled peanuts, ie at the national level a consumption of around 60,000 t / year of unshelled peanuts; Congo produces 25,000 t / year of unshelled groundnuts, it covers only 41% of its needs[4].

The government's groundnut objective is to cover national needs and export surpluses (Republic of Congo, 2018). The rehabilitation of the Huilka oil mill in Nkayi aims to export a large part of the production. Here again, a distinction must be made between the requirements for edible peanuts and the requirements for industries such as oil mills.



[3] Industrial farms run by private expatriates (Spaniards, South Africans, a Chinese) are mainly located in Bouenza and cultivate land that they have in concession.

[4]Population of Congo 5.125 million, ie a national consumption of 40,487 t / year shelled or if 3 kg of shelled peanuts produce 2 kg of shelled peanuts, the national demand is 60,000 t / year of unshelled groundnuts. Curiously, the Piasan report (Republic of Congo, 2018) indicates that the Congo covers 145% of the country's internal consumption needs in peanuts.

Figure 14: Peanut shelled in kg / person / year. (a) Food availability in quantity (in blue), (b) demand corresponding to 5.26 kg / pers / year shelled groundnut or 7.9 kg / person / year unshelled (in red). There has been a net deficit since the mid-1990s. This graph shows that the peanut value chain has become clearly in deficit since the 1990s.

Non-industrial groundnuts are produced, processed and marketed mainly by women. Overall, 70% of the agricultural labor force in small family farms are women in Congo. The average farm is 1.4 ha and there are 115,000 small farms managed by 145,000 workers who occupy an area of about 0.4 million hectares, which is not much given the size. from Congo[5] (source PIASAN).

Social context

The share of household income allocated to food is around 50% (Republic of Congo, 2018). 74.8% of the Congolese rural population is below the poverty line which is set at 839 FCFA. The situation has clearly worsened for the rural population since 2005, when it was 64.8%, while this figure has clearly improved for the urban population, which rose from 42.3 to 29.4 in Brazzaville according to ECOM (Republic of Congo 2012). A large part of the Congolese population suffers from undernourishment; groundnuts, which are a source of protein, are not sufficiently consumed.

Industrial peanut agriculture can be the source of displacement of populations that provide labor.

Environmental context

Industrial agriculture, poorly supervised, could generate pollution due to the ill-reasoned use of pesticides and fertilizers and erode soils due to excessive mechanization.

It can also reduce the cultivable areas of populations with reduced fallow time, resulting in soil impoverishment. The affected indigenous populations will be tempted to exploit new forest land, resulting in deforestation and / or degradation.

2. Actors

Facilitating actors

The disappearance of the Office des cultures vivrières (OCV) which ensured the marketing of groundnuts probably contributed strongly or decline to this value chain that we observed above.

The Support Program for the Development of Sectors (PADEF), which aims to sustainably improve food security and the incomes of small farmers, had not yet, during our mission, produced a study on the groundnut sector. .

Currently, the Commercial Agriculture Development Support Project (PDAC) aims to provide multi-faceted support to producers.

Central Actors

<u>Peanut Mouth Value Chain:</u>

At the level of peanut production, the central actors are mostly women who use traditional cropping practices, most often in combination of cultivated species. Then, along the value chain, we observe collectors, transporters, wholesalers who store and process peanuts (shelling, roasting) or not, and finally retailers who buy peanuts, shelled or not, and proceed to

[5] Congo has an area of 32.4 million ha.

processing (peanut paste, roasted, salted or sweet peanut) and especially to its retail sale. Most of the added value is at the level of these retailers; but this activity just allows many women in town to "boil the pot" of their family.

Agricultural services provided at the production level are currently weak.

Industrial value chain:

For the moment, the central player in industrial CDV is the Eco-Oil company. However, the company is currently working in partnership with smallholders who practice traditional agriculture.

3. Functional analysis

Mapping

Two products are obtained from the peanut in shell:

- Hulls that can be used as organic fertilizer, mulch, feed for livestock, or as a source of energy.
- And the shelled peanut.

The shelled peanut gives the following products:

- Crude oil which can itself be transformed into refined oil and spread.
- Oil cake in the industrial sector.
- In the family farming sector, shelled peanuts can be consumed in roasted peanuts (plain or salted), in peanuts coated with caramelized sugar, in peanut paste, or finally in peanut oil produced in the traditional way. (JMN, 2018).

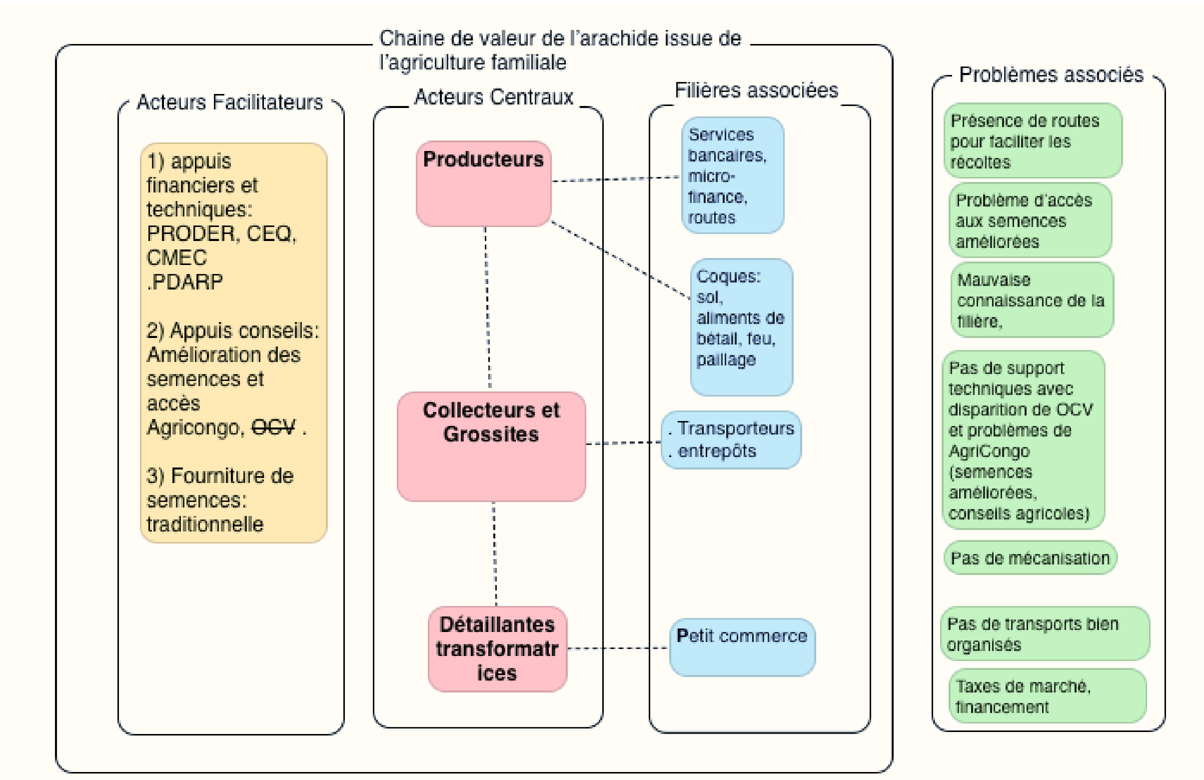


Figure 15: Mapping of the peanut value chain from family farming

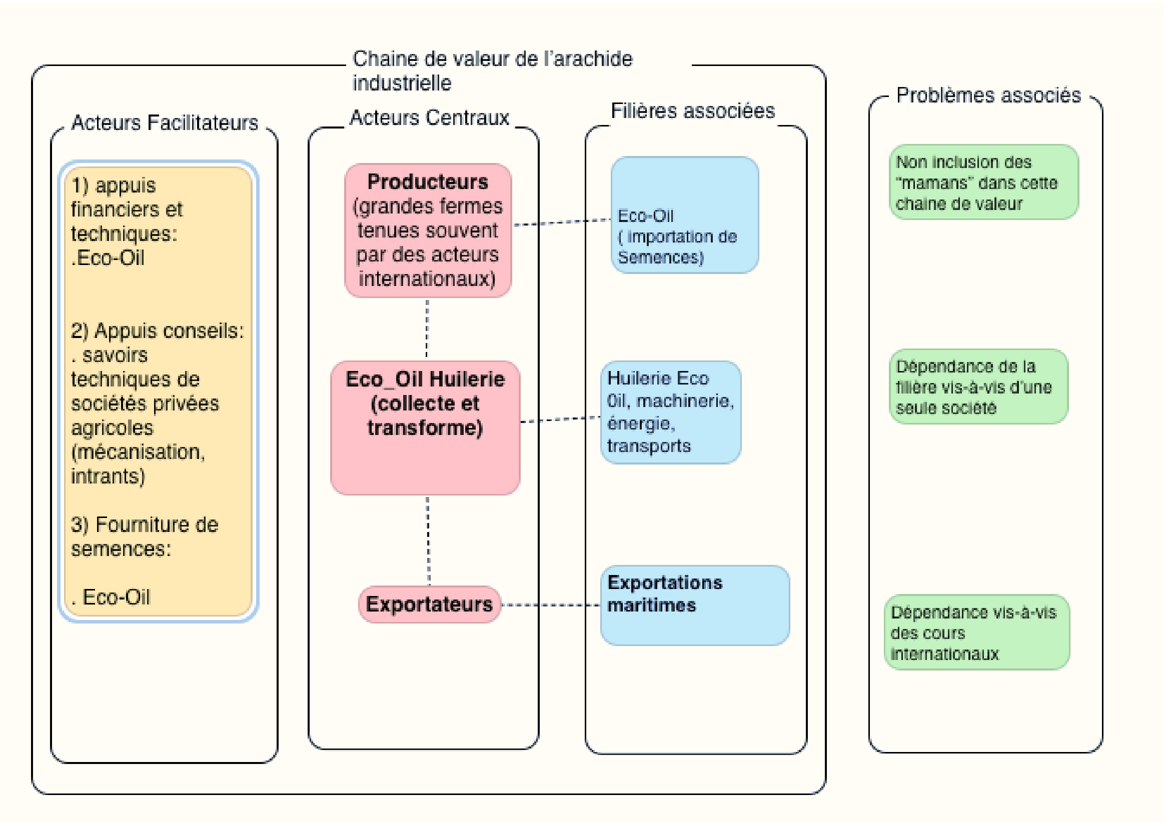


Figure 16: Mapping of the industrial peanut value chain

4. Cost structures

Producer prices

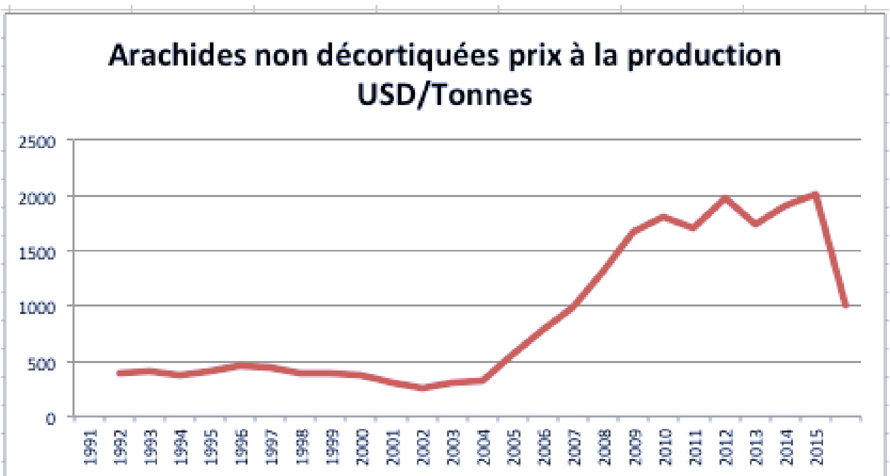


Figure 17: Producer price of unshelled groundnuts in USD / t (source FAOStat)

Producer prices were around $ 1,700 / ton in the 2000s and more recently prices have fallen again to less than $ 1,000 / ton or 555 FCFA / kg approximately in 2016 when it was 1,100 FCFA / kg in 2015, prices can therefore vary rapidly. It should be noted that the period 2005-2014 when prices to producers rose sharply, corresponds to a relatively peaceful period.

Retail price shelled peanuts

Retail in Dolisie		Box price		Price per kg	
	Weight / box in kg	Mini price	Max	Mini price	Max
Kwaker		4	5	7	8

Table 4: Retail price of peanuts in Dolisie Source: personal communication

Retail in Brazzaville		Price per container		Price per kg	
	Weight / container in kg	Mini price	Max	Mini price	Max
Kwaker					
Glass					

Table 5: Retail price of peanuts according to two packaging in Brazzaville

Source: data collected by consultants

Prices and costs observed in Brazzaville

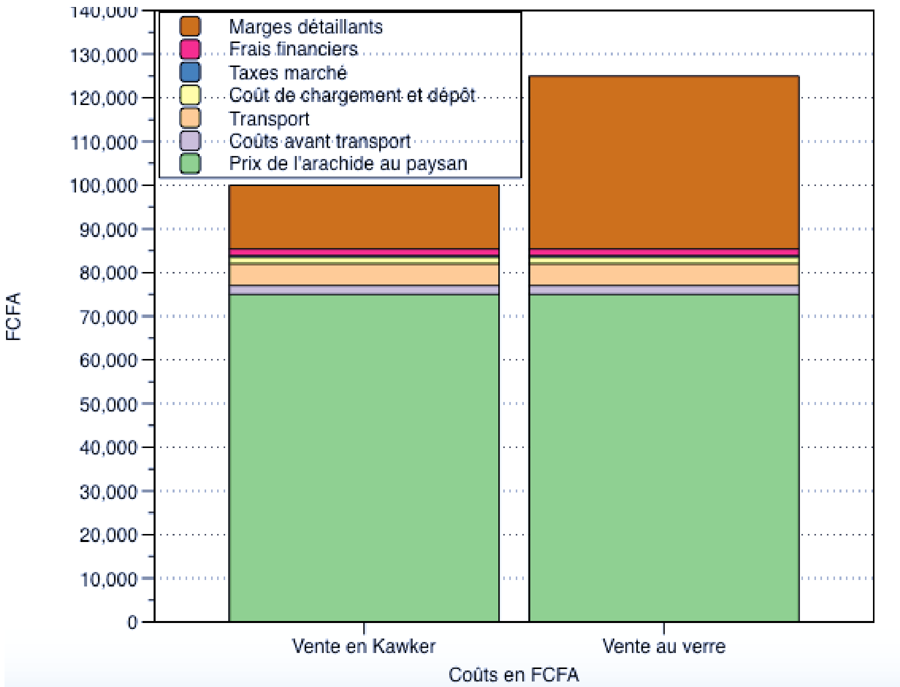


Figure 18: Cost structure of 100 kg of groundnuts according to two types of packaging in Brazzaville

FCFA per 100 kg shelled peanuts by the glass	costs	Price
For 1 bag of 100 kg shelled		
Consumer price in Brazza per glass		1
retailing margins		
Financial expenses		
Market taxes		
Loading and deposit costs		
Transport		
Manual costs and collection before transport		
Groundnut price (to the farmer)		

Table 6: Cost structure of 100 kg of peanuts according to glass packaging in Brazzaville

FCFA per 100 kg Kwaker shelled peanuts	costs	Price
For 1 bag of 100 kg shelled		
Consumer price in Brazza per glass		10
retailing margins		
Financial expenses		
Market taxes		
loading and deposit cost		
Transport		
manual cost and collection before transport		
Groundnut price (to the farmer)		

Table 7: Cost structure of 100 kg of peanuts according to packaging by Kwaker in Brazzaville

In the peanut value chain of family farming, the most important part of the added value occurs at the level of agricultural production, which is not very mechanized. It is mainly about labor. Another important part of the added value is at the level of the retailer margin.

5. Bottlenecks

The bottlenecks affecting the peanut value chain produced by smallholder women farmers, mothers, are:

- Poor quality and degeneration of seeds; in this regard we can clearly see all the difficulties that Eco-Oil has had to obtain quality seeds. The degradation of state agricultural services is reflected in the drop in groundnut productivity since the 1990s (see fig 13). The lack of improved seeds is a real problem in the development of groundnut cultivation.

- Post-harvest losses,
- The arduousness of the work, work which until then had only been done by women and with rudimentary tools (hoe, machete, ax and timidly the introduction of the chainsaw) at the field level and also at the level of the transformation of the peanuts, the brakes are also in the acquisition of equipment, its maintenance and repairs,
- Inappropriate processing techniques,
- A lack of support for the organization of marketing,
- In general, the weakness of State support for small-scale groundnut producers in connection with the disappearance of the OCV and the virtual disappearance of AgriCongo.

The figures above clearly show that despite the increase in cultivated areas and therefore the efforts of "mothers", production increases very slightly because yields fall; moreover, this production is insufficient to feed the population (figure 11). The price of peanuts to the producer, in normal times, is the highest item. All this indicates that the main bottleneck is the low yield of agricultural production of groundnuts. With better yields, producer prices could fall, leaving more margins for distribution actors and the VC would be stimulated, creating more demands for the benefit of better food for the population.

6. Environmental and Social Risk Analysis

Risks	***Reduction measures***
Environment	
Soil degradation linked to the use of mechanization (industrial agriculture)	• The government invests in research and extension for second generation agriculture with use reasoned of inputs, economical and agroforestry. • The government invests in research and extension for the development of a small accessible mechanization women farmers.
Pollution linked to inputs agricultural pesticides and fertiliz (industrial agriculture)	
Deforestation and degradation forests due to agriculture itinerant and extensive (family peanut)	
Social	
The mechanization of large farms can cause disappearance of agriculture family controlled by women	• Information processes with local actors before the choice of technologies should make it possible to consider with the actors concerned the necessary support measures.
Political instabilities that affect prices to producers and all the CDV	• Guarantee national cohesion and unity
Economic	
The development of an industrial intended for export can dump its surpluses on the domestic market, breaking price and killing family farming at same time.	• It is necessary gradually through research and development to intensify family farming (improved seeds, small mechanization) make it less vulnerable to industrial agriculture (and imports).
Fall in production due to the lack technical support.	• Support research and extension to support women farmers. • Encourage manufacturers to share their technologies with

	small farmers (improved seeds, etc.).

In the departments targeted by the project, these risks are currently potential.

7. Conclusions

Groundnuts, both for their nutritional qualities and for their family production systems, allow many women farmers to support their families. Practiced in association with other crops, groundnut cultivation is of great importance in Congo because this cropping system is economical in inputs and therefore has a place in the future green agriculture of Congo.

However, family farming presents many vulnerabilities, it must necessarily evolve, but it should do so while keeping its qualities (frugal in inputs, accessible to women, generator of added value, inclusive). Improving agricultural yields is the main bottleneck; the measures to remedy this are classic (improved seeds, support for women farmers, development of small-scale agricultural mechanization, credit systems.)

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Plantain CDV Chapter

1. Context

There are two types of bananas, the dessert banana (sweet) and the Plantain banana, the value chain of which we study below. Bananas are grown everywhere in the Congo, however there are regions more specialized in this product: Niari, Kouilou, Sangha, Likouala, Pool for the regions that concern us.

The plantain is one of the key crops in family farming. It employs almost 0.5 million farmers of whom 70% are women farmers, generates 90% of the country's agricultural production on any small farm of 1-2 ha (World Bank, 2017). Improving the plantain CDV could help strengthen the viability of these small family farms.

Economic

In Congo, the plantain value chain, after cassava, is one of the main sources of income in the countryside. Also after cassava, plantain is one of the favorite foods of the Congolese. They consume 30 kg of it per person per year (PDCE, 2017). It is therefore both a culture for subsistence and a culture for sale.

Figure 19: Historical prices of plantain to producers. They have long been significantly higher in Congo than in Cameroon, because they are products primarily intended for the local market, which is why plantains are imported from Cameroon or the DRC. Source:http://www.fao.org/faostat/en/#compare

Plantain prices are higher in Congo than in Cameroon (fig 19), because consumer prices for foodstuffs are generally higher; the price index is also higher, which indicates that these prices are increasing faster in Congo than in Cameroon. Services to farmers are also of better quality in Cameroon than in Congo.

Plantain production in Congo is around 80,000 tonnes per year (fig 20), or 5% of total food production, which is around 1.5 million tonnes per year.

We also observe that plantain production has been strongly affected by the crises.

During the civil war from 1997 to 2002 production fell sharply by around 25%. During crises, CDVs are disorganized, the risks increase very strongly for carriers and intermediaries, so the main adjustment value is the price to producers; In addition to the drop in prices at their level, these latter have difficulty in selling and also end up lowering the level of their production. Bananas are relatively fragile products. Excessive controls which slow down the movement of vehicles and poor road conditions can lead to the loss of an entire load. The losses are very important, around 23% of the production (PDCE, 2017).

The country only covers a fraction of its food needs, around 40-60% for plantains (PDCE, 2017). Also the Congo imports plantain from the DRC and to a lesser extent from Cameroon (PDCE, 2017).

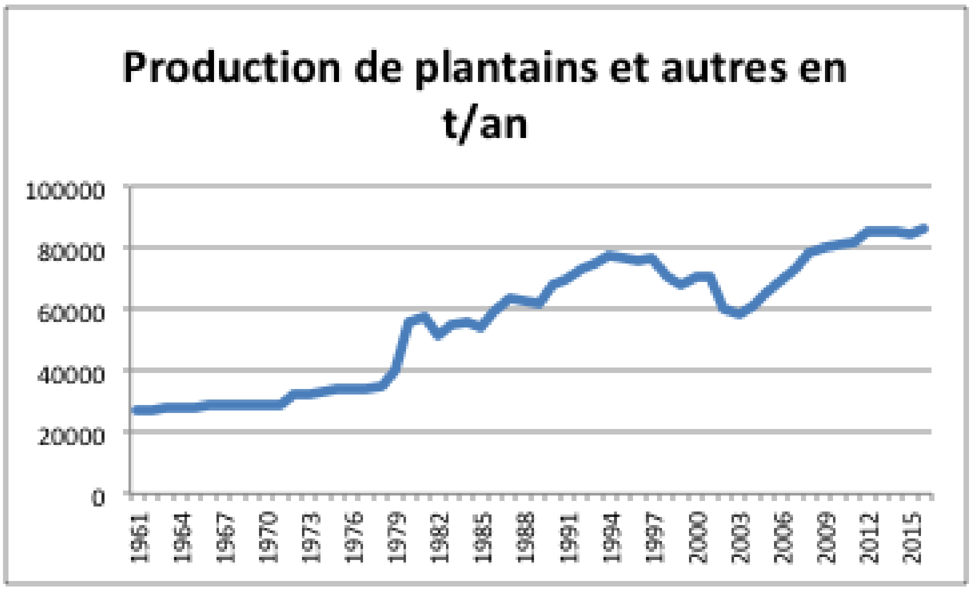

Figure 20: Plantain production in Congo in t / ha. Source: http: //www.fao.org/faostat/fr/

We can observe (fig 20) drops in production during political crises. This indicates that this CDV is very vulnerable during these periods, which can be explained because the banana is a very perishable product and the CoV is easily disorganized by transport problems.

2. Actors

Facilitating actors

Development and agricultural support projects have significant effects, in particular through the development of tracks. According to (PDCE, 2017), the PDARP (Agricultural Development and Rural Roads Rehabilitation Project) significantly increased plantain production per household in Niari, Kouilou, Sangha and Pool. Its activities are stopped and will be taken over by a new project which is the PDARC. In the same field of action, the Congo has just initiated an ECAAT project supported by the World Bank on the financial level, the IRF and the IRA on the technical level.

Central Actors

Producers are generally small family farmers sometimes groups of farmers who cultivate bananas in association with other crops. The production takes the form of home gardens or agroforestry systems. These farms are less than 1 ha and are often run by elderly people who have few inputs. There are producers, much rarer, who have several dozen hectares and the means to invest in their production.

3. Functional analysis

Mapping

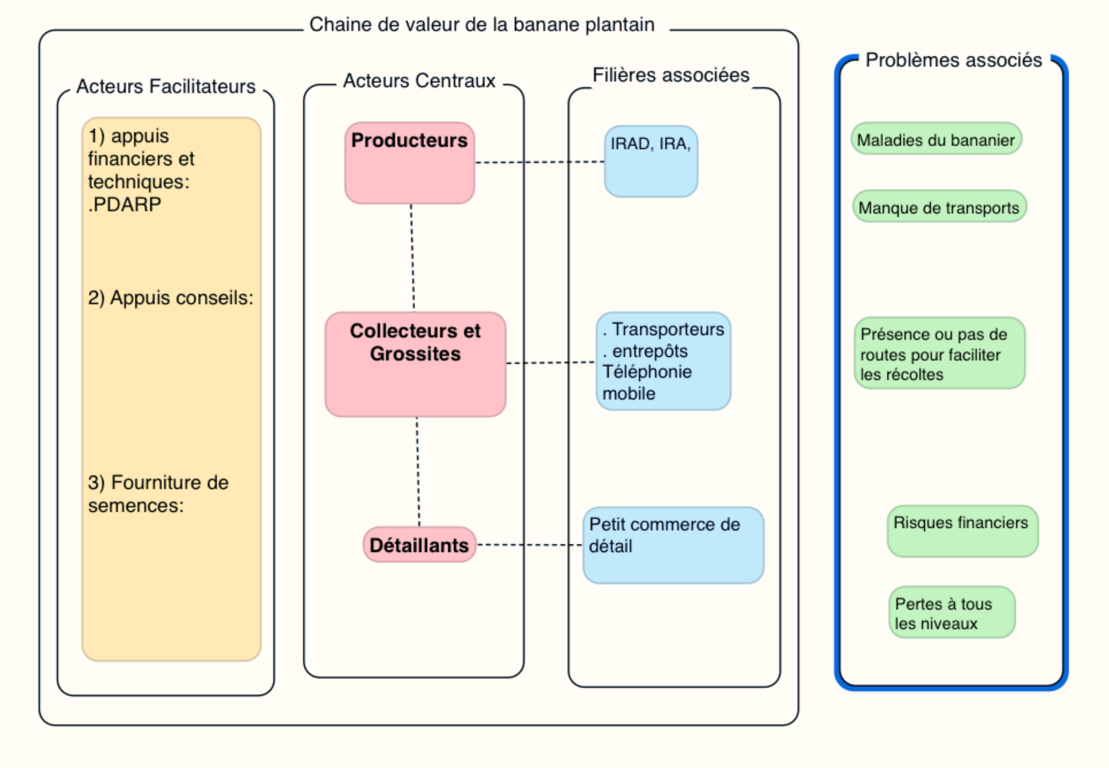

Figure 21: mapping of plantain CDV in Congo

Bottlenecks:

At the level of small producers, improving productivity is a necessity. Indeed, yields are very low, around 4 t per hectare, whereas they are around 15 t in Cameroon and that in the world they can reach 50 t per hectare and per year (PDCE, 2017).

- It is necessary to qualify the low level of these yields which is partly linked to the associations of cultures in the home gardens, which mean that the density of planting is low.
- Yields are low because small farmers use little or no fertilizers or phytosanitary products, but in a context of uncertain selling price, it makes sense to reduce costs on inputs.

- Another explanation is the low use of improved varieties. This can be partly explained by the weakness of the agricultural services of the State (agricultural research and extension) following the various crises that the country has suffered.

Self-consumption is for small producers an assurance of being able to use part of the production. The sale depends on the arrival of collectors whose costs are partly linked to the state of the road infrastructure, itself dependent on public investments and the means and choices of the State.

In the departments of Pool and Plateaux, closer to the urban market of Brazzaville, farmers benefit from more agricultural services, they have access to mechanized agricultural services that save on labor and also obtain more elaborate ground preparations (much deeper plowing, for example).

Transport is also a problem for producers. When their production is ripe, with no transport available, they can lose it. The uncertainty on the selling price is also mainly related to transport, the costs varying seasonally depending on the state of the network. Indeed this uncertainty is reduced as evacuation to the city is easy (proximity / presence of tarred axes). Producers in the Pool (in areas near Brazzaville) and / or along roads in good condition have lower transport costs and a regular possibility of evacuation (less uncertainty about crop loss).

4. Cost structures

Producer prices

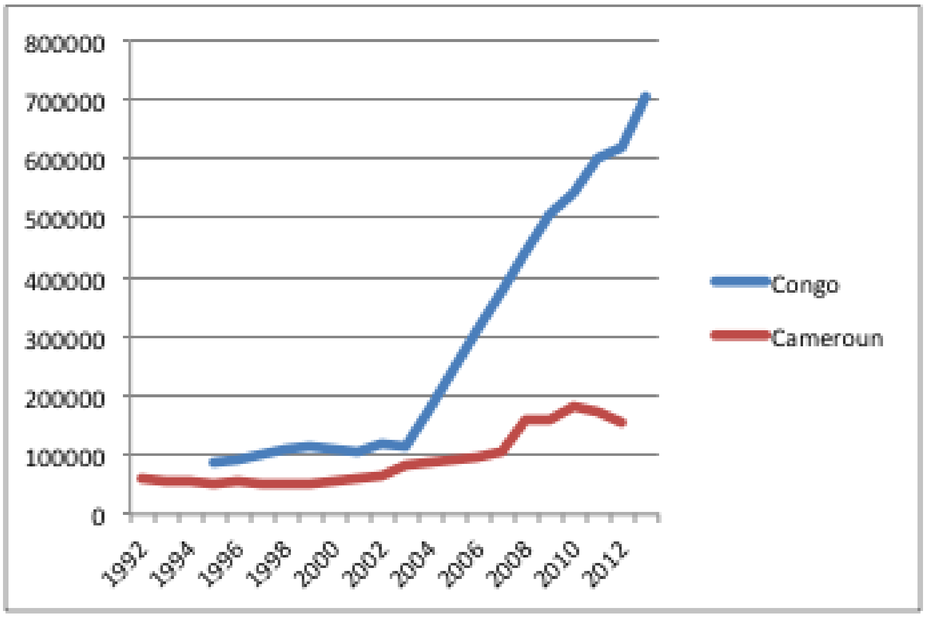

Figure 22: Recent prices of Plantain and others to producers, comparison Cameroon and Congo (FCFA / tonne) - Source FAO Stat

We observe that producer prices are much higher in Congo than in Cameroon, which is why there are imports from Cameroon.

Costs at the production level

In the departments of Pool and Plateaux, the cost of plowing is 40,000 F CFA per hectare, the same for spraying the plot, or 80,000 F CFA per hectare of agricultural service costs (PDCE, 2017).

The main costs are those of installation and maintenance. The preparation of the land (plowing and spraying) the acquisition of suckers and their transport are the main expenses of the first year.

Transport costs are higher in the South than in the North.

Consumer price

The source (PDCE, 2017) indicates the following prices:

- 3,500 to 5,000 FCFA per diet outside Brazzaville
- 4000 to 6000 FCFA per diet in Brazzaville.

Producer prices vary greatly depending on the time of year, in times of shortage and in the event of political crises. Mobile telephony and remote payment systems are recent innovations, which make it possible to directly link producers to sellers in the markets. This reduces the role of collectors and may allow producers to capture more of the added value. It is certainly the most important innovation along the value chain in recent years.

Cost structure

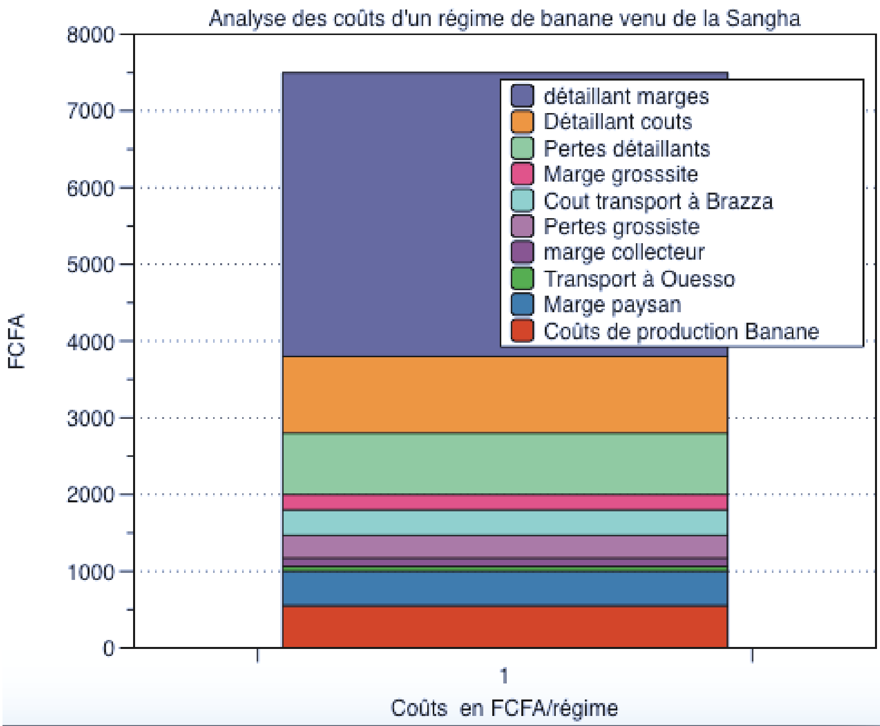

Figure 23: Cost structure of plantain, from Sangha, at the Brazzaville market.

For 1 diet	Costs	Price	Hypotheses
			Diet 15 kg

Brazza consumer price		7500	15 hands of 5 fingers / diet at 500 FCFA per hand
retailer margins	3700		
Retailer costs	1000		Taxes 1000
Retailer losses	800		8% or 1.6 hand value
Wholesale price in Brazza		2000	6000 FCFA per boot (team observation)
Wholesale margin	200		
Transport cost	333		For a 3-speed boot
Wholesale losses	300		15% of the cargo
Price in Ouesso		1167	3,500 FCFA the bunch of 3 in Ouesso (informant)
collector margin	107		
Village transport	50		
Farmer price		1000	or 70,000 FCFA / tonnes (FAO Stat)
Peasant margin	450		
Banana production costs	550		Evaluated from source (1)

Table 8: Cost structure of plantain, from Sangha, at the Brazzaville market. Source: data collected by consultants

The margins of retailers are important because they finance and they take risks, bananas are often wasted because they are very perishable. The transport and storage infrastructure for production is deficient, which is the cause of significant losses. These structural causes could be circumvented by organizing and intensifying production as close as possible to cities where many spaces remain available. The major brake would then be land.

Another possibility would be to do upstream processing, for example crisps, which are much less perishable.

Transformation

There are artisanal transformations of Plantain bananas, for example in Brazzaville small workshops making banana chips. Bags of crisps can be found in some supermarkets. These are products suitable for urban consumption. However, the processing of plantains is mainly done directly at the level of families and restaurants (fries etc…).

Transport

Diets are transported either via road or via rail. The plantain is transported by all kinds of means, small or large vehicles in company or not other products. Brazzaville and Pointe-Noire are the main markets for plantains. There are wholesale markets where consumers and retailers source and secondary markets of retailers.

Marketing

Banana marketing corresponds to only ¼ of production (RC, 2018). Some producers sell directly to the markets by providing transport themselves, others have family relationships with saleswomen in town who cover the cost of transport, others use collectors or better organized producers, who then take care of the marketing for them.

5. Environmental and Social Risk Analysis

Risks	***Reduction measures***
Environment	
Pollution linked to inputs agricultural pesticides and fertiliz (industrial agriculture) Deforestation and Degradation forests Increase in poaching	• The government is investing in research and extension for second generation agriculture with reasoned use of inputs, thrifty and agroforestry. • Anti-poaching, erosion control method
Social	
Political instabilities that affect prices to producers and all the CDV No mastery of foreign labor	• Guarantee national cohesion and unity • Control and management of foreign labor
Economic	
Fall in production due to the absence of technical support.	• Support research and extension to support farmers.

8. Conclusion

The plantain value chain deserves the attention of the public authorities because of the domestic market which is partially covered by national production, and the multiple possibilities of improving the incomes of the various actors at all levels of this value chain. It is a priority for the government to ensure food security, the development of employment but also at a more macro level, to participate in the diversification of income for the national economy and improve the trade balance. Plantain is a speculation and has been selected under the PND to support the diversification of the economy. The Government should mobilize adequate resources to support projects relating to this program.

9. Main bibliographic sources

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General Conclusions

The Congo has about 270,000 farms, mainly households, which practice family farming mainly for subsidence. From 2002 Nephew[6]questioned the capacity of small family farming to survive globalization and announced that the majority of these farms in developing countries risked not surviving there. The Congolese peasantry finds itself, for the moment, alone, both in the face of this globalization and in the face of the peasantry of neighboring countries and finally, perhaps tomorrow it will find itself for certain products facing competition from large funded agricultural farms. by foreign companies or elites located in Congo.

Thus on the world side, Congolese farmers are, with their hoes, in direct competition with industrial agriculture (machinery, selected seeds, pesticides, fertilizers) very competitive, often subsidized, often located on other continents (Americas, Europe, Asia) ; these products are distributed in the city in frozen form or as finished products, depriving the Congolese peasant (e) of access to the urban middle class market. The Congolese peasantry is still in competition with Cameroonian peasants who benefit from support, agricultural programs and better organized sectors than in the Congo; this support still exists in Cameroon despite past structural adjustments. Cameroon has been less affected than the Congo by the "Dutch syndrome" (see history of the Congo above).

[6]Neveu A., (2002), Can small peasant agriculture survive globalization? Economic problems: 15-19

The prices of foodstuffs on the local urban markets therefore adjust to the low capacity to pay of the small townspeople; family farms are also not encouraged to produce and most of the production is self-consumed.

There are exceptions, some regions have benefited from support programs such as market gardening around cities (Brazzaville) or the Pool department, where there were more efficient farms in the past; but the latter is struggling to come out of the disorganization caused by the unrest and violence of recent years.

Insufficient support in the form of services to farmers seems to be the main constraint to the development of the above-mentioned value chain common to value chains in Congo and this lack of support results in:

- Difficulty accessing credit
- Insufficient technical supervision
- Lack of improved plant materials; we have seen for cassava that the productivity was 6 to 8 t / ha / year in Congo (ADF, 2018) while the elite clones of IITA can reach 50 t. Access to this plant material requires technical supervision, applied research and access to the above credits.
- Management of crop diseases (especially cassava, cocoa and bananas)
- The lack of small mechanization suitable for both crops and product processing.
- Damage and predators (rats, birds and wild animals)
- Lack of manpower
- Transport problems