Africa LEDS Project:
Côte d'Ivoire Final Report

REPUBLIQUE DE COTE D'IVOIRE

Union Discipline Travail

September 30, 2019

Prepared by

The Center for Climate Strategies

With Support from the European Commission, the United Nations Environment Programme, the LEDS Global Partnership and the Africa LEDS Partnership

Acknowledgments

The Center for Climate Strategies (CCS) would like to thank all of Côte d'Ivoire's Africa Low Emissions Development Strategies (Africa LEDS) project team members for their contributions to the projects in the field, as well as their invaluable input and attentiveness during workshop and remote training sessions. The team included over two dozen staff from government ministries, universities, and non-government organizations.

Professor Véronique Yoboue led the work of the energy sectors team (Université Félix Houphouët-Boigny). This team also included Sylvain Gnamien N'Douffou Konan (also of the Université Félix Houphouët-Boigny) and Ange Benjamin Brida (Ministry of Environment and Sustainable Development). The resource sectors team (agriculture and forestry) was led by Professor K. Ignace Kouassi and Jean Claude Konan both of the Université Nangui Abrogoua. The socio-economic assessment team was led by Dr. Tite Becket (CIRES) and Jean Claude Koya (Ministry of Planning). CCS support staff on the project included Stephen Roe, Thomas Peterson, Arianna Ugliano, Scott Williamson and Holly Lindquist.

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Acronyms & Abbreviations

Africa LEDS	Africa Low Emissions Development Strategies (Program)
ANADER	National Agency of Support to Rural Development of Côte d'Ivoire
BAU	business as usual
CBA	cost-benefits analysis
CCS	the Center for Climate Strategies (USA)
CE	cost effectiveness
CFA	Central African Franc
CH_4	methane
CO_2	carbon dioxide
EU	European Union
EX-ACT	Ex-ante Carbon Tool
EX-ACT VC	Ex-ante Carbon Tool – Value Chain
FOLU	forestry & other land use
GDP	gross domestic product
GIS	geographic information system
GHG	greenhouse gas
GRP	gross regional product
GWP	global warming potential
Ha	hectare
INDC	Intended Nationally-Determined Contribution (to the Paris Accord)
IPCC	Intergovernmental Panel on Climate Change
IRR	internal rate of return
MINEDD	Ministry of Environment and Sustainable Development of Côte d'Ivoire
kg	kilogram
km	kilometer
LEAP-IBC	Long-range Energy Alternatives Planning – Integrated Benefits Calculator (tool)
LEDS	low emissions development strategies
LPG	liquefied petroleum gas
N_2O	nitrous oxide
NDC	Nationally-Determined Contribution (to the Paris Accord)
NPV	net present value
PS	project (or program) scenario
QA	quality assurance
t	metric tons (tonnes)
Tg	teragram (one million metric tons)
tCO_2e	tonnes of carbon dioxide equivalent
UNEP	United Nations Environment Program
USD	United States Dollar
yr	year

1.0 Overview

The Africa Low Emissions Development Strategies (Africa LEDS) Project was implemented to improve the analytic capacity within institutions in 7 partner countries across the African continent to inform and scale-up low carbon action, support implementation of Nationally-Determined Contributions (NDCs), and other related decisions and policies in sustainable development. The Africa LEDS Project was funded by the European Commission and implemented in partnership by the United Nations Environment Programme, the LEDS Global Partnership and the Africa LEDS Partnership. One of these countries, Côte d'Ivoire, received capacity development assistance from the Center for Climate Strategies (CCS) as technical and capacity building expert.

The capacity of a local planning team to design and assess low emissions development strategies (LEDS) was developed through learning-by-doing exercises based on actual on-the-ground projects. The three Africa LEDS project components were:

(1) LEDS Planning and Implementation Support

(2) LEDS Modeling Support

(3) Peer Learning and Exchanges

CCS' support to the Africa LEDS Project Team in Côte d'Ivoire (the "local team") began with a workshop devoted to understanding key LEDS planning concepts, including baseline development, direct (microeconomic) impacts analysis of LEDS project or program[1] implementation, and indirect (macroeconomic) impacts analysis of LEDS project/program implementation. Also, during the workshop, available models or other analytical tools were reviewed to support LEDS planning. The local team identified three models that would be the initial focus for adoption into a linked modeling system for LEDS planning in the country (details of the modeling system are provided in Annex A). Components of the modeling system were applied to analyze two pilot programs initiated to improve the rice value chain. Rice is already key crop in the country and is expected to be expanded significantly in the coming years to reach the country's goal of becoming self-sufficient in rice production.

This report summarizes the application of the Côte d'Ivoire LEDS Modeling System by the local team to assess the physical, economic, and financial costs and benefits of implementing key activities in the rice value chain. The analyses were done at the level of the actual pilot projects conducted, and then these results were scaled to the national level to inform national planning. In addition to the assessment of societal costs and benefits (direct and indirect) which are central to LEDS planning, the results reported here also include a financial analysis for one of the pilot projects in order to identify key LEDS implementation support issues, including financial support mechanisms. As will be shown in this report, with this initial focus on the rice value chain, Côte d'Ivoire's Africa LEDS activities addressed three of the highest emitting sectors in the country: agriculture; energy demand; and the forestry and other land use (FOLU) sector.

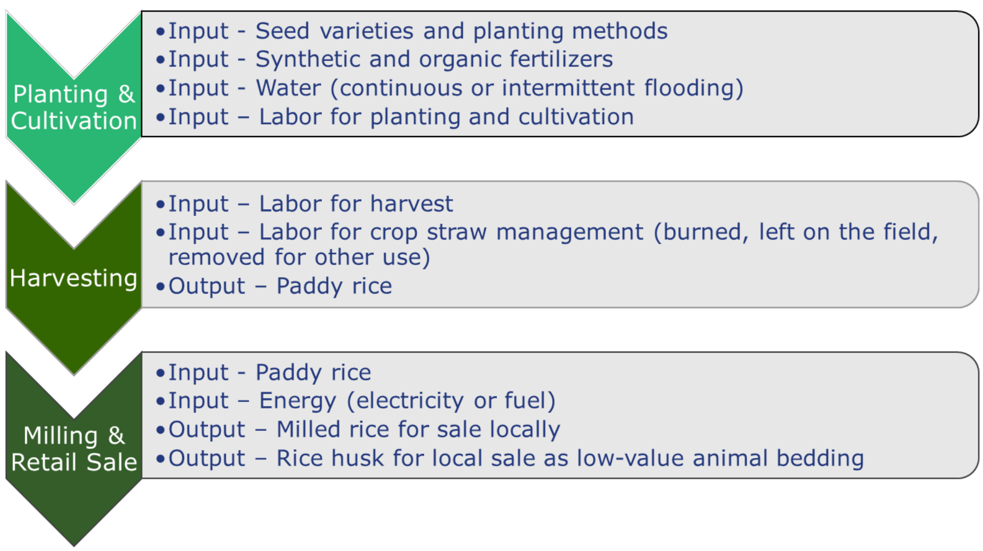
[1] In this report, a LEDS "program" can be thought of as a collection of individual projects implemented throughout a local area or as scaled-up to the country level.

2.0 The Rice Production Value Chain

Côte d'Ivoire's agriculture sector and energy demand for cooking fuel wood contribute to deforestation in a country with one of the highest rates of deforestation in the world. To support reductions in deforestation, reduced emissions and broader development goals, the Africa LEDS activities in Côte d'Ivoire focused on replacing cooking wood fuel with rice husk briquettes (Pilot 1) and broader climate smart agriculture for rice production (Pilot 2). These activities provide a clear link between the energy, agriculture and FOLU sectors allowing for synergies across the sectors and aligning with broader objectives under the Africa LEDS Project. Through displacement of fuelwood and charcoal with rice husk briquettes, demand on local forests for biomass is reduced which reduces forest degradation. Climate smart practices applied to rice cultivation can not only reduce emissions associated with cultivation, but can also increase crop yields, which reduces the need for additional cropland that often results in deforestation.

Figure 2.1 below provides a basic overview of the rice value chain for small producers[2] consistent with the study area for the pilots in the region of Gagnoa (see map below). As described further below, the pilots address activities in all 3 phases of production.

Figure 2.1. Typical Small-Producer Rice Value Chain



The local team carried out two separate pilots addressing the rice value chain (see Annex B for details on the field activities carried out by the local team). For Pilot 1, the local team worked to enhance the value of an agricultural by-product (rice husk at the rice mill) in order to increase local economic opportunities, while reducing greenhouse gas (GHG) emissions. The team worked with the local rice mill operator in the town of Gagnoa (see Figure 2.2) to assess the added value to her business for an ongoing rice husk briquetting process. The rice husk produced by the mill has been either open burned as a waste material or given away/sold as low value animal bedding. Early attempts to produce cooking fuel briquettes directly from rice husk proved unsuccessful, since those briquettes produced too much smoke and ash. Recently, the mill operator added a rice husk pyrolizer (carbonizer) to the process to produce a material that had

[2] "Small production rice" as referred to in this report is the collection of farmers and rice mill operators with milling capacity of < 2 metric tons/day of paddy rice.

performance characteristics much closer to the wood and charcoal that it would offset if accepted in the local cooking fuel market (see Figure 2.3).

Figure 2.2. Location of Gagnoa in Southwest Côte d'Ivoire

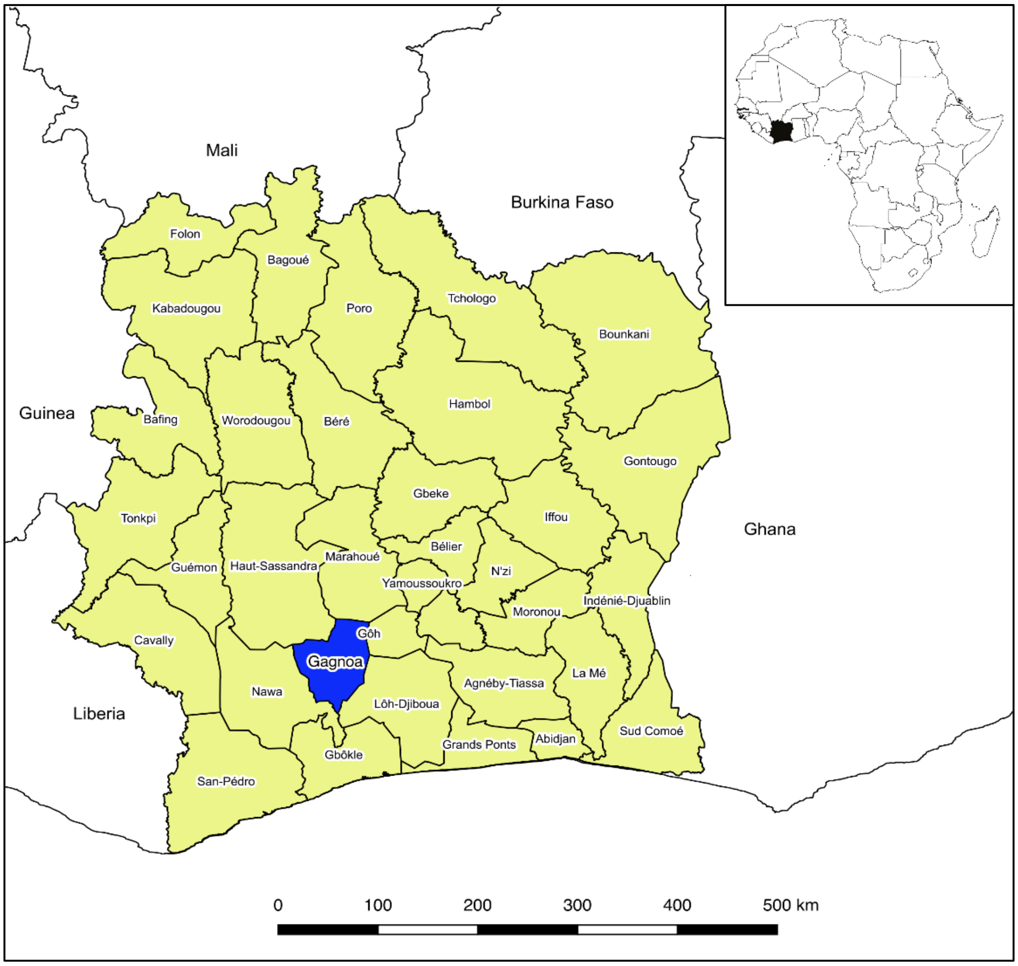


Figure 2.3. Rice Husk Briquettes. Left top: pile of rice husk behind the rice mill; Right top: rice husk carbonizer; Left middle: original dried husk biomass briquette without carbonization (pyrolysis); Right middle: briquettes using carbonized rice husk (these burn cleaner and produce more energy per unit of mass); Left bottom: motorized briquette press; Right bottom: drying of briquettes in a greenhouse.

The benefits of Pilot 1 include positive local economic impacts (increased revenue for the mill operator, new jobs for rice husk briquette production), reduced reliance on unsustainable cooking fuel supplied (e.g. local firewood and charcoal, liquefied petroleum gas or LPG), and the following GHG benefits:

- Direct emissions reduction from local switching of cooking fuels: especially to the extent that local users switch from LPG;

- Indirect emissions reduction from lower demand on forest biomass: BAU harvests for firewood and charcoal production are not sustainable.

Pilot 2 was carried out at rice growing locations in the Gagnoa area (Tipadipa and Tiétiékou). Figure 2.4 shows the locations of the two climate smart cultivation pilots.[3] In these pilots, local farmers received training in rice cultivation methods that were designed to achieve multiple benefits, including:

- Reduced GHG emissions: a switch from continuously-flooded cultivation to intermittent flooding reduces emissions of methane (CH_4) on the field;
- Composting of crop straw and animal manure, and then application of the compost back to the field: this displaces chemical fertilizer and avoids of agricultural burning. Therefore, GHGs emitted directly from crop straw burning on the field are avoided and indirectly GHG emissions from the production and transport of chemical fertilizers are also avoided along with the costs of these fertilizers;[4] and
- Use of higher quality seedlings and planting methods: to increase crop yields and reduce pressure on land conversion for rice production.

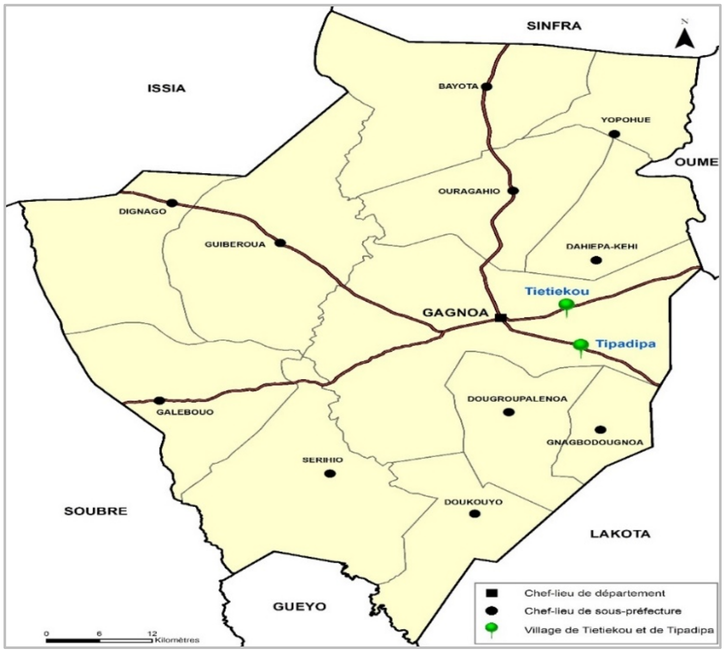
By surveying about 100 households and restaurants, the Africa LEDS Project team confirmed that the current market sentiment is that rice husk briquettes have a low energy capacity and poor combustion characteristics. Therefore, local marketing strategies need to be developed and implemented in order to gain wider acceptance by the public. The project team supported this by completing a socio-economic cooking test study which initiated better local market acceptance and also determined that briquettes are best used in specific types of cook stoves. The project team also assessed the cash flows in a business plan analysis. These cash flows covered those for the rice mill operator for adding in the rice husk briquetting process as compared to business as usual (BAU) treatment of rice husk as low value animal bedding or waste material. These issues are explored in more detail in Section 5 of this report.

For Pilot 2, the Africa LEDS team started by assessing the BAU situation of rice farming and determined that growers use inorganic fertilizer and dispose of rice by-products (crop straw) through open burning. A second BAU study, based on interviews with 75 farmers, was also completed to inform them about climate smart agriculture activities within the rice sector. These data were also used for the impacts modeling elaborated in Section 4 of this report.

Figure 2.4. Locations of the Smart Rice Cultivation Pilot Studies

[3] Total area = 150.5 hectares (Ha); one 89.5 Ha plot and another at 61 Ha.

[4] For the purposes of analysis of GHG impacts, it was assumed that the levels of nitrogen application were the same whether by chemical or compost application. This issue requires more analysis by the team. Also, the forms of nitrogen in both cases could lead to potentially more GHG reduction to the extent that nitrogen in the compost is in a more stable form. Also, application of compost could lead to greater levels of accumulation of soil carbon, which indirectly sequesters CO_2 from the atmosphere. This is another potential GHG benefit that requires further analysis by the team.



Building on the studies for Pilot 2, the team identified rice producers in two communities approximately 20 kilometers (km) east of Gagnoa and worked to educate the farmers on climate-smart agriculture through demonstrations of agricultural practices and trainings. Figure 2.5 shows a typical (BAU) flooded rice cultivation plot with rice straw burning residue in the foreground and photos of the pilot program rice seedling nursery, farmer training, and transplantation of improved seedling varieties. Climate smart practices included: a switch from continuously-flooded irrigation systems to intermittent flooding systems (for reduction of methane emissions); composting of crop straw and animal manure for displacement of chemical fertilizer and avoidance of agricultural burning; and the use of higher quality seedlings and planting methods (increased yields).

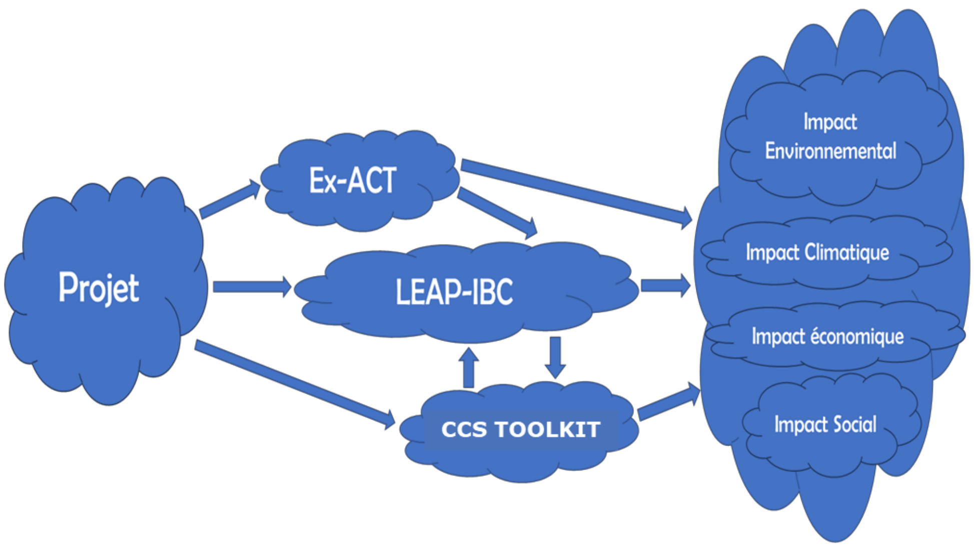
The team held development training sessions focused on water management and water infrastructure as well as low carbon planting and cultivation techniques. The Africa LEDS team also trained rice farmers on composting as well as two water management and two rice marketing committees to carry this work and ongoing training forward after the completion of the Africa LEDS Project.

Figure 2.5. Pilot 2 Demonstration Site Photos. Left top: BAU flooded rice cultivation plot in the background; burned remnants of crop straw from previous harvest in foreground. Right top: nursery seedlings of higher quality rice strain prior to transplantation. Left bottom: training session with local farmers. Right bottom: transplanting of higher yielding seedlings with appropriate spacing. Not shown in these photos: composting of rice straw with manure and application back to the field.

3.0 Integrated Modelling Platform for Societal Cost-Benefit Analysis

To assess energy, emissions, and economic impacts for the two pilots described in Section 2, the Côte d'Ivoire team designed and applied an integrated modelling system shown in Figure 3.1 below. More details can be found in Annex A. Modelling was conducted to assess the costs and benefits for each pilot, as well as for both pilots if implemented together. The modelling system includes the following tools: *LEAP-IBC* (Long range Energy Alternatives Planning – Integrated Benefits Calculator); *EX-ACT* (Ex-ante Carbon Tool); *Microeconomic costs and Macroeconomic Assessment Tools from the Center for Climate Strategies* analytical toolkit (CCS toolkit); and a geographic information system (GIS as a data source for the other tools in the modelling system).

Figure 3.1. Modelling Tools Selected for the Côte d'Ivoire LEDS Modelling System



As indicated in Figure 3.1, the energy model built within LEAP-IBC serves as a central tool to conduct direct (microeconomic) impacts analysis with linkages to other tools. The EX-ACT tool is used to assess non-energy, such as forest carbon and crop production emissions, and can also be used to analyze the direct costs for implementing a project or program. Over time, the Team will build linkages between EX-ACT and the LEAP-IBC model, so that both energy and non-energy impacts can be summarized within a combined LEAP-IBC model.

Tools within the CCS toolkit were also be selected to fill additional gaps for modeling net direct societal costs and benefits and assessments of the potential for positive macroeconomic (indirect) impacts. The first of these is an MS Excel-based tool referred to as the CCS Cost-Benefit Analysis ("Societal CBA") tool. This tool was selected to fill the following needs:

- Learning tool: the pilot program analyses address all pilot program impacts and costs, including those associated with energy supply/demand and resource management. This allowed the local team to see a complete build-up of net impacts and costs across the rice production value chain. Users can view each input and trace the calculations of every stream of energy, resources, emissions and cost impacts;

- Quality assurance (QA) tool: given its transparent nature, the tool allows members of the local team to compare their results to a separate analysis to de-bug any issues with set up or application of the model built with LEAP-IBC or EX-ACT; and
- Assessment of potential macroeconomic impacts: within the CCS CBA tool, a semi-quantitative tool used to assess the potential for positive macroeconomic impacts (growth in gross regional product) was incorporated. This functionality allows the local team to assess whether the project or program being analyzed is expected to have positive macroeconomic impacts based on the results of the microeconomic impacts assessment.

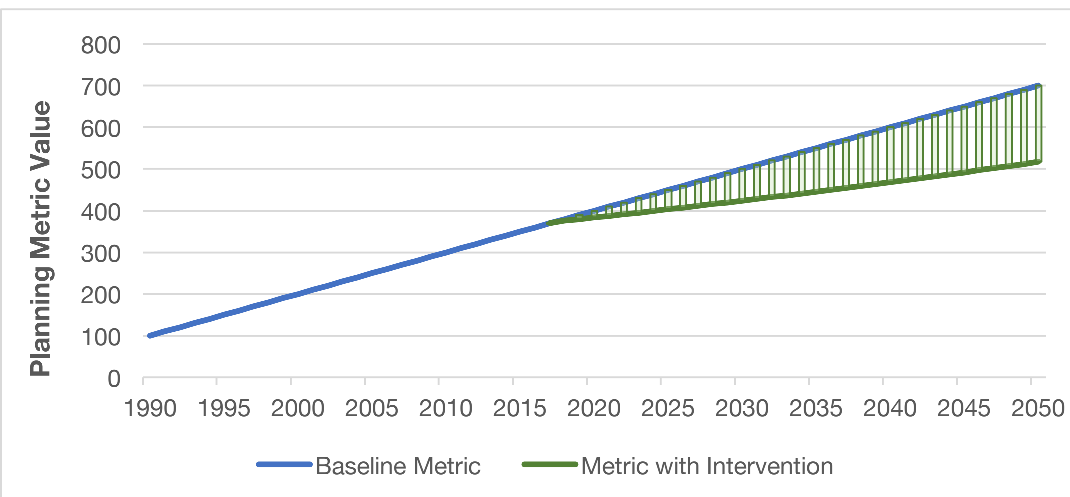
Annex A contains more details on the integrated modelling system including example screenshots.

4.0 Societal CBA Modelling Approach and Results for Rice Value Chain Improvements

This section provides a summary of the approach to modelling the net societal benefits and costs for the two pilots described in Section 2. Each is presented separately, and then the results of an analysis of the combined impacts is presented. It should be noted that these rice value chain improvements apply to small growers and rice mills (e.g. less than 2 tons of paddy rice milled/day). For the rice mill pilot in particular, the application of a briquetting process may not be relevant, since rice husk is often used for other purposes (e.g. as a fuel for drying incoming paddy rice). Although it is referred to as "Pilot 2" in the project, the application of climate smart rice cultivation practices is presented first, since it naturally precedes what happens at the rice mill (the focus of Pilot 1) in the rice value chain.

Societal CBA is done using a scenario-based approach, sometimes also referred to as "baseline shift analysis". This approach involves constructing a baseline for any metric (e.g. energy use, resource consumption, emissions). The baseline often includes historic data as well as a constructed BAU forecast for the metric which factors in future growth of the metric without any interventions (e.g. energy efficiency measure, change in resource management, etc.). Once the baseline is constructed for the planning metric, then the change in the forecasted values for the metric are quantified based on the design of the intervention (e.g. reduction in energy use per unit production, increase in yield, etc.). Figure 4.1 provides a simple representation of baseline shift analysis. The baseline values for the planning metric are represented by the top (blue) line in the chart. The values for the metric after implementation of the LEDS intervention measure are shown in the green line. The shaded bars in between indicate the annual benefit of implementation of the LEDS measure

Figure 4.1. Baseline Shift Analysis



For any year of the planning period, the net change in the value of the planning metric is calculated based on the following generic equation:

$$\text{Net Change} = \text{PS} - \text{BAU}$$

where:
Net Change = annual net value of any energy, resource, emissions or cost metric
PS = annual value of the metric under the project/program scenario
BAU = annual value of the metric under business as usual conditions

The same generic equation is used to evaluate the change in physical impacts of project/program implementation (e.g. energy, resources, emissions), as well as the net costs for implementation. The following sections demonstrate how this approach to societal CBA was applied to the two rice value chain pilots.

4.1 Application of Climate Smart Rice Cultivation Practices

4.1.1 Physical Impacts – Energy, Resources and Emissions

BAU rice cultivation methods rely on a system where standing water is always on the field ("continuous-flooding"). This creates an anaerobic environment conducive to methane (CH_4) formation and release to the atmosphere. Also, chemical nitrogen fertilizers are often used to enhance yields. Small growers also often do not have access to the best rice seeds/seedlings for their region and may not know the best planting techniques (e.g. spacing) to obtain the best yields. Finally, after harvesting the paddy rice, the remaining crop straw is often managed by burning, which does not replenish the soil and causes GHG emissions.[5]

The climate smart rice cultivation pilot includes several changes to the BAU system designed to enhance yields while reducing GHG emissions. First, rather than continuous-flooding, an intermittent-flooding irrigation regime is used. This reduces the amount of time that the soil is subject to anaerobic conditions and lowers CH_4 emissions. Improved seedlings and planting techniques were provided to the farmers involved in the pilot (and other more local farmers were trained in the techniques). Rather than burning the crop straw, it was composted along with animal manure and re-applied to the field.

Initial pilot results showed a 90% reduction in the need for chemical nitrogen fertilizers[6], while paddy rice yields increased by a factor of 2.5.

The first step in conducting a societal cost-benefit analysis (CBA) is to identify the changes to the BAU system targeted by the intervention. Ultimately, since GHG emissions are a key metric of LEDS programs, then there is a need to identify each of the changes that result in a GHG effects (increase or decrease in GHG emissions). These changes could be any of the following:

- Change in energy production;
- Change in energy demand;
- Change in inputs to a system (e.g. fertilizers, other consumables); and
- Change in system management (including those that impact natural carbon stores).

It's helpful to display and document each of the project/program impacts and the subsequent GHG effects in a causal chain. Figure 4.2a and 4.2b provide a causal chain for the climate smart rice cultivation pilot. Each of the colored boxes represents a GHG impact. The star symbol represents an impact that is considered significant and needs to be quantified.

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[5] GHG emissions include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O); however, the CO_2 is typically treated as carbon neutral and not included in the overall GHG emissions expressed in carbon dioxide equivalents (e.g. tonnes of carbon dioxide equivalent; tCO_2e).

[6] Since nitrogen is still being added back to the soil with the compost, the potential change in N_2O emissions associated with avoiding chemical fertilizers is currently unclear and requires further investigation. The form of nitrogen in the compost may be more stable than nitrogen from chemical fertilizers which could lead to N_2O reductions. Regardless, the GHG emissions avoided from the production and transport of chemical fertilizers is still significant (although this occurs outside of the Gagnoa region and mostly outside of the country).

Figure 4.2a. GHG Causal Chain for the Climate Smart Rice Cultivation Pilot

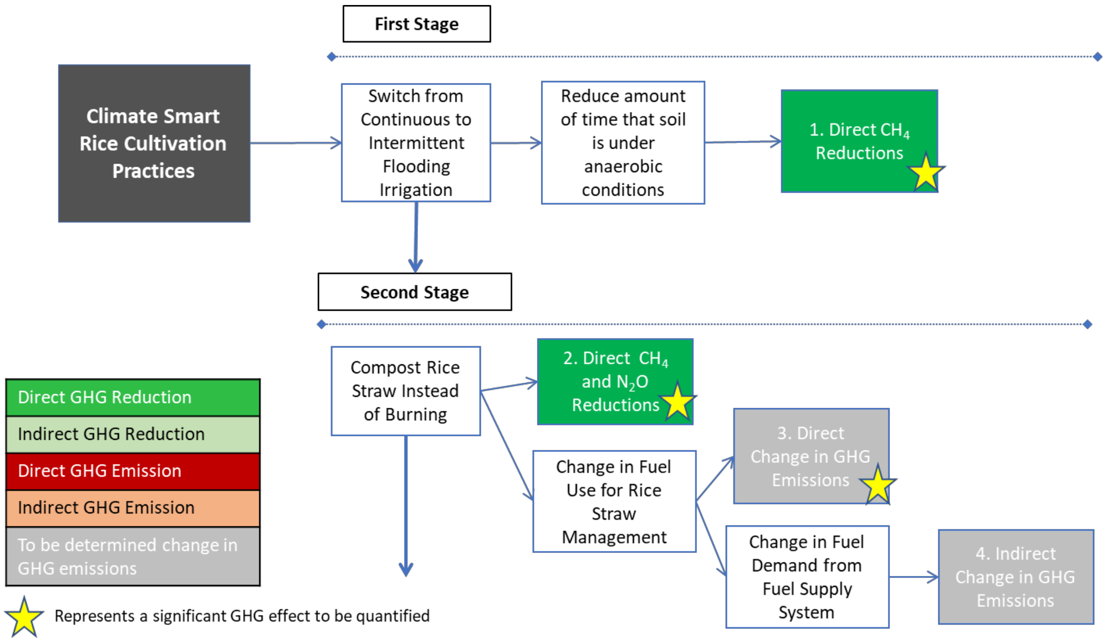
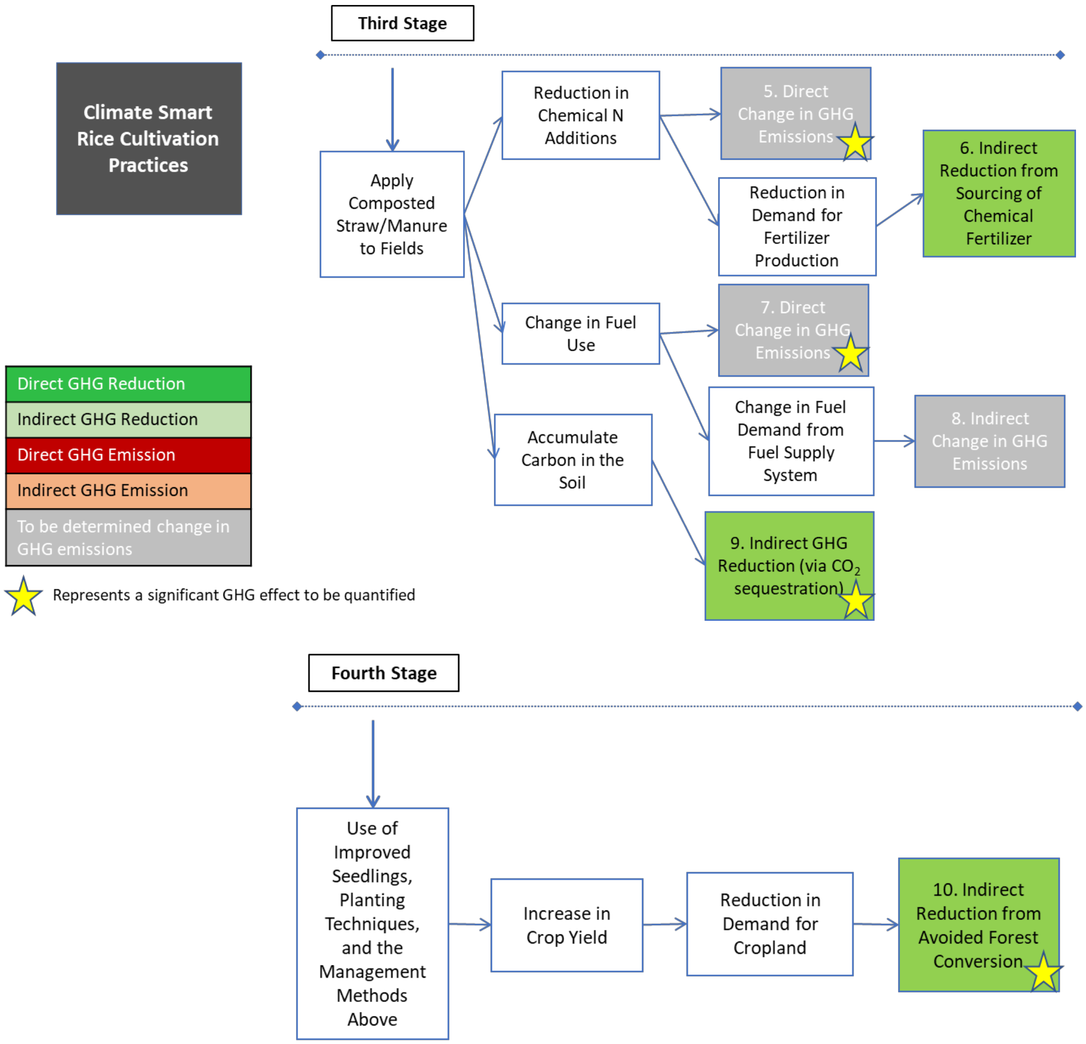


Figure 4.2b. GHG Causal Chain for the Climate Smart Rice Cultivation Pilot (continued)



In Figure 4.2a, the first stage of the chain addresses the change in irrigation described previously that results in direct CH_4 emission reductions (GHG Impact #1). The second stage covers the change in management of crop straw. The change from BAU management by burning on the field to the pilot scenario where the crop straw is removed from the field and composted with manure. The reduction in crop burning leads to GHG Impact #2, which is the reduction of CH_4 and N_2O emissions. The local team did not identify any change in fuel use associated with this stage (i.e. this is all hand labor), so there is no expected GHG impact. These are GHG Impacts #3 and #4 in the causal chain. The first of these represents the change in emissions for fuel combustion between the BAU and pilot scenarios. GHG Impact #4 refers to GHG emissions that are increased/reduced indirectly as a result of higher/lower fuel demand (e.g. oil extraction, processing and transport). Since these types of upstream emissions occur outside of the Gagnoa region, they have not been considered significant enough to include in the analyses of this LEDS project.

Figure 4.2b provides the third stage of the causal chain where the composted crop straw is returned to the field prior to planting. To the extent that total nitrogen additions are reduced (both chemical and organic), then one would expect a reduction in N_2O emissions (GHG Impact #5). Reports from the field indicated a

90% reduction in the amount of chemical nitrogen applied; however, it is unclear whether the total amount of nitrogen applied has decreased (field data are still lacking as to the nitrogen content of the compost and the amount applied to the field). In addition, changes in the form of nitrogen applied could lead to lower rates of nitrogen loss. Some of the nitrogen in compost is organic nitrogen which requires mineralization to inorganic forms (ammonium and nitrate), before it can be taken up by plants (and is therefore not available to take part in the soil denitrification which releases N_2O). Additional research is needed by the local team to determine the size and direction of any N_2O shifts caused by the addition of compost. It is clear that any reduction in chemical nitrogen use will lower demand for these fertilizers which will indirectly reduce emissions from fertilizer manufacturing and transport (GHG Impact #6). However, these reductions will occur outside of the Gagnoa region and likely outside of the country. So, they won't be included in the analysis.

As with the composting process itself in Stage 2, the application of the finished compost in Stage 3 could involve an increase from BAU in the use of fuels. However, the local team found that this work was all done by hand. So GHG Impact #7 is not considered significant. Keeping with the above-mentioned conventions on the treatment of indirect GHG emissions for the fuel supply chain, these impacts won't be included in the analysis (GHG Impact #8).

GHG Impact #9 covers the build-up of carbon in the soil which represents an indirect sequestration of carbon from the atmosphere. This results from the addition of composted rice straw and manure.

Finally, the application of the management techniques mentioned above combined with improved seedlings and planting techniques should result in significant improvements in crop yields. Initial findings from the field indicate that paddy rice yields increased by a factor of 2.5. As a result of these higher yields, there will be lower demand for new land to be devoted to rice cultivation (as the country continues to push towards its goal of self-sufficiency in rice production). Under BAU conditions, that new land would have come from conversions of forested land. Therefore, there is a forest carbon benefit listed as GHG Impact #10. This includes the one-time loss of forest carbon from clearing, as well as the continued future losses of annual CO_2 sequestration that would have occurred on those cleared lands.

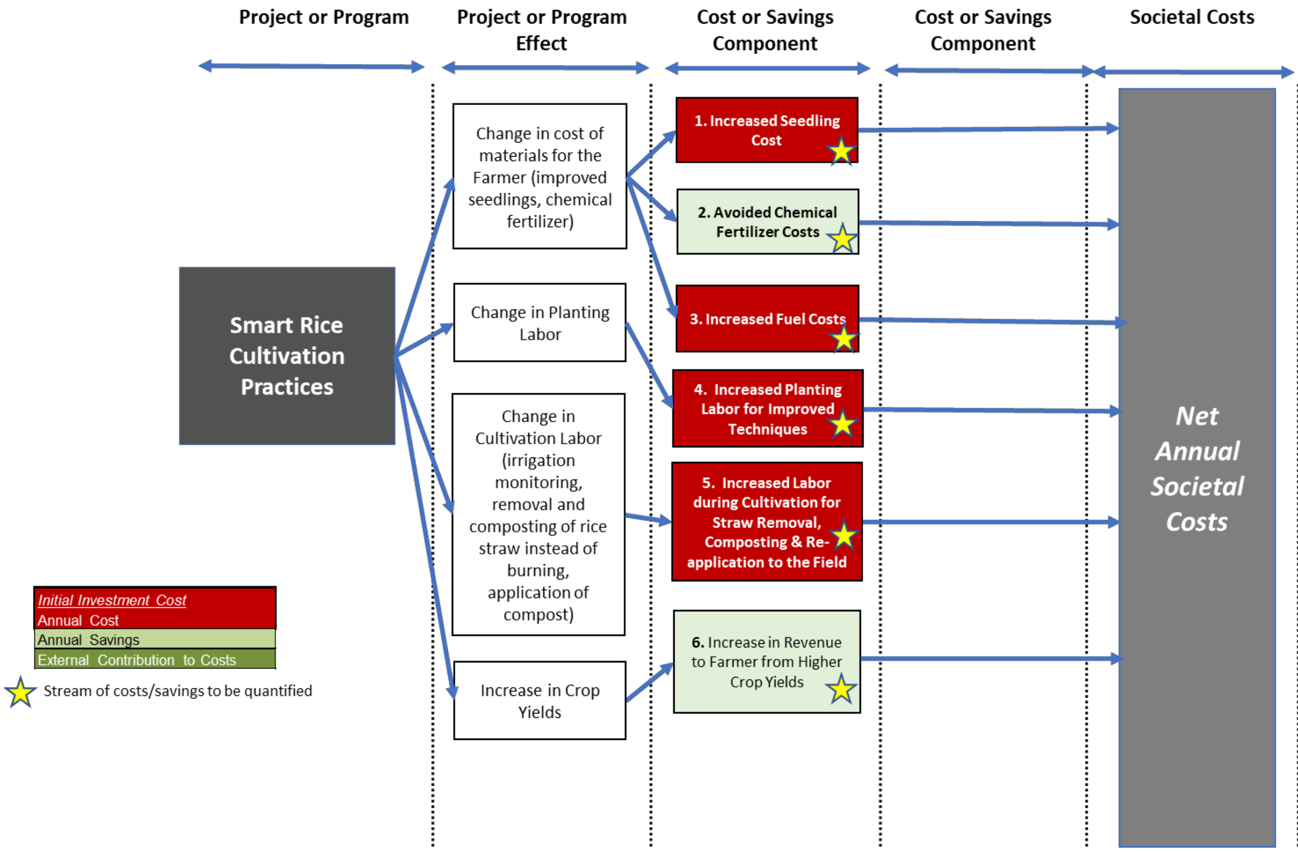
4.1.2 Direct Costs and Savings of Implementation

Direct costs and savings for implementing the smart rice cultivation practices do not include any one-time investments in equipment, lands, etc.; however, there are a number of changes in the annual costs of cultivation. These include: higher costs for improved seedlings (either purchased or self-produced); increased labor costs during planting; increased labor to remove rice straw from the field, compost it with manure and re-apply it to the field; and potentially higher fuel costs (to the extent that equipment are used during rice straw management).[7] There are also savings from lower use of chemical nitrogen fertilizers, and an increase in farmer income due to the higher yields obtained. Figure 4.3 provides a net societal costing chain that summarizes all of the identified cost components. Each of the colored boxes represents an annual change in cost streams as a result of implementing the program. For each year of analysis, these costs and savings are summed to provide a net societal cost.

Figure 4.3. Net Direct Societal Costing Chain for Climate Smart Rice Cultivation[8]

[7] Although as indicated earlier, for the Gagnoa pilots, all planting, cultivation and harvesting was done by hand, so the fuel costs are zero for those pilots.

[8] Note that this costing chain does not include government/institutional technical support costs which are an important component of the pilot program. These costs were added into the analytical results presented later in this report.



The first three cost components relate to the change in costs for farmer material inputs when converting from BAU cultivation techniques to climate smart cultivation. These include higher costs for improved seedlings, a savings for reduced chemical nitrogen fertilizer application, and a higher cost for fuels to the extent that mechanized equipment is needed to remove crop straw from the field, compost it, and re-apply the compost to the field (for the Gagnoa pilots all work was done by hand).

Cost component #4 is the increase in the cost for labor associated with improved planting techniques. Component #5 addresses the increase in labor costs for removing crop straw from the field for composting (instead of BAU straw burning on the field), composting the material with manure,[9] and re-applying the composted material to the field. Finally, cost component #6 covers the increased revenues to the farmer for the expected higher yields for paddy rice.

Not included in the costing chain above are the government/institutional costs for carrying out the training programs for local farmers. If these can be quantified by the local team, then they should be added to the total societal costs. Also, there may be work required by local farmers on irrigation systems to better support intermittently-flooded cultivation practices (especially for low land rice systems). The cost of labor and materials for these improvements should also be added to future estimates of total net societal costs.

[9] Note that there could also be a cost associated with purchasing/transporting livestock manure to the composting site; however, no costs were identified for the Gagnoa pilot.

4.1.3 Results of the Microeconomic Analysis of the Climate Smart Rice Cultivation Pilot

The microeconomic (direct) impacts analysis is documented below. The first subsection addresses the approach and results for physical impacts, including energy production/consumption, resource consumption/change in management (e.g. crop straw management, chemical nitrogen fertilizer), and GHG emissions. The second subsection provides the assessment of net direct costs/savings, including the calculation of the cost effectiveness for the pilot. Cost effectiveness (CE) is a metric that indicates the total societal cost/savings to reduce one metric ton of CO_2 equivalent emissions. See Annex C for the detailed inputs used for calculating the physical impacts and net direct implementation costs for the pilot.

Physical Impacts

The first step in assessing the physical impacts for the pilot is to review each of the project impacts noted in the GHG causal chain above in Figure 4.2. Each of these impacts needs to be assessed for data input requirements related to energy, resources and emissions affects. For example, in the first stage of the chain, there is a switch from continuous to intermittent flooding. In the case of the pilot program, all of the irrigation is gravity-fed, so there is no change in energy for pumping water. The only expected change is in the amount of CH_4 released for these two irrigation regimes. Hence, reliable emission factors are needed from either International Panel on Climate Change (IPCC) guidance or the literature. Annex C provides all of the data input requirements identified for the physical impacts analysis. Using these inputs, the CCS CBA Tool is set up to calculate annual values for each of the metrics required to assess GHG emissions, as well as to support the direct net societal cost analysis presented in the next subsection below.

Table 4.1 provides the BAU values for each of the metrics needed to support the direct impacts analysis. Values are calculated annually, but only values at five-year increments are shown. After the year, the next column begins with the key planning variable that drives the rest of the analysis. Because the pilot addresses a change to land management, the variable is the area of the pilot project. There is a total of 100 hectares (Ha) shown which is the total of the two 50 Ha pilots. The value is the same in each year, including the sum, since these values aren't cumulative. During BAU cultivation conditions, each of the succeeding columns shows the total chemical nitrogen fertilizer applied, total crop straw burned, total GHG emissions from crop straw burning, N_2O emissions from nitrogen additions, CO_2 sequestered in the soil, and CH_4 from continuous-flooding. Soil carbon sequestration is estimated to be zero during BAU conditions, since crop straw is burned and there are no other carbon inputs to the soil.

Table 4.1. BAU Direct Impacts Summary for Climate Smart Rice Cultivation

Conditions habituelles: énergie, émissions et matériaux BAU: Energy, Materials & Emissions							
	Zone de culture	**Engrais azoté chimique appliqué**	**Paille de riz brûlée**	**Émissions de méthane et oxyde nitreux provenant de la combustion de la paille**	**Émissions d'oxyde nitreux des ajouts d'azote**	**Séquestration du carbone dans le sol**	**Emissions de méthane provenant de la culture du riz**
	Crop Area	Chemical N Fertilizer Applied	Rice Straw Burned	CH4 + N2O Emissions from crop residue burning	N2O Emissions from nitrogen additions	Soil carbon sequestration	Methane emissions from rice cultivation
An Year	**Ha**	**kg N**	**kg**	**kg CO_2e**	**kg CO_2e**	**kg CO_2**	**kg CO_2e**
2019	151	14,147	312,127	19,341	18,220	0	657,384
2020	151	14,147	312,127	19,341	18,220	0	657,384
2025	151	14,147	312,127	19,341	18,220	0	657,384

2030	151	14,147	312,127	19,341	18,220	0	657,384
2035	151	14,147	312,127	19,341	18,220	0	657,384
2040	151	14,147	312,127	19,341	18,220	0	657,384
2045	151	14,147	312,127	19,341	18,220	0	657,384
2050	151	14,147	312,127	19,341	18,220	0	657,384
Somme	**151**	**452,704**	**9,988,071**	**618,901**	**583,026**	**0**	**21,036,288**

Table 4.2 provides the Project Scenario (PS) impacts summary. It is laid out in a similar format to the BAU summary; however, each of the GHG impacts are numbered to follow the GHG causal chain described above (see Figure 4.2) and the column for the amount of rice straw burned is not included (it is zero under PS). Also, a final column was added to show the impact of increased PS rice yields on reducing the need for new forest conversions that would have occurred under BAU to support growing demand for rice production.[10] Note that the values for this metric are much larger in the first year than in subsequent years. This is because all of the one-time losses of forest carbon that have been avoided as a result of higher rice yields have all been assigned to the first year. The subsequent years address just the loss of annual sequestration potential for the forest.

Table 4.2. PS Direct Impacts Summary for Climate Smart Rice Cultivation

An	**1. Emissions de méthane provenant de la culture du riz**	**2. Émissions de méthane et oxyde nitreux provenant de la combustion de la paille**	**3 & 7. Changement dans l'utilisation de carburant de la gestion de la paille de riz**	**5. Émissions d'oxyde nitreux des ajouts d'azote**	**9. Séquestration du carbone dans le sol**	**10. Réduction indirecte par conversion de forêt évité**
Year	1. Methane emissions from rice cultivation	2. CH4 + N2O emissions from crop residue burning	3 & 7. Change in fuel use from rice straw management	5. N2O emissions from nitrogen additions	9. Soil carbon sequestration	10. Indirect Reduction from Avoided Forest Conversion
	kg CO_2e	**kg CO_2e**	**kg CO_2e**	**kg CO_2e**	**kg CO_2**	**kg CO_2**
2019	341,840	0	0	18,220	(476,210)	(43,677,023)
2020	341,840	0	0	18,220	(476,210)	(726,731)
2025	341,840	0	0	18,220	(476,210)	(726,731)
2030	341,840	0	0	18,220	(476,210)	(726,731)
2035	341,840	0	0	18,220	0	(726,731)
2040	341,840	0	0	18,220	0	(726,731)
2045	341,840	0	0	18,220	0	(726,731)
2050	341,840	0	0	18,220	0	(726,731)
Somme	**10,938,870**	**0**	**0**	**583,026**	**(5,714,518)**	**(66,205,696)**

Table 4.3 provides a summary of the net change between the PS and BAU scenarios. The 150.5 Ha pilot program is expected to reduce 14,147 kilograms (kg) of nitrogen additions from chemical fertilizers each

[10] Note the one could have also included these as emissions under BAU, and then shown zero emissions related to forest carbon losses under PS. Either way, the total netting of emissions across all GHG effects needs to capture the avoided one-time loss of forest carbon stocks and the annual sequestration for those lands.

year, as well as avoid over 300,000 kg of rice straw burning. Over the entire planning period (through 2050), the program will avoid almost 80,000 tCO_2e in GHG emissions. The reason for the large reduction during the first year was noted above (one-time avoided loss of forest carbon due to reduced land conversion as a result of higher paddy rice yields). Also, soil carbon accumulation from compost additions is expected to last about 20 years before the soil reaches steady-state conditions, rather than the entire 30-year planning period.

Table 4.3. Net Direct Impacts Summary for Climate Smart Rice Cultivation

Changement net: énergie, matériaux et émissions Net Change: Energy, Materials & Emissions Change				
	Engrais azoté chimique appliqué	**Paille de riz brûlée**	**Conversion de forêt évitée**	**Total des impacts de GES**
An	N Fertilizer Use	Rice Straw Burned	Forest Conversion Avoided	Total GHG Impacts
Year	**kg N**	**kg**	**Ha**	**tonnes CO_2e**
2019	(14,147)	(312,127)	(90)	(44,488)
2020	(14,147)	(312,127)	0	(1,538)
2025	(14,147)	(312,127)	0	(1,538)
2030	(14,147)	(312,127)	0	(1,538)
2035	(14,147)	(312,127)	0	(1,062)
2040	(14,147)	(312,127)	0	(1,062)
2045	(14,147)	(312,127)	0	(1,062)
2050	(14,147)	(312,127)	0	(1,062)
Somme	**(452,704)**	**(9,988,071)**	**(90)**	**(82,637)**

Net Direct Societal Costs/Savings

As with the physical impacts assessment, the direct net societal cost analysis begins with an evaluation of costs that change between BAU rice cultivation and the pilot project scenario. The individual cost components were identified in Figure 4.2 above. Table 4.4 below provides a summary of the costs under the BAU scenario, while Table 4.5 provides the costs under the pilot program scenario. As indicated above, there are no initial investment costs. Rather, the cost changes represent differences in input and labor costs between the two systems. Also, based on field data, there are no changes in fuel consumption, since all planting, cultivation and harvesting activities are done by hand.

Table 4.5 presents the direct costs estimated for the pilot program. In addition to the higher costs for inputs and labor, the value of the paddy rice resulting from higher yields is shown. The change in net societal costs are then summarized in Table 4.6. These are derived by: 1. summing the BAU costs and the pilot program costs; 2. Subtracting total BAU costs from the pilot program costs to derive the net costs/savings in each year; and then 3. Discounting the annual stream of net costs/savings to present values (2019 Central African Francs or CFA). The sum of the stream of discounted net costs/savings is referred to as the net present value (NPV) of implementation costs (negative values indicate a cost savings to society). In this case, just like for physical impacts is conducted through 2050. The cost effectiveness of the program is then derived by dividing the NPV of implementation costs by the total GHG reductions estimated earlier.

Table 4.4. Direct Costs for BAU Rice Cultivation

Conditions habituelles: coûts directs BAU Direct Costs						
	Coûts matériels: semences et engrais	**Main d'oeuvre de plantation**	**Main d'oeuvre de culture et de récolte**	**Coûts du carburant diesel pendant la culture**	**Bénéfice paysan**	**Valeur du riz paddy**
An	Material costs: seeds and fertilizer	Planting Labor	Cultivation and harvesting labor	Diesel fuel costs during cultivation	Farmer Profit	Value of Paddy Rice
Year	**CFA**	**CFA**	**CFA**	**CFA**	**CFA**	**CFA**
2019	8,381,947 CFA	771,523 CFA	12,858,720 CFA	0 CFA	5,095,319 CFA	-67,937,581 CFA
2020	8,549,586 CFA	786,954 CFA	13,115,894 CFA	0 CFA	5,197,225 CFA	-69,296,333 CFA
2025	9,439,434 CFA	868,860 CFA	14,481,007 CFA	0 CFA	5,738,156 CFA	-76,508,751 CFA
2030	10,421,898 CFA	959,292 CFA	15,988,202 CFA	0 CFA	6,335,388 CFA	-84,471,843 CFA
2035	11,506,617 CFA	1,059,136 CFA	17,652,267 CFA	0 CFA	6,994,781 CFA	-93,263,740 CFA
2040	12,704,235 CFA	1,169,372 CFA	19,489,529 CFA	0 CFA	7,722,803 CFA	-102,970,705 CFA
2045	14,026,502 CFA	1,291,081 CFA	21,518,015 CFA	0 CFA	8,526,598 CFA	-113,687,979 CFA
2050	15,486,392 CFA	1,425,458 CFA	23,757,627 CFA	0 CFA	9,414,054 CFA	-125,520,715 CFA
Somme	**370,708,618 CFA**	**34,122,179 CFA**	**568,702,990 CFA**	**0 CFA**	**225,350,806 CFA**	**-3,004,677,417 CFA**

Table 4.5. Direct Costs for the Smart Rice Cultivation Pilot Program

Scénario du programme pilote: coûts directs Pilot Program Scenario (PS): Direct Costs					
	1-2. Coûts matériels: semis et engrais	**3. Coûts du carburant pendant la culture**	**4. Main d'oeuvre de plantation**	**5. Main d'oeuvre de culture et de récolte + Bénéfice paysan**	**6. Valeur du riz paddy**
An	1-2. Material costs: seedlings and fertilizer	3. Fuel costs during cultivation	4. Planting Labor	5. Cultivation and harvesting labor + Farmer Profit	6. Value of Paddy Rice
Year	**CFA**	**CFA**	**CFA**	**CFA**	**CFA**
2019	19,755,919 CFA	0 CFA	1,002,980 CFA	25,597,016 CFA	-169,843,953 CFA
2020	20,151,038 CFA	0 CFA	1,023,040 CFA	26,108,957 CFA	-173,240,832 CFA
2025	22,248,374 CFA	0 CFA	1,129,519 CFA	28,826,398 CFA	-191,271,877 CFA
2030	24,564,003 CFA	0 CFA	1,247,080 CFA	31,826,673 CFA	-211,179,608 CFA
2035	27,120,644 CFA	0 CFA	1,376,877 CFA	35,139,218 CFA	-233,159,351 CFA
2040	29,943,382 CFA	0 CFA	1,520,183 CFA	38,796,536 CFA	-257,426,763 CFA
2045	33,059,913 CFA	0 CFA	1,678,405 CFA	42,834,511 CFA	-284,219,948 CFA
2050	36,500,816 CFA	0 CFA	1,853,095 CFA	47,292,761 CFA	-313,801,788 CFA
Somme	**873,745,633 CFA**	**0 CFA**	**44,358,833 CFA**	**1,132,080,006 CFA**	**-7,511,693,543 CFA**

The total pilot program costs shown in Table 4.6 also include an estimate of the technical support costs provided by national government and non-government organizations.[11] These covers a wide array of costs: identification of beneficiary farmers, land and irrigation preparation, seed acquisition and seedling nursery prep., and training, supervision and monitoring of farmers. Since seedling costs were estimated separately as a materials cost, these were subtracted from the rest of the lump sum of support costs. After

[11] Taken from the local project team's Final Expenditure Report for this Africa LEDS project.

accounting for these support costs, the results still indicate a strong savings to society (negative societal cost values).

Table 4.6. Net Direct Costs for the Smart Rice Cultivation Pilot Program

Coûts sociétaux directs nets **Net Direct Societal Costs**				
	Coûts de support technique	**Total des coûts du programme**	**Total des coûts du programme actualisés**	**Efficacité des coûts**
An	Technical Support Costs	Total Program Costs	Total Discounted Policy Costs	Cost Effectiveness
Year	**CFA**	**CFA**	**2019 CFA**	**2019 CFA/ tCO_2e**
2019	1,799,700 CFA	-80,858,265 CFA	-80,858,265 CFA	
2020		-84,311,124 CFA	-78,690,382 CFA	
2025		-93,086,293 CFA	-61,532,760 CFA	
2030		-102,774,790 CFA	-48,116,180 CFA	
2035		-113,471,672 CFA	-37,624,946 CFA	
2040		-125,281,895 CFA	-29,421,216 CFA	
2045		-138,321,335 CFA	-23,006,225 CFA	
2050		-152,717,931 CFA	-17,989,956 CFA	
Somme	**1,799,700 CFA**	**-3,653,916,547 CFA**	**-1,363,440,430 CFA**	**-16,499 CFA**

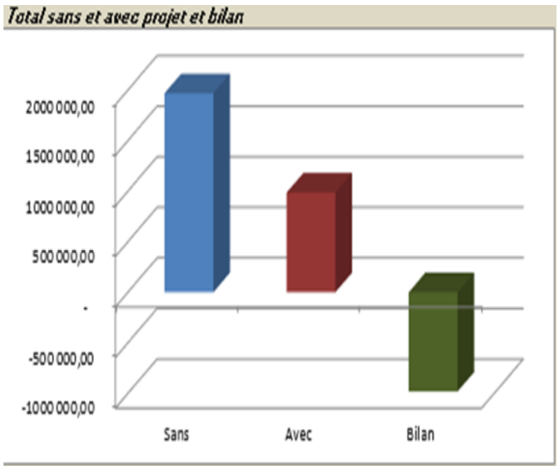
4.1.4 Comparison of Direct Impact Results to Local Team's Assessment

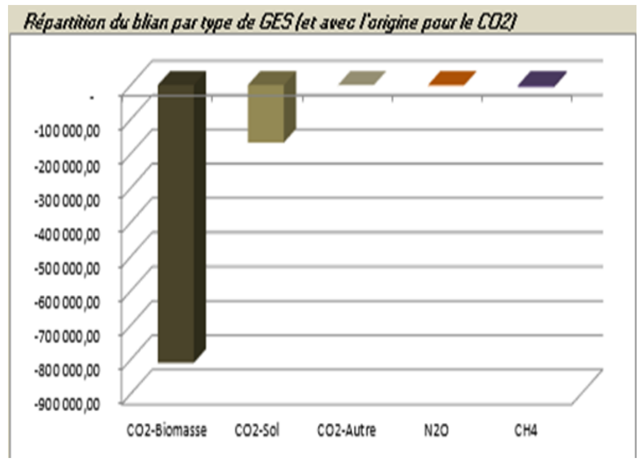
The local team analysed the physical impacts of the pilot using EX-ACT. EX-ACT does not address implementation costs; however, there is an additional tool called the EX-ACT Value Chain tool (EX-ACT VC)[12] that can build estimates of costs to the farmer (sometimes referred to as "farm-gate costs"). Conceivably, those could be used to satisfy some of the needs for net societal cost estimation. For example, it appears that all of the cost components shown in Figure 4.2 above could be addressed. One would just need to add in any government support costs needed to implement the program. To date, EX-ACT has been applied mainly to estimate physical impacts.[13] Figure 4.4 shows some summary results from the local team application of EX-ACT. On a carbon dioxide equivalent basis, over 20 years the 150.5 Ha pilot program would reduce about 985,725 tCO_2e of GHG emissions (N_2O and CH_4 have been converted to CO_2 equivalents in this total). Overwhelmingly, the source of reductions is reduced deforestation achieved via higher yields (GHG impact #10 from Figure 4.2b above).

[12] http://www.fao.org/tc/exact/ex-act-tool-for-value-chains/en/.

[13] The final progress report from the local team did indicate some limited application of EX-ACT VC. A value-added estimate of $50,000 USD in avoided fertilizer costs was reported along with the generation of 24 jobs. CCS has not yet had the opportunity to review the derivation of these values; however, the fertilizer savings is similar in both assessments.

Figure 4.4. Local Team Results Using EX-ACT. First chart indicates GHG emissions (tCO_2e) over 20 years without the project ("Sans"), with the project ("Avec"), and the net change or GHG balance ("Bilan"). Second chart breaks down the total emissions into separate components: "CO2-Biomasse" is the avoided carbon removed from forests due to higher crop yields; "CO2-Sol" is the carbon retained in soil (due to compost additions); the remaining emissions refer to reductions from changes in nitrogen additions, avoided straw burning, and changes in irrigation.





Répartition du blian par type de GES		
CO2	-977468	tCO2
N2O	-2,94765	tN2O
CH4	-238,619	tCH4

Application of the CCS tool described above produced a total reduction of 51,225 tCO_2e over the first 20 years of implementation. The big difference results from the two different methods used to calculate the area of forest saved from deforestation resulting from the higher crop yields (this area saved is then used as input to EX-ACT to calculate GHG impacts). The local team estimated that a total of 142 Ha/yr of deforestation will occur to satisfy the needs of the population in Gagnoa for fuelwood/charcoal. Further, by installing the project, this rate of deforestation would be halved. While this could occur if the pilot was rolled out to all of the rice production areas in the department of Gagnoa; the value needed for the analysis needs to correspond to the actual size of the two pilots, 150.5 Ha of rice cultivation, not the amount of charcoal consumed by the local population. Hence, a large over-estimate resulted.

Within the application of the CCS tool, an increase in yield of 2.5 would increase production efficiency to a level that only 60.5 Ha would be needed to produce the same amount of rice. Hence, 90 Ha of land would no longer be needed for rice production. The assumption is that this reduction in demand for crop land reduces deforestation pressure by the same amount. As shown in Table 4.7 below, CCS conducted some additional analysis using EX-ACT to demonstrate that similar results can be produced between the two tools, as long as similar inputs are used.

Table 4.7. Comparison of Results between EX-ACT and the CCS Micro-Analysis Tool Using Similar Inputs

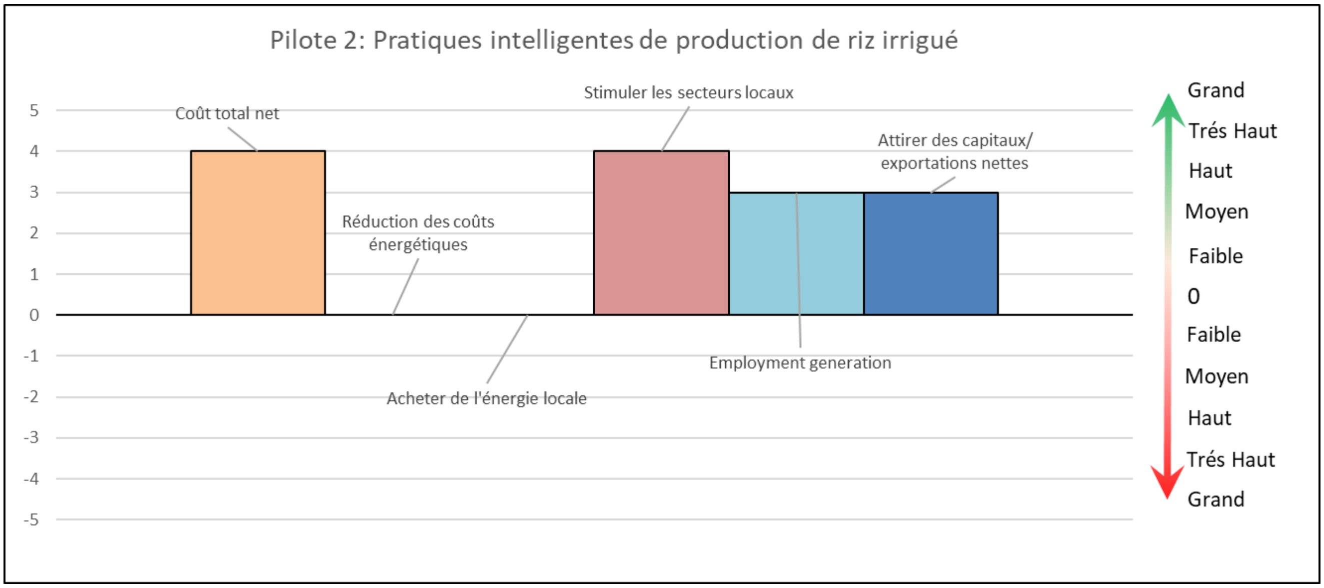
Source	EX-ACT	CCS Tool	Comments
1. Direct CH_4 emissions	-9,015	-10,097	EX-ACT emission factors updated to match CCS analysis. GWP factors can not be updated.
2. Direct CH_4 and N_2O from straw burning	-706	-619	EX-ACT allows user to update the amount of crop residue, but other parts of the emission factor for crop burning is hidden. GWP factors can not be updated.
5. Direct N_2O from nitrogen additions	-3	0	CCS analysis assumes no change, since the total N additions remain. EX-ACT results in a small value, which may have to do with rounding, since the total N is the same in both scenarios and the emission factors are the same.
6. Indirect reduction from sourcing of chemical fertilizer	-2,252	NA	Upstream emissions were not calculated in the CCS analysis.
9. Indirect GHG reduction from soil sequestration	-5,719	-5,715	CCS analysis assumes sequestration for 12 years. EX-ACT seems to assume 20 years. EX-ACT emission factor was updated to match CCS analysis (default factor is 0).
10. Indirect GHG reduction from avoided forest converstion	-63,008	-66,206	Assumes preservation of 90.3 hectares. Carbon stock and growth factors updated to match CCS analysis
Total	**-80,703**	**-82,637**	

4.1.5 Assessment of Indirect Economic Impacts

The CCS Macro-economic Indicators Tool was applied to assess the potential for positive local indirect economic benefits. Specifically, the tool was applied to determine whether the changes in direct costs or savings for implementation described in Section 4.1.3 are expected to produce positive impacts to local gross regional product (GRP; or overall local economic activity). See Annex D for the User's Guide to the tool including background and supporting information. Application of the tool provides users with an understanding of how the shifts in local direct spending/savings achieved through implementation of the project/program are likely to affect the broader economy's overall employment or total productivity.

Six macro-economic indicators are evaluated that can affect GRP (if conducting an analysis at the national level, then gross domestic product or GDP would be the applicable national metric). Each of the direct cost/savings streams analyzed above is tied to one or more of the indicators based on its characteristics – i.e. what is being bought or sold, and who is doing the buying and selling, in each case. Figure 4.5 is a graphic resulting from this assessment which provides a combined quantitative and expert based judgement based understanding of whether the changes in costs between the BAU and pilot program scenarios will produce positive or negative impacts within the local economy (e.g. the department of Gagnoa).

Figure 4.5. Macro-economic Indicators Assessment of Smart Rice Cultivation



The first indicator corresponds to overall net implementation costs and savings in comparison to baseline (as with all of the indicator-based analyses) and since those indicated a strong savings to society, the macro-indicator is shown as being very high. The next indicator corresponds to a change in local energy costs. There were no energy impacts for this pilot, so this indicator, as well as the next indicator regarding purchases of local energy sources, is zero. The next indicator corresponds to stimulation of local sectors. The direct cost stream corresponding to this indicator is the increase in value of paddy rice to the farmer. This is a significantly positive impact due to the increase in yields (~a factor of 2.5 times greater than BAU). The employment generator is also strongly positive due to the overall increase in labor costs for rice cultivation (planting, crop straw management). Finally, the indicator for attraction of foreign capital/increase in net exports is highly positive. The corresponding net direct cost stream is the net cost of crop inputs. Specifically, there is significant savings to the farmer for substituting locally-derived compost for chemical fertilizers used in the BAU scenario.

All around, the macro-indicators assessment indicates that the spending and savings involved in smart rice cultivation practices have characteristics associated with future growth in the local economy. Note that the pilot program technical support costs have not been factored into this assessment of macro-economic indicators, since the funds originate from outside of the local region and are largely used to support staff that are also located outside of Gagnoa.

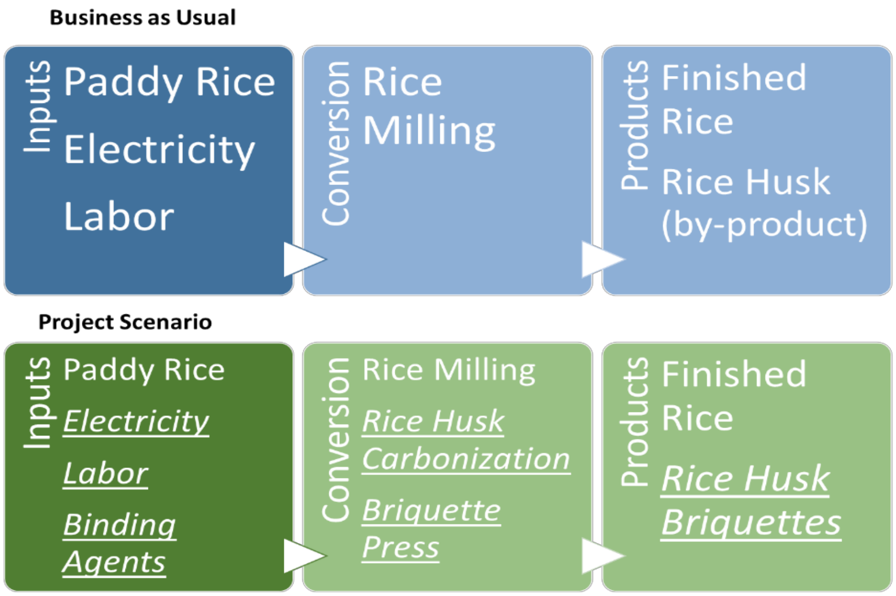
4.2 Rice Husk Briquetting and Use as a Local Cooking Fuel

4.2.1 Physical Impacts – Energy, Resources and Emissions

Figure 4.6 provides a simplified process flow diagram indicating the change in practice at the rice mill produced by the project. Prior to the pilot (BAU), the mill took in paddy rice from local farmers and using an electrically-powered mill converted the paddy rice into finished rice and a by-product (rice husk). With the pilot, a carbonizer and an electrically-powered briquette press are added to the process. This requires additional electricity, labor and binders[14] as inputs, but there are now two products: finished rice and rice husk briquettes.

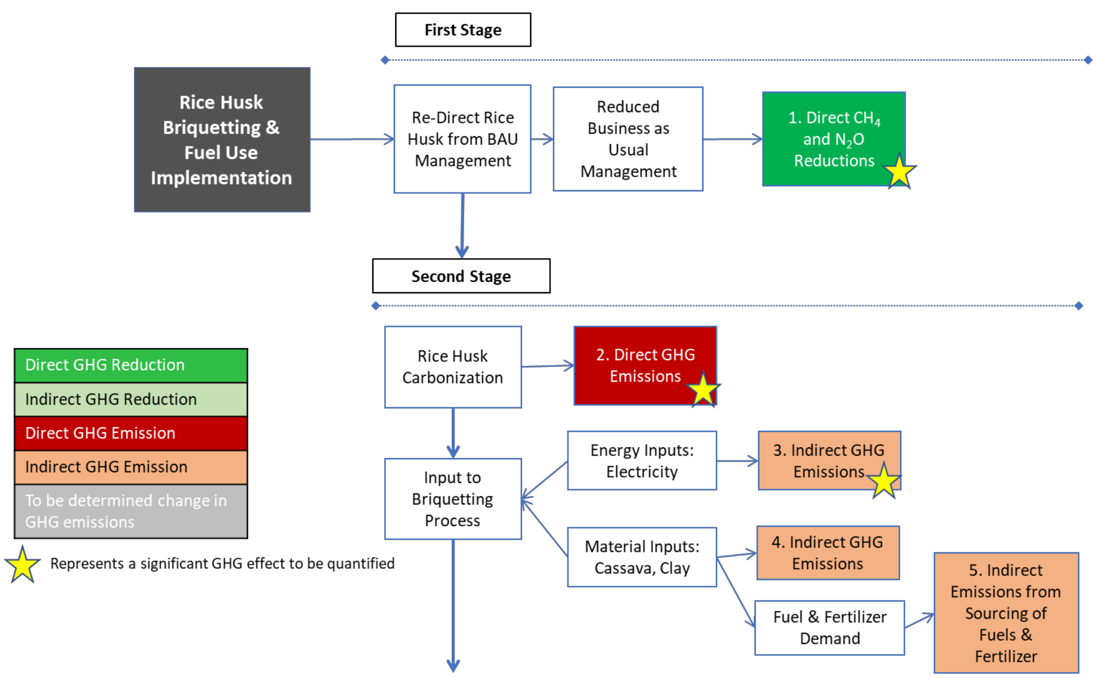
[14] Binding agents added to carbonized rice husk include powdered clay and cassava.

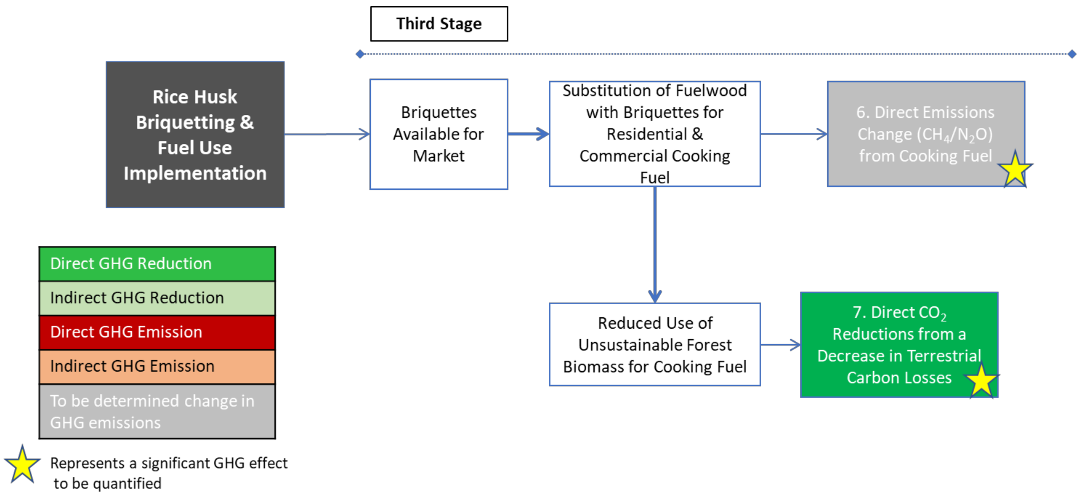
Figure 4.6. Simplified Process Flow Diagram for the Rice Husk Briquetting Pilot



A GHG causal chain is provided in Figure 4.7. In the first stage, rice husk is re-directed from BAU management (use as animal bedding material) to briquette production. Under BAU conditions for the pilot, the rice husk is expected to decompose aerobically emitting minimal GHG emissions (the carbon dioxide emitted in this case is of biogenic origin and sustainably produced, so those emissions are considered carbon neutral). Alternatively, if the rice husk was combusted or landfilled under BAU conditions, CH_4 and N_2O emissions would have resulted, and those should be quantified.

Figure 4.7. GHG Causal Chain for the Rice Husk Briquetting Project





In the second stage, the rice husk is carbonized (combusted in a low oxygen environment). This results in GHG emissions, including CH_4, N_2O, and volatile organic compounds. In this Africa LEDS project, GHGs considered were limited to the six Kyoto Protocol gases.[15] The carbonized rice husk is then fed into the briquette press along with locally-sourced binders (cassava and clay). Electricity is required to run the briquette press, and indirect GHG emissions are produced at grid generation facilities to meet this demand (GHG impact #3). There are also indirect emissions associated with producing and transporting the powdered clay and cassava binders (GHG impacts #4 and #5). However, much of that activity is done by hand labor, so the GHG emissions are expected to be negligible.

In the third stage, the rice husk briquettes are introduced into the local market as cooking fuel. This will offset the use of other cooking fuels, mostly charcoal and firewood. This results in GHG impact #6. As shown in the figure, this refers to the difference in direct CH_4 and N_2O emissions between combusting briquettes and combustion of charcoal/fuelwood. The CO_2 emitted by briquette combustion is carbon neutral (sustainably produced each year); but not the CO_2 from charcoal/fuelwood combustion (local fuelwood harvests are not sourced sustainably. This CO_2 benefit achieved via reduced demand for local charcoal/fuelwood is captured in GHG impact #7.

4.2.2 Direct Costs and Savings of Implementation

A net direct societal costing chain is shown in Figure 4.8 below. The first project effect is a requirement for investment in equipment (carbonizer and briquette press). This is a one-time cost split into two cost components. The first recognizes a possible government subsidy from a national or international source in form of a grant to buy-down the overall equipment costs. The remainder is annualized for re-payment by the mill operator (cost component #2).

The second effect of the program driving a change in costs between BAU and Pilot Scenarios captures the production requirements for the briquetting process. These are a series of annual cost components including labor costs, input costs, energy costs, and the profit that the mill operator will add to the cost of production (cost components #3-6).

The final project effect addresses the avoided cost to society for fuels that are being offset by rice husk briquettes. For the Gagnoa pilot, these are expected to be mainly charcoal/fuelwood; however, LPG is another fuel that could be offset, and is therefore listed separately. Another societal cost component not

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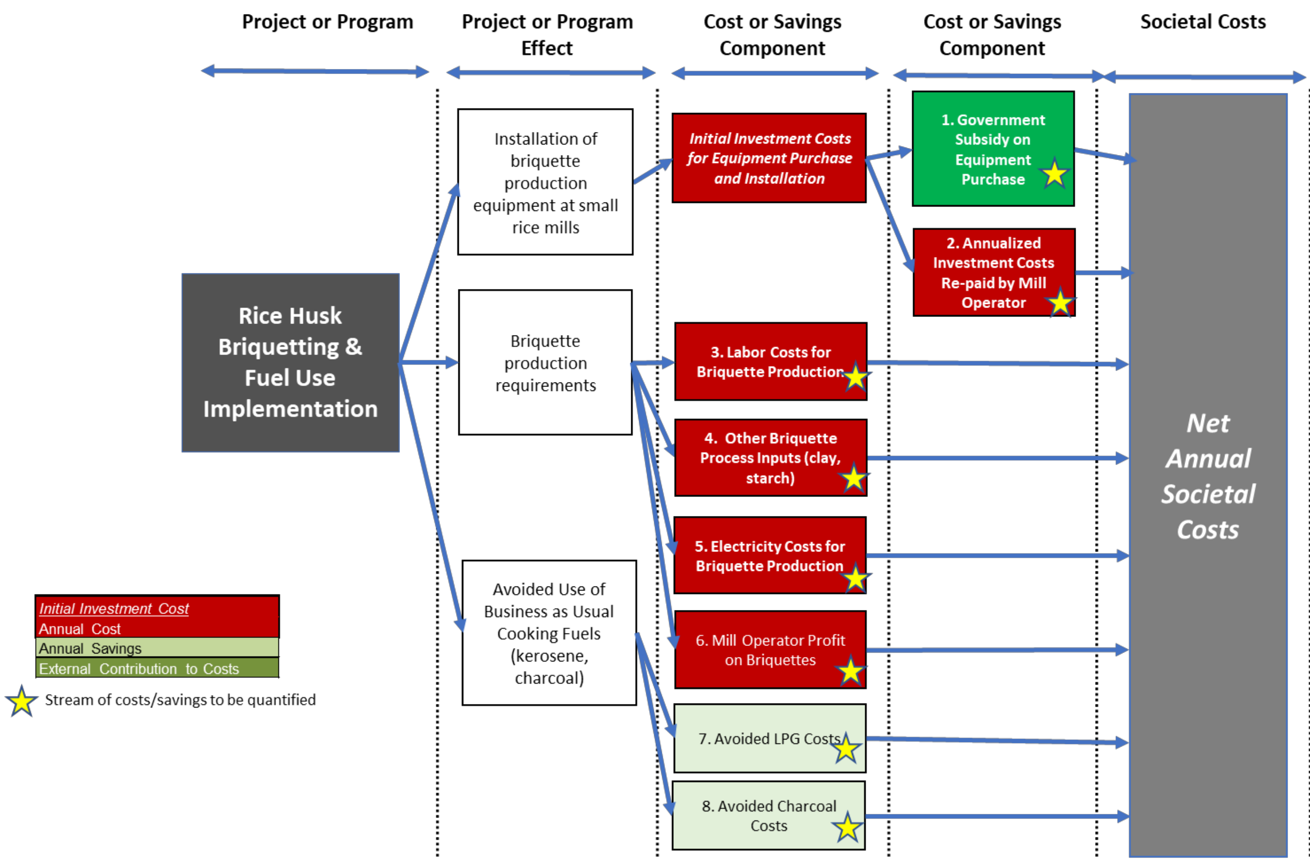
[15] CO_2, CH_4, N_2O, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

shown in Figure 4.8 is the technical support costs provided by government or institutions. Estimated support costs from the local team were, however, included in the final estimates of direct costs described below. Also, it is possible that some international program could recognize carbon offsets for the pilot, however, these have not been included.

4.2.3 Results of the Microeconomic Analysis of the Rice Husk Briquetting Pilot

The microeconomic (direct) impacts analysis is documented below. As documented above for the smart rice cultivation pilot, the first subsection addresses the approach and results for physical impacts, including energy production/consumption, resource consumption/change in management (e.g. crop straw management, chemical nitrogen fertilizer), and GHG emissions. The second subsection provides the assessment of net direct costs/savings, including the calculation of the cost effectiveness for the pilot. See Annex E for the detailed inputs used to calculate both the physical impacts and net direct costs of implementation.

Figure 4.8. Net Direct Societal Costing Chain for the Rice Husk Briquetting Pilot[16]



[16] Note that this costing chain does not include government/institutional technical support costs which are an important component of the pilot program. These costs were added into the analytical results presented later in this report.

Physical Impacts

Table 4.8 provides a summary of the physical impacts calculated for the pilot project. The first column provides the amount of rice husk by-product produced by the mill each year. This is the overall controlling variable for the analysis, since it represents the total amount of material available for producing renewable energy. Under BAU conditions, the rice husk is stock-piled and either given away or sold as low-value animal bedding material. Under these conditions, the material should decompose aerobically and produce negligible GHG emissions. Under BAU conditions, there is local combustion of cooking fuels, which are mainly charcoal and fuelwood. An estimate is provided of the amount of GHG emissions produced by these cookstoves based on the equivalent heat content of rice husk briquettes. Under BAU, the emissions for rice husk carbonization and electricity consumption for the briquette press are zero. The final column for forest carbon remaining in the forest as a result of rice husk briquette introduction into the local market is also zero under BAU.[17]

Table 4.8. BAU Physical Impacts for the Rice Husk Briquetting Pilot

Conditions habituelles: énergie, émissions et matériaux BAU: Energy, Materials & Emissions					
	Balle de riz produite	**Émissions de GES liées à la gestion des balles de riz**	**Émissions de GES liées à la combustion de combustibles compensées par les briquettes**	**Émissions de GES provenant de la consommation d'électricité et de la carbonisation**	**Carbone forestier restant dans la forêt**
An	Rice Husk Produced	GHG emissions from rice husk management	Fuel combustion GHG emissions offset by briquettes	GHG emissions from electricity consumption and carbonization	Forest carbon remaining in the forest
Year	**kg**	**tCO_2e**	**tCO_2e**	**tCO_2e**	**tCO_2**
2019	36,000	0.00	6.8	0.00	0.00
2020	36,000	0.00	6.8	0.00	0.00
2025	36,000	0.00	6.8	0.00	0.00
2030	36,000	0.00	6.8	0.00	0.00
2035	36,000	0.00	6.8	0.00	0.00
2040	36,000	0.00	6.8	0.00	0.00
2045	36,000	0.00	6.8	0.00	0.00
2050	36,000	0.00	6.8	0.00	0.00
Somme	**1,152,000**	**0.00**	**217**	**0.00**	**0.00**

Table 4.9 summarizes the physical impacts for the pilot project scenario. As shown, there is no difference in the amount of rice husk produced; however, the next column shows the values for its conversion to bio-briquettes. The next two columns show emissions for the bio-briquette process: direct GHG emissions for rice husk carbonization; and indirect emissions for electricity to power the briquette press. The next column indicates that GHG emissions for charcoal/LPG combustion offset by these briquettes are now zero under the pilot project scenario.

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[17] The final two columns are presented in the tool to provide structural consistency between the BAU and pilot program scenarios. CCS has found that this practice is helpful during capacity building exercises.

Table 4.9. Pilot Project Physical Impacts for the Rice Husk Briquetting Pilot

Scénario du programme pilote: énergie, matériaux et émissions
Pilot Program Scenario (PS): Energy, Materials & Emissions

An Year	**Balle de riz produite** Rice Husk Produced	**Bio-briquettes produites** Bio-briquettes produced	**Émissions de GES de la carbonisation** GHG emissions from carbonization	**Émissions de GES provenant de la consommation d'électricité** GHG emissions from electricity consumption	**Émissions de GES: combustion de charbon de bois / GPL** GHG emissions: charcoal/ LPG combustion	**Émissions provenant de la combustion de bio-briquettes** GHG emissions: bio-briquette combustion	**Carbone forestier restant dans la forêt** Forest carbon remaining in the forest	**Surface forestière évitée dégradée par les récoltes de bois de chauffe** Avoided forest area degraded by fuel wood harvests
	kg	**kg**	**tCO_2e**	**tCO_2e**	**tCO_2e**	**tCO_2e**	**tCO_2**	**Ha**
2019	36,000	16,560	22	3.5	0.0	4.4	(170)	(16)
2020	36,000	16,560	22	3.5	0.0	4.4	(170)	(16)
2025	36,000	16,560	22	3.5	0.0	4.4	(170)	(16)
2030	36,000	16,560	22	3.5	0.0	4.4	(170)	(16)
2035	36,000	16,560	22	3.5	0.0	4.4	(170)	(16)
2040	36,000	16,560	22	3.5	0.0	4.4	(170)	(16)
2045	36,000	16,560	22	3.5	0.0	4.4	(170)	(16)
2050	36,000	16,560	22	3.5	0.0	4.4	(170)	(16)
Somme	**1,152,000**	**529,920**	**689**	**112**	**0.0**	**141**	**(5,425)**	**(16)**

In the seventh column of Table 4.9, GHG emissions from bio-briquette combustion are provided. These emissions are only slightly lower than fuel combustion emissions in the BAU scenario, because only a small amount of LPG (10%) is expected to be offset with bio-briquettes (mainly, the briquettes will offset charcoal/fuelwood). It's also important to understand how forest carbon CO_2 emissions are being accounted for in this analysis. Those emissions (CO_2 from combusting unsustainable forest biomass combustion in the form of charcoal/fuelwood) are shown in the next column. The CO_2 emissions from combusting bio-briquettes are carbon neutral, since the biomass is sourced from a sustainable supply source (i.e. rice husk). Hence, the emissions shown in the seventh column consist of just the CH_4 and N_2O emissions from bio-briquette combustion. The eighth column provides the estimated CO_2 emissions associated with biomass that remains in the forest due to decreased use of charcoal/fuelwood.[18] The final column of the table provides an estimate of the forest area protected from degradation by fuelwood harvests.

Table 4.10 provides the net physical impacts calculated for implementing the pilot program. These results include the total area of forest protected by implementation of the project (these are not cumulative annual values, just the total amount area protected as long as the project operates and the briquettes are consumed in the local market). The total net GHG benefits are also provided annually through 2050.

[18] Note that the GHG benefits calculated here could be considered conservative (low), since there has not been an accounting of the additional upstream emissions associated with charcoal production (e.g. CH_4 emissions); although this was done for the pilot project fuel (rice husk carbonizer).

Table 4.10. Net Direct Impacts Summary for the Rice Husk Briquetting Pilot

Changement net: énergie, matériaux et émissions Net Change: Energy, Materials & Emissions Change					
	Surface forestière évitée dégradée par les récoltes de bois de chauffe	**1-3. Changement dans la gestion de la balle de riz**	**6. Réduction des émissions de GES provenant de combustibles BAU compensateurs**	**7. Impacts du carbone forestier**	**Total des impacts de GES**
An	Avoided forest area degraded by fuel wood harvests	1-3. Change in Rice Husk Management	6. GHG Reduction from Off-setting BAU Fuels	7. Forest Carbon Impacts	**Total GHG Impacts**
Year	**Ha**	**tCO_2e**	**tCO_2e**	**tCO_2**	**tCO_2e**
2019	(16)	18	(2.4)	(170)	(154)
2020	(16)	18	(2.4)	(170)	(154)
2025	(16)	18	(2.4)	(170)	(154)
2030	(16)	18	(2.4)	(170)	(154)
2035	(16)	18	(2.4)	(170)	(154)
2040	(16)	18	(2.4)	(170)	(154)
2045	(16)	18	(2.4)	(170)	(154)
2050	(16)	18	(2.4)	(170)	(154)
Somme	**(16)**	**583**	**(76)**	**(5,425)**	**(4,918)**

Net Direct Societal Costs/Savings

As with the physical impacts assessment, the direct net societal cost analysis begins with an evaluation of costs that change between BAU rice husk management at the rice mill and the pilot project scenario. The individual cost components were identified in Figure 4.8 above. Table 4.11 below provides a summary of the costs under the BAU scenario. As indicated in this table, BAU management costs are zero, since the material is simply stock-piled until it is either sold or given away as low cost livestock bedding material. The value of the material indicates assumed for this analysis was 10 CFA/kg husk (about 0.017 USD/kg).

Table 4.11. BAU Rice Husk Management Costs

Conditions habituelles: coûts directs BAU Direct Costs		
	Coûts de gestion de la balle de riz Rice Husk Management Cost	**Valeur du produit en balle de riz** Value of Rice Husk Product
An Year	**CFA**	**CFA**
2019	0 CFA	-360,000 CFA
2020	0 CFA	-367,200 CFA
2025	0 CFA	-405,418 CFA
2030	0 CFA	-447,615 CFA
2035	0 CFA	-494,203 CFA
2040	0 CFA	-545,640 CFA
2045	0 CFA	-602,431 CFA
2050	0 CFA	-665,132 CFA
Somme	**0 CFA**	**-15,921,731 CFA**

Table 4.12 provides a summary of the costs under the pilot project scenario. The estimated stream of costs for each of the cost components identified in Figure 4.8 is shown in the table with the corresponding number from the societal costing chain. The second dark blue column indicates the total investments needed for equipment (carbonizer, briquette press). The third column (cost component #1) indicates that no government subsidies (grants) were identified to buy down these investment costs to the mill operator. The annual costs for cost component #2 are provided in the fourth column. These are the annualized costs to the operator for financing all of the equipment costs. The next three columns provide annual costs for briquette process operations: labor, inputs (binding agents), and power. Cost component #6 is the profit on the rice husk briquettes for the mill operator.

Cost components #7 & 8 are the fuel savings to society for avoided LPG and charcoal (negative values indicate a savings to society). Other direct implementation costs to society that could be considered in future assessments are the technical support costs from government or institutions to support the rice mill operator in equipment procurement/set up, training on process operations, and local market support. The latter of these is critical. Without a local market ready to accept this new form of cooking fuel, similar projects are not likely to be successful. Local market support in this case should include a combination of marketing the new briquette fuel to local commercial and residential customers (e.g. through demonstrations) and cookstove support programs. Compressed bio-briquette products, such as these rice husk briquettes, will often perform best in cooking stoves optimized for their use. Hence, local cooking stove demonstration and sales programs are critical to success.

Table 4.12a. Pilot Project Rice Husk Management Costs

Scénario du programme pilote: coûts directs Pilot Program Scenario (PS): Direct Costs					
	Coûts d'équipement de production de briquettes	**1. Subvention gouvernementale nationale ou internationale pour les coûts d'équipement**	**2. Coûts d'équipement annualisés**	**3. Production de briquettes: travail**	**4. Autres intrants de production**
	Briquette Production Equipment Costs	1. National/International Government Subsidy for Equipment Costs	2. Annualized Equipment Costs	3. Briquette Production Labor	4. Other Production Input Costs
An Year	**CFA**	**CFA**	**CFA**	**CFA**	**CFA**
2019	4,934,800 CFA	0 CFA	541,815 CFA	166,093 CFA	2,154,125 CFA
2020			541,815 CFA	169,415 CFA	2,197,207 CFA
2025			541,815 CFA	187,048 CFA	2,425,894 CFA
2030			541,815 CFA	206,516 CFA	2,678,383 CFA
2035			0 CFA	228,011 CFA	2,957,152 CFA
2040			0 CFA	251,742 CFA	3,264,934 CFA
2045			0 CFA	277,944 CFA	3,604,751 CFA
2050			0 CFA	306,872 CFA	3,979,937 CFA
Somme	**4,934,800 CFA**	**0 CFA**	**8,127,218 CFA**	**7,345,822 CFA**	**95,270,541 CFA**

Table 4.12b. Pilot Project Rice Husk Management Costs (continued)

Scénario du programme pilote: coûts directs Pilot Program Scenario (PS): Direct Cost				
	5. Coûts d'électricité	**6. Bénéfice de l'opérateur d'une rizière sur les ventes de briquettes**	**7. Coût évité du GPL**	**8. Coût évité du charbon de bois**
	5. Electricity Cost	6. Rice Mill Operator Profit on Briquette Sales	7. Avoided Cost of LPG	8. Avoided Cost of Charcoal
An Year	**CFA**	**CFA**	**CFA**	**CFA**
2019	332,440 CFA	1,118,065 CFA	-603,612 CFA	-1,043,280 CFA
2020	339,088 CFA	1,136,634 CFA	-615,684 CFA	-1,064,146 CFA
2025	374,381 CFA	1,235,198 CFA	-679,765 CFA	-1,174,903 CFA
2030	413,347 CFA	1,344,021 CFA	-750,516 CFA	-1,297,188 CFA
2035	456,368 CFA	1,274,536 CFA	-828,630 CFA	-1,432,200 CFA
2040	503,867 CFA	1,407,190 CFA	-914,874 CFA	-1,581,264 CFA
2045	556,310 CFA	1,553,652 CFA	-1,010,095 CFA	-1,745,844 CFA
2050	614,212 CFA	1,715,357 CFA	-1,115,227 CFA	-1,927,552 CFA
Somme	**14,702,812 CFA**	**43,906,238 CFA**	**-26,695,966 CFA**	**-46,141,175 CFA**

Table 4.13 provides the net societal costs calculated for the pilot project. To generate the total pilot costs, the sum of BAU costs were subtracted from the sum of pilot scenario costs. Total societal costs are positive indicating that costs exceed savings. Cost effectiveness is estimated to be 13,015 CFA/tCO_2e ($22/t$CO_2$e). Technical support costs for future projects should be substantially lower due to lessons-learned on this project in addition to the fact that they would be spread over multiple projects, rather than

just one.[19] The technical support costs were excluded, the NPV of implementation costs would be 64 million CFA (or about $110,000). This indicates the size of direct costs to the local economy over the planning period. The cost effectiveness in that case is 9,144 CFA/tCO_2e ($16/t$CO_2$e).

Table 4.13. Rice Husk Briquetting Pilot Project Net Societal Costs

Coûts sociétaux directs nets Net Direct Societal Costs				
	Coûts de support technique	**Total des coûts du programme pilote**	**Total des coûts du programme pilote actualisés**	**Efficacité des coûts**
An	Technical Support Costs	Total Pilot Program Costs	Total Discounted Pilot Program Costs	Cost Effectiveness
Year	**CFA**	**CFA**	**2019 CFA**	**2019 CFA / tCO_2e**
2019	19,037,180 CFA	22,062,826 CFA	22,062,826 CFA	
2020		3,071,530 CFA	2,866,761 CFA	
2025		3,315,087 CFA	2,191,369 CFA	
2030		3,583,994 CFA	1,677,922 CFA	
2035		3,149,440 CFA	1,044,291 CFA	
2040		3,477,236 CFA	816,594 CFA	
2045		3,839,149 CFA	638,545 CFA	
2050		4,238,731 CFA	499,317 CFA	
Somme	**19,037,180 CFA**	**131,474,400 CFA**	**64,003,694 CFA**	**13,015 CFA**

Mechanisms that could improve the societal direct costs for the pilot include some cost share of the initial investment costs (briquette press, carbonizer, mixer). These could include either domestic or international grant programs. Direct societal costs are also sensitive to the local prices of fuels that are displaced by the pilot project (LPG and charcoal), as well as the locally-perceived value of the new fuel source (rice husk briquettes. As indicated in the analytical inputs provided in Annex E, the local price of charcoal is estimated to be less than half the cost of producing rice husk briquettes. So, local marketing efforts will need to be successful in positioning the new fuel as being cleaner, longer-lasting, more efficient, or more convenient than charcoal. Production subsidies paid to the mill operator could help reduce production costs and make the briquettes more competitive with charcoal. Also, sales taxes could be put in place or adjusted for charcoal to make the fuel costs more competitive. Carbon crediting programs should also be investigated to determine whether they could provide additional support towards production costs.

4.2.4 Comparison of Direct Impact Results to Local Team's Assessment

The local team analysed the physical impacts of the pilot using LEAP-IBC. As of the date of preparation of this report, the local team was still building out this functionality with the LEAP-IBC model for Côte d'Ivoire. To assist in them in completing that process, the CCS Micro-Analysis Tool has been provided. That tool contains all of the input data and equations needed to generate the direct implementation costs at the project level. Those project level costs could then be scaled to estimate regional or national implementation costs. The comparison for this report just addresses physical impacts.

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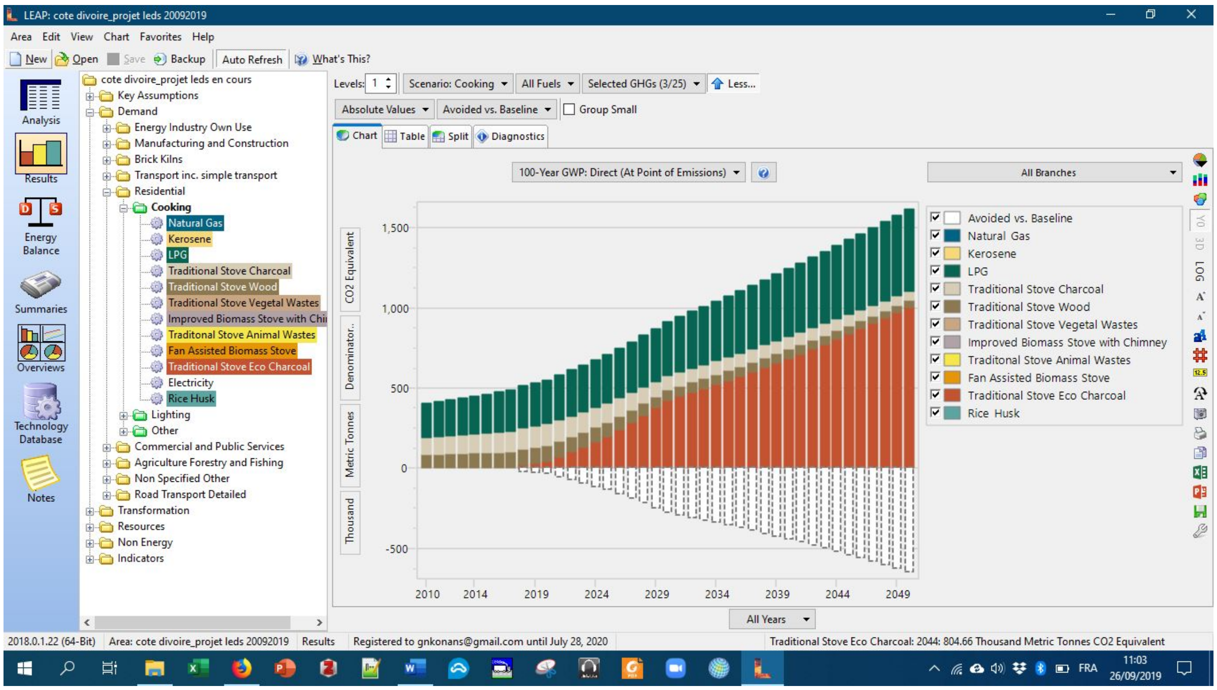
[19] Technically-speaking, the technical support costs are borne by entities with staffing located outside the Gagnoa region (e.g. ANADER, MINEDD, university researchers). Hence, these costs would not normally be included in a net societal cost representing the Gagnoa region. They are included here to provide a full accounting of costs, so that the reader can appreciate the level of effort required to successfully implement such pilot programs/projects.

Figure 4.9 below provides a screenshot from the local team's application of LEAP-IBC to estimate the energy impacts of implementation of the rice husk briquetting pilot. This assessment was done at a national scale rather than project scale like those above. As shown in the figure, the LEAP-IBC analysis indicates in excess of 600,000 tCO_2e reduced in 2050. Section 4.3 below provides a simple scale-up method to the national level for the two pilots, if implemented together. As indicated in that section, the expected 2050 GHG reductions for the rice husk briquetting pilot are over 875,000 tCO_2e.

Figure 4.9. Local Team LEAP-IBC Modeling Results for the Rice Husk Briquetting Pilot



The discrepancies between the two analyses result from the way in which the amount of rice husk available for briquette production was determined (this is the key variable for this pilot). In the analysis within the CCS tool, the amount of rice husk available was calculated based on the capacity of the rice mill. The LEAP-IBC analysis used a different approach which appears to be related to the amount of rice *straw* burned on the field (this has no relationship to the amount of rice *husk* produced from paddy rice at the mill).

The current LEAP-IBC Côte d'Ivoire model is built at the national level. Adding in a pilot project level scenario consistent with the one presented above will show very small impacts against a national baseline of energy demand; however, it is the next step needed by the local team. The team should then build up a national scale rice husk bio-briquetting program scenario based on the total number of small rice mills (e.g. < 2 t/day of paddy rice) operating in the country. The team should also factor in the impacts of smart rice cultivation (higher yields providing more rice husk for briquettes), assuming that both pilots will be scaled-up together. The CCS Micro-Analysis Tool also has an assessment of national program-level impacts that can be used to construct that scenario (see Section 4.3).

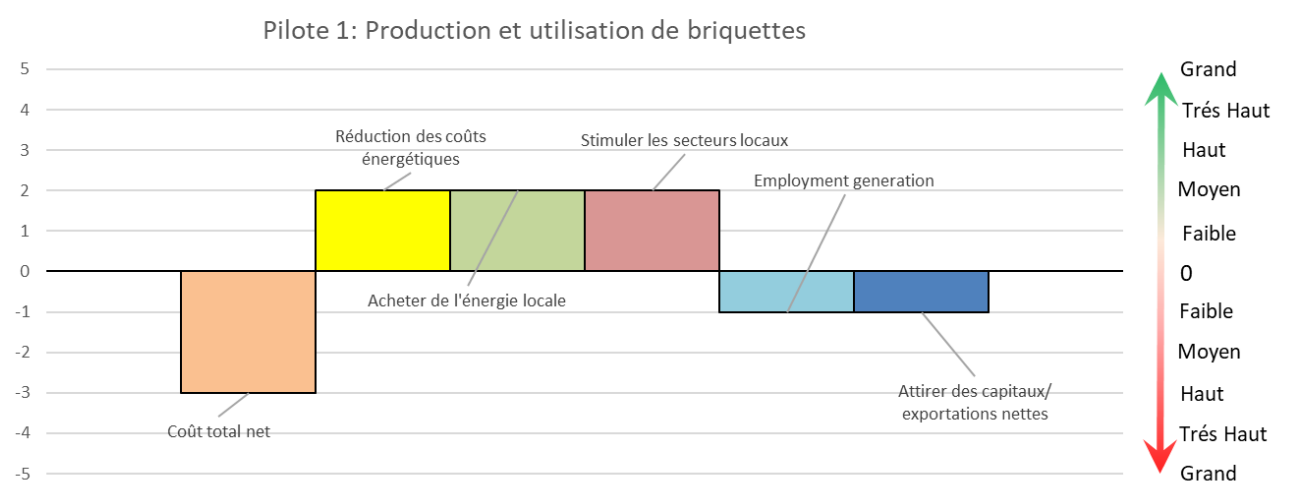
4.2.5 Assessment of Indirect Economic Impacts

The CCS Macro-economic Indicators Tool was applied to assess the potential for positive local indirect economic benefits. Specifically, the tool was applied to determine whether the changes in direct costs and savings for implementation described in Section 4.2.3 have characteristics associated with positive impacts to local GRP (or overall local economic activity) or overall employment. The assessment also looks for the reverse of any of these characteristics, which would be causes for concern about impact to the local economy. See Annex D for the User's Guide to the tool including background and supporting information. Application of the tool provides users with an understanding of whether or not the shifts in local direct spending/savings achieved through implementation of the project/program are likely to have a net positive local macro-economic impact, namely stimulation of overall GRP.

Six macro-economic indicators are evaluated. Each of these is tied to one or more of the net direct cost streams analyzed above. Figure 4.10 is a graphic resulting from this assessment which provides a qualitative understanding of whether the changes in costs between the BAU and pilot program scenarios are associated with positive or negative impacts within the local economy (e.g. the department of Gagnoa). The assessment indicated that three of the six indicators are positive.

The first indicator corresponds to overall net implementation costs and since those indicated a net cost to society, rather than a net savings, the macro-indicator is shown as being negative. This is a cause for concern, but if the spending involved has positive characteristics, this concern is substantially lessened. A combination of financial support mechanisms (e.g. national or international grant programs for initial investment costs) and successful local marketing programs of rice husk briquettes will be needed to reduce these local societal costs. As described under the microeconomic cost analysis above, another contributor to the overall size of the societal costs being positive is due to the inclusion of technical support costs originating from outside the local region (government, non-government organization, and university training and technical support costs). One could consider excluding those costs here, since the financial flow occurs largely outside of the region. That would still not turn this indicator into a positive direction (net societal costs would still be positive). They are included here, so that their importance to successful pilot program implementation is not overlooked.

Figure 4.10. Macro-economic Indicators Assessment of the Rice Husk Briquetting Pilot



The next indicator corresponds to a change in local energy costs. This indicator is positive to the extent that some relatively high cost LPG is displaced by locally-derived bio-briquettes (if the bio-briquettes only reduce locally derived charcoal/fuelwood, then this indicator would be near zero and dependent on local market prices for both fuels). The next indicator corresponds to purchases of local energy, and it behaves much like the previous one in that, to the extent that imported LPG demand is reduced, then purchases of local energy sources are increased.

The fourth indicator corresponds to stimulation of local sectors (other than energy). The direct cost stream corresponding to this indicator is the increase in purchases of other local process inputs (binding agents cassava and clay). The last two indicators are shown to be negative. The first of these, employment generation, addresses a trade-off in new local labor needed to produce bio-briquettes and the local labor lost for gathering and producing charcoal/fuelwood. On a net basis, the production and consumption of bio-briquettes appears to reduce overall spending on employment, lowering overall incomes in the local economy (on an energy basis, labor to produce briquettes is lower than gathering/transporting/producing charcoal/fuelwood). Hence, the indicator is shown as negative. This points to the need for consideration of this impact during program scale-up (e.g. hiring of local workers from the fuelwood/charcoal production chain in the bio-briquetting projects; training programs for impacted workers in other lines of work; etc.).

The final indicator is for "attraction of capital/net exports". It is tied to the investment costs for new equipment, which are largely tied to the cost of the briquette press. Since this equipment is likely to be sourced from international suppliers, the purchase results in a net flow of cash outside of the local economy. Its size is not significant, but it does produce a weakly negative indicator, signifying a cause for concern. That impact could be reduced through some type of financial support mechanism, like a grant from the national government or from international sources.

All around, the macro-indicators assessment indicates that, without outside financial support, the rice husk briquetting pilot is likely to have a mixed effect on the local economy. Note that the pilot program technical support costs have not been factored into this assessment of macro-economic indicators, since the funds originate from outside of the local region and are largely used to support staff that are also located outside of Gagnoa.

4.3 National Scale-up of Rice Value Chain Pilots

A simple scale-up assessment of the societal costs and benefits was performed in order to gauge the significance of impacts for an expanded program to the national scale. The first step in this assessment was to identify the interaction(s), if any, between the rice cultivation improvements and the activities at the mill to produce bio-briquettes.[20] Nothing done at the mill is expected to have a notable impact on local rice cultivation. Its possible that a profitable bio-briquetting activity will lead to some value being placed on the rice husk itself (which could support a higher price paid to the farmer for paddy rice). However, any such effect is not considered here. The main interaction of the two pilots is tied to the higher yields achieved through smart rice cultivation (~2.5x increase). This means that there will now be 2.5x more paddy rice run through the mill for all local production that has adopted the smart rice cultivation techniques.

Table 4.14 provides the total physical impacts calculated for both Gagnoa pilots implemented together. The limitation to this interaction is the capacity of the rice mill. At a current capacity of 1.0 tonne/day of paddy rice, it was assumed that the mill could expand this capacity by a factor of 2.5 to accommodate the higher rice yields without requiring new/additional equipment (e.g. through running additional shifts).

The physical impacts for the smart rice cultivation pilot ("Scenario 2 Pilote" in Table 4.14) are the same as presented earlier, since nothing has changed on the field. The total GHG impacts for the rice husk briquetting pilot ("Scenario 1 Pilote") are now greater as a result of more rice husk processed into bio-briquettes, and those bio-briquettes are presumed to be taken up by the local cooking fuel market.

The total results shown for "Scenario 3: Les deux pilotes" represent the total GHG reductions for both pilots if implemented together. GHG reductions are still dominated by the effect of higher rice yields achieved by Pilot 2, and their impact on reduced deforestation. This shows up mainly as a large reduction in the first year of implementation and corresponds to the forest carbon that would be lost to accommodate the new hectares needed for rice cultivation (if the project was not implemented).

[20] Note: that the bio-briquetting pilot scale-up is assumed to only be applicable for small rice mills (<2 tonnes/day capacity). Larger commercial mills often use the rice husk as fuel (e.g. for a drier) or possibly for other purposes.

Table 4.14. Physical Impact Results for Both Pilots Implemented Together (Scenario 3)

Changement net: énergie, matériaux et émissions Energy & Emissions Change						
	Scenario 2 Pilote				**Scenario 1 Pilote**	**Scenario 3: Les deux pilotes**
	Engrais azoté chimique appliqué	**Paille de riz brûlée**	**Conversion de forêt évitée**	**Total des impacts de GES**	**Total des impacts de GES**	**Total des impacts de GES**
An	N Fertilizer Use	Rice Straw Burned	Forest Conversion Avoided	Total GHG Impacts	Total GHG Impacts	Total GHG Impacts
Year	**kg N**	**kg**	**Ha**	**tCO_2e**	**tCO_2e**	**tCO_2e**
2019	(14,147)	(312,127)	(90)	(44,488)	(350)	(44,838)
2020	(14,147)	(312,127)	0	(1,538)	(350)	(1,888)
2025	(14,147)	(312,127)	0	(1,538)	(350)	(1,888)
2030	(14,147)	(312,127)	0	(1,538)	(350)	(1,888)
2035	(14,147)	(312,127)	0	(1,062)	(350)	(1,412)
2040	(14,147)	(312,127)	0	(1,062)	(350)	(1,412)
2045	(14,147)	(312,127)	0	(1,062)	(350)	(1,412)
2050	(14,147)	(312,127)	0	(1,062)	(350)	(1,412)
Somme	**(452,704)**	**(9,988,071)**	**(90)**	**(82,637)**	**(11,207)**	**(93,844)**

It has been estimated that around 5,000 small rice mills are in operation around the country.[21] If the results presented above for Scenario 3 (both pilots implemented together) were scaled up to half of this number at the national level, then the physical impacts would be significant. This simple scale-up analysis assumes that both pilots are implemented at 2,500 small mills and surrounding rice cultivation areas by 2035. As shown in Table 4.15, over 225,000 Ha of forest would be conserved from conversion to rice production. This avoided level of deforestation would result in GHG reductions of over 296 teragrams[22] (Tg) of CO_2 through 2050.

[21] Small rice mills have paddy rice capacities of 2 tonnes or less per day. Food Fortification Initiative, CÔTE D'IVOIRE, Global Alliance for Improved Nutrition (GAIN). Summary of rice production and imports. Produced 2016 or 2017. Note: as of September 2019, this document has been removed from the GAIN website.

[22] A teragram is equal to one million tonnes.

Table 4.15. National Scale Physical Impact Results for Both Pilots Implemented Together

	Scenario 3: Les deux pilotes				
	Conversion de forêt évitée	CO_2 évité de la déforestation	Autres réductions de GES: culture intelligente	Réduction des GES: Bio-briquettes	Total des impacts de GES
An	**Forest Conversion Avoided**	CO_2 Avoided from Deforestation	Other GHG Reductions: Smart Cultivation	GHG Reductions: Bio-briquettes	Total GHG Impacts
Year	**Ha**	**tCO_2**	**tCO_2e**	**tCO_2e**	**tCO_2e**
2019	(90)	(43,677)	(811)	(350)	(44,838)
2020	(6,682)	(3,232,826)	(60,832)	(26,267)	(3,319,925)
2025	(14,367)	(7,609,768)	(866,299)	(374,057)	(8,850,124)
2030	(10,593)	(6,514,091)	(1,647,157)	(711,221)	(8,872,469)
2035	(13,406)	(8,193,373)	(2,027,737)	(875,551)	(11,096,661)
2040	0	(1,816,828)	(2,027,737)	(875,551)	(4,720,116)
2045	0	(1,816,828)	(2,027,737)	(875,551)	(4,720,116)
2050	0	(1,816,828)	(2,027,737)	(875,551)	(4,720,116)
Somme	**(225,750)**	**(151,942,750)**	**(49,740,630)**	**(21,477,363)**	**(223,160,743)**

With the additional GHG reductions from smart rice cultivation and rice husk briquetting, the total GHG reductions through 2050 are estimated to be over 223 $TgCO_2e$. Through just 2030, about 110 $TgCO_2e$ would be reduced. To put this value into some context, the Intended Nationally Determined Contribution (INDC) of the country to the Paris Accord is to achieve a 28% reduction in GHG emissions as compared to BAU.[23] Notably, as shown in Table 4.16, that baseline does not include the forestry sector. As currently expressed, the INDC would produce ~10 Tg of GHG reductions by 2030. By comparison, the combined GHG impacts of both pilots scaled to the national level would produce the ~110 Tg mentioned above. Clearly, a national baseline including the forestry sector is needed to fully evaluate the impacts of pilots such as those analyzed here and for other INDC measures.

23 https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/C%C3%B4te%20d'Ivoire%20First/INDC_CI_22092015.pdf.

Table 4.16. Summary of Côte d'Ivoire's INDC Commitment

Sous-secteurs	2012	BAU (2030)		Scénario bas carbone (2030)	
	Emissions (ktonne Equiv. CO_2)	Emissions (ktonne Equiv. CO_2)	Pourcentage de hausse par rapport à 2012	Emission (ktonne Equiv. CO_2)	Pourcentage de baisse par rapport à BAU
Production d'électricité	3 442,63	11 892,00	52,93	9 216,56	-7,81
Transport	2 389,36	6 441,27	25,38	4 477,55	-5,73
Industrie	1 000,81	2 698,01	10,63	1 875,48	-2,40
Approvisionnement en énergie	781,64	2 136,39	8,49	1 485,08	-1,90
Bâtiments	627,03	1 690,34	6,66	1 175,02	-1,50
Agriculture	6 140,80	7 059,16	5,75	4 722,57	-6,82
Déchets	1 582,08	2 336,09	4,72	1 623,90	-2,08
Total	**15 964,35**	**34 253,25**	**114,56**	**24 576,16**	**-28,25**

Table 4.17 provides a summary of net societal costs for both pilots scaled to the national level assuming the scale-up is completed at 2,500 rice mills by 2035. The analysis indicates that a program of this size would have profound impacts on direct societal costs for small scale rice production systems in Côte d'Ivoire. At the program's peak in 2035, when all 2,500 small rice mills have begun producing briquettes and 150 hectares of smart rice cultivation have been established around each, the program will save over 88 billion CFA per year (almost $152 million USD). A net savings to society results of almost 9,000 CFA/tCO_2e ($15/$tCO_2$e).

Table 4.17. Total Net Societal Costs for Scaling-Up Both Pilots to the National Level

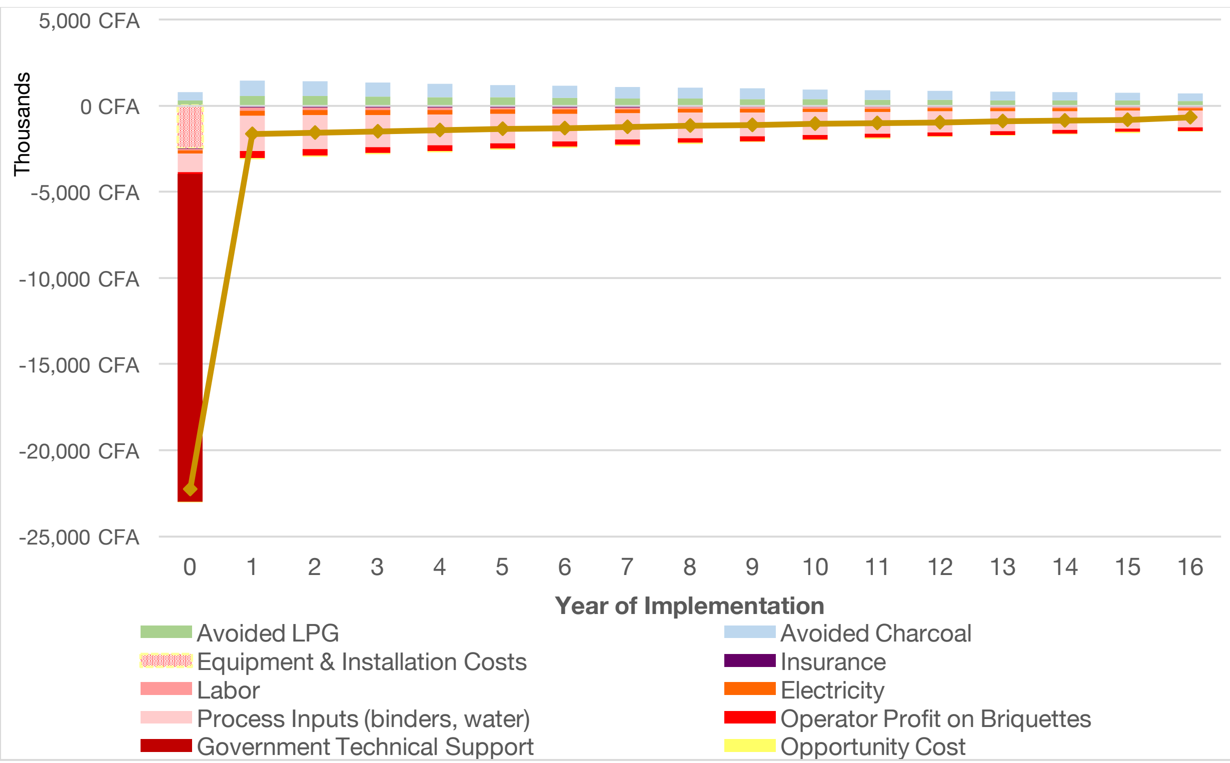
L'échelle nationale National Scale		
	Les deux scénarios	Les deux scénarios
	Total des coûts du programme actualisés	Efficacité des coûts Cost Effectiveness
An Year	million CFA 2019	CFA 2019/tCO_2e
2019	-56 CFA	
2020	-5,460 CFA	
2025	-60,873 CFA	
2030	-90,606 CFA	
2035	-88,150 CFA	
2040	-68,930 CFA	
2045	-53,900 CFA	
2050	-42,148 CFA	
Somme	**-2,004,737 CFA**	**-8,983 CFA**

5.0 Financial Analysis of the Rice Husk Briquetting Pilot

To further inform future support efforts on pilot project implementation in Gagnoa and to scale-up the pilot to regional and national levels, a financial analysis of the pilot project was conducted. The financial analysis was developed from the business producer perspective of the project owner (rice mill operator), rather than consumers or society as a whole. However, a similar approach (discounted cash flow analysis) and inputs are used. This type of analysis is useful to explore the reasons behind the ultimate financial success or failure of a project or program and the diagnoses of financial benefits, needs, risks, and sources. The main difference from direct net societal cost analysis is that only the financial cost and revenue streams to the project owner are included and are represented from that perspective rather than from a consumer or social values impact. In this case, the technical support costs and the consumer and societal savings from fuels avoided through the introduction of rice husk briquettes (LPG and charcoal) are excluded. Also, operator profit is treated as income to the mill operator, while in a societal cost analysis, it is one of the costs that society must pay for the new fuel source.

Figure 5.1 below is a chart showing the discounted societal cost/benefits analysis of the Gagnoa rice husk briquetting pilot project. In this example, societal benefits are shown as positive values, while societal costs are shown as negative values. This was done to provide consistency with the financial analysis to follow.

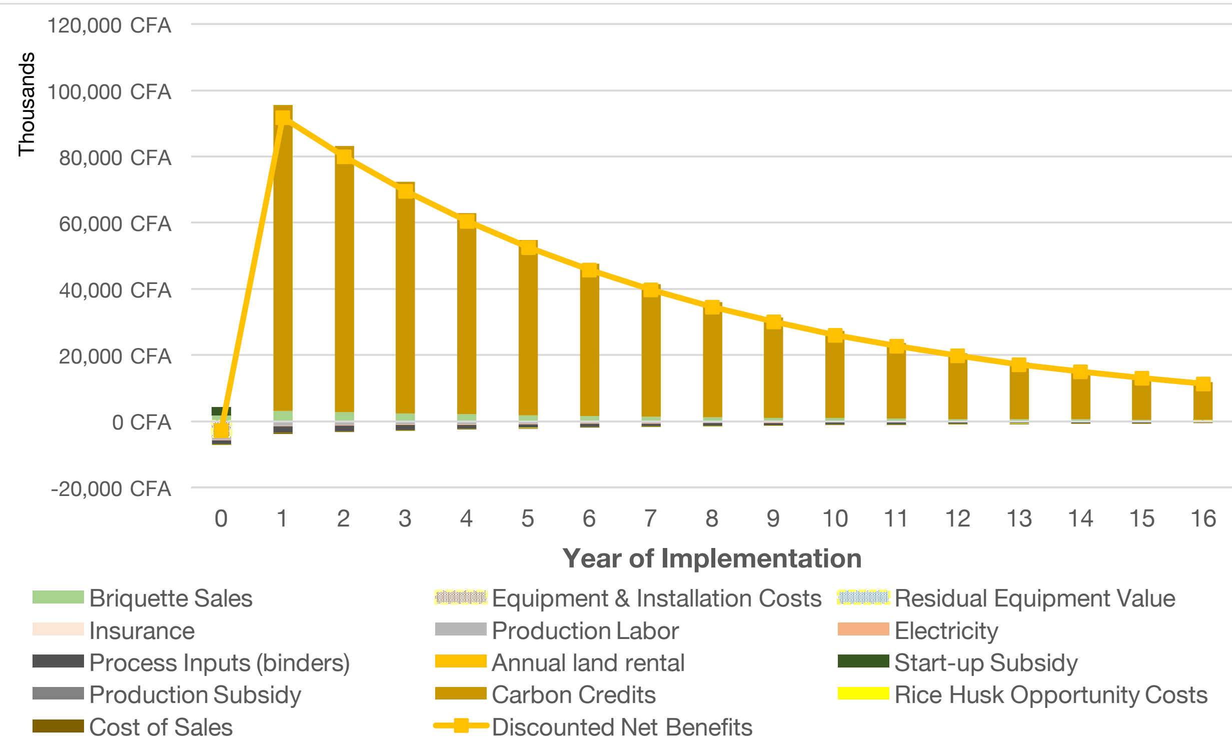
Figure 5.1. Discounted Net Societal Cost Analysis of the Gagnoa Rice Husk Briquetting Pilot Project



In addition, as shown in Figure 5.1, the initial investment costs are all placed in year 1 without any presumed financing (unlike the net societal costs assessment in Section 4 which assumed 100% financing of equipment over 15 years).[24] Consistent with the analysis shown in Section 4, the results indicate that the societal costs outweigh the benefits, so the discounted net benefits value never exceeds 0 during the life of the pilot (assumed to be 15 years based on expected equipment life).

Figure 5.2 below provides a similar chart for the financial analysis of the pilot (from the mill operator's perspective). Only the cost components relevant to the operator's business are retained, so items like society's avoided cost of LPG and charcoal use have been removed. Importantly, just as in the societal analysis, the net costs always exceed the benefits (or "income" from the pilot). Note that although other forms of income like carbon credits and subsidies have been added to the legend, they are set at zero in this example consistent with the societal cost analysis.

Figure 5.2. Financial Analysis of the Gagnoa Rice Husk Briquetting Pilot Project



In addition to the financial analysis appearing unattractive from both an operator and lender perspective, production costs for rice husk briquettes are roughly twice the local price of charcoal. Charcoal sells for roughly 70 CFA/kg locally in 100 kg bags. The estimated briquette production costs are ~160 CFA/kg which excludes annualized equipment costs. With 100% of equipment costs annualized over their expected 15-year life, the production costs exceed 190 CFA/kg of briquette. Therefore, to support the success of any scale-up efforts for the pilot to regional and national scales, financial support mechanisms will be needed for the producer in addition to other interventions to support cooking fuel market transformation. The latter could include taxation schemes on charcoal to minimize the difference in market prices between it and green fuels, like rice husk briquettes or other sustainable sources of biomass.

[24] Note that in the actual Gagnoa pilot, the rice mill operator was provided with some used briquetting equipment that had been rehabilitated for use in the pilot. To inform pilot scale-up, the analyses in this report assume that the equipment would need to be purchased new.

Additional marketing efforts will be needed to support the positioning of these fuels as not only more sustainable, but superior in terms of cooking performance, air pollution, and other attributes. This should involve working with institutions in Côte d'Ivoire with expertise in clean cookstoves, as well as other African countries with such experience. In particular, those type of cookstoves that have been optimized to use compressed carbonized biomass fuels.

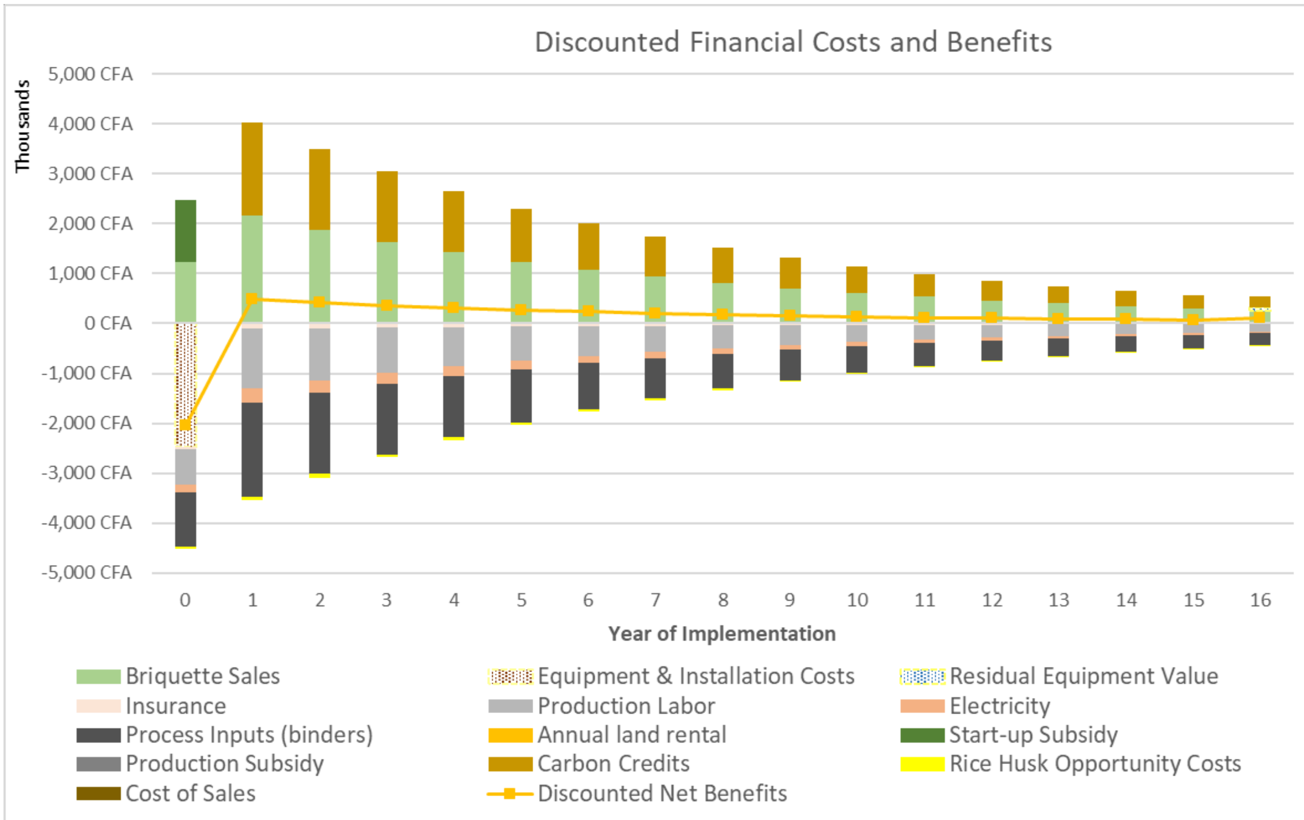
For operators of small rice mills, some type of subsidy will be needed and possibly more than one type. Start-up subsidies, such as national/international grant programs to offset a portion of equipment costs will be helpful; however, as indicated above, the annualized equipment costs are a relatively small piece of the puzzle, as it relates to rice husk briquette competitiveness. Operational costs need to come down and likely be supported by some type of production subsidy. Ideally, this would be in the form of a carbon crediting program, whereby the mill operator is provided a carbon offset for every kilogram sold into the local market.

The effect of the application of subsidies is shown in Figure 5.3 below. In Figure 5.3, a start-up subsidy (international grant) of 50% of equipment costs has been added. More importantly, a carbon crediting program was also added. Each briquetting project will protect a given amount of forest based on the amount of briquettes produced and sold into the local market. For example, a project the size of the Gagnoa pilot is estimated to protect about 128 Ha. Note that this is the total amount of forest that is protected as long as the briquettes are produced and sold into the local market (not an additional 128 Ha each year of the project). So, the total carbon offset is divided by the project life (15 years), and credit payments are applied annually. A carbon credit value of 65,000 CFA/tCO_2 is assumed in this assessment (about $112/t$CO_2$e).[25] This level of project subsidy barely exceeds the break-even point for the operator (net present value of the project over 15.5 years is almost 1.3 million CFA; or $2,230 USD). The discounted payback period is 6.8 years and the internal rate of return (IRR) is -10%. At an assumed market value of 150,000 CFA/t, the briquettes would still be sold at a loss (note that this is still well-above the local charcoal price).

Figure 5.4 shows an alternative analysis, assuming an additional 30% up-front subsidy on initial investments and with the same carbon credit value. With this level of subsidies, the project financials look more positive for the mill operator: 3.3-year payback period; IRR = 35%; and a 13% profit on briquettes (first full year of production).

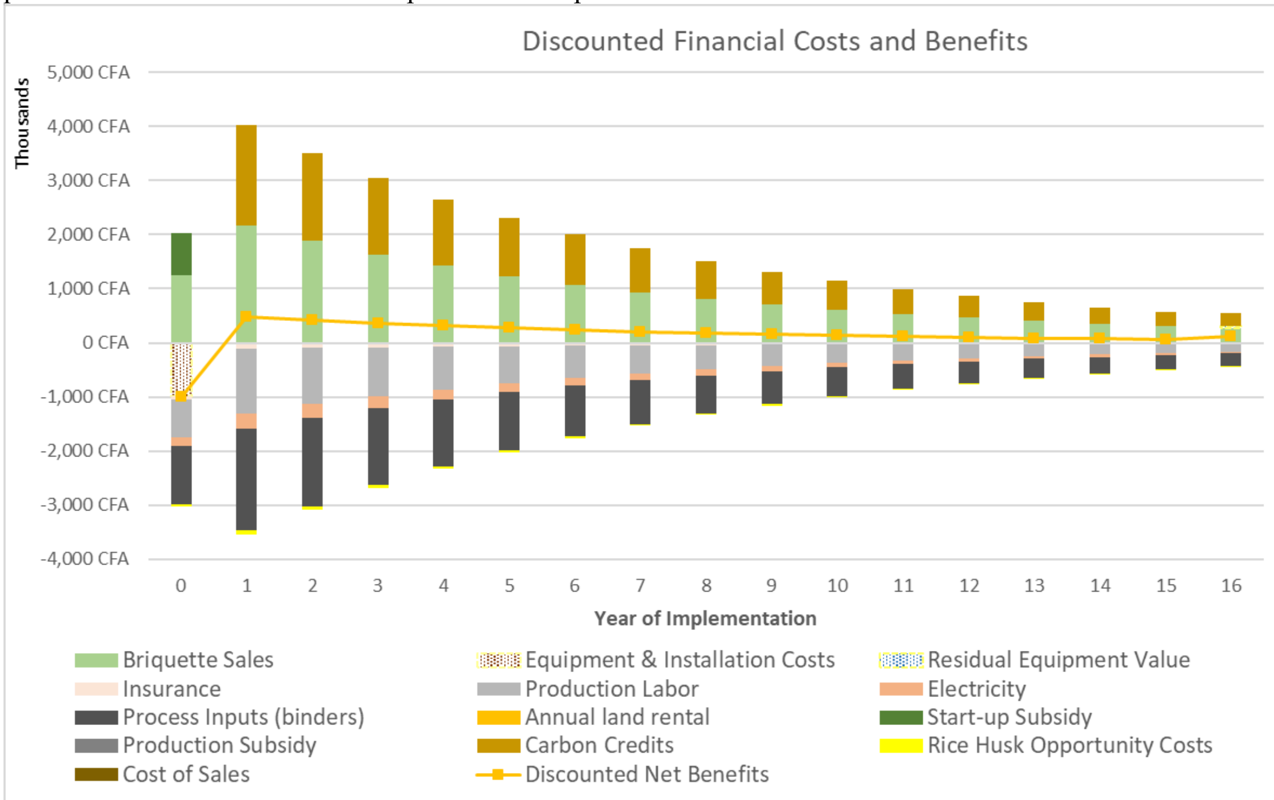
Figure 5.3. Financial Analysis of a Small Rice Husk Briquetting Project with Subsidies. Includes a 50% cost share of initial equipment costs and a carbon credit of 65,000 CFA/tCO_2. This level of subsidy produces a break-even point for the operator.

[25] Additional financial assumptions include a discount rate of 10% and a risk premium of 5%; equipment residual value of 10% after 15 years, 16.6 t/yr of briquette production, total initial investments of 4,934,800 CFA.



Discounted Financial Costs and Benefits
Thousands
5,000 CFA
4,000 CFA
3,000 CFA
2,000 CFA
1,000 CFA
0 CFA
-1,000 CFA
-2,000 CFA
-3,000 CFA
-4,000 CFA
-5,000 CFA
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Year of Implementation
Briquette Sales
Equipment & Installation Costs
Residual Equipment Value
Insurance
Production Labor
Electricity
Process Inputs (binders)
Annual land rental
Start-up Subsidy
Production Subsidy
Carbon Credits
Rice Husk Opportunity Costs
Cost of Sales
Discounted Net Benefits

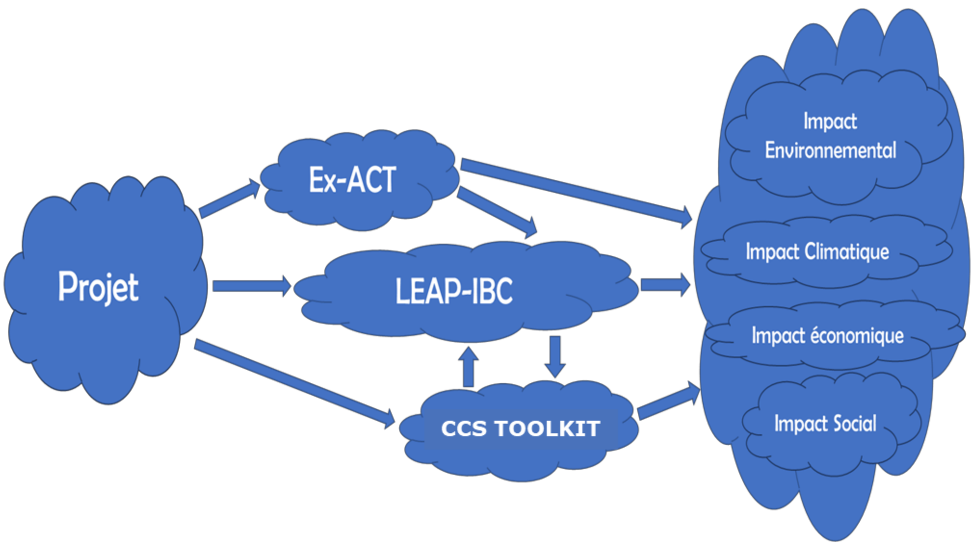
Figure 5.4. Financial Analysis of a Small Rice Husk Briquetting Project with Subsidies. Includes a 80% cost share of initial equipment costs and a carbon credit of 65,000 CFA/tCO_2. This level of subsidy produces a better than break-even point for the operator.



Annex A. Côte d'Ivoire LEDS Modelling System

The Africa LEDS team designed and applied an integrated modelling system shown in the Figure below to assess climate and economic impacts for the two pilots described in Section 2, as well as for both pilots if implemented together. The modelling system includes the following tools: *LEAP-IBC* (Long range Energy Alternatives Planning – Integrated Benefits Calculator)[26]; *EX-ACT* (Ex-ante Carbon Tool)[27]; *Microeconomic Costs and Macroeconomic Assessment Tools from the Center for Climate Strategies* analytical toolkit (CCS toolkit)[28]; and a geographic information system (GIS; as a data source for the other tools in the modelling system).

Figure A-1. Modelling Tools Selected for the Côte d'Ivoire LEDS Modelling System



The following is a breakdown of additional activities that were undertaken in modelling the ground demonstrations and their scale-up as described in in the report.

Activity	Sub-activities and Related Results
Capacity building of the modelling team.	Training and capacity building workshops focusing on key modelling tools used: - LEAP, EX-ACT, CCS toolkit - for Côte d'Ivoire national experts.
Design, modelling, and communication of the LEDS strategy with the actors involved in the implementation of NDCs.	- Facilitating acquisition of modelling tools (computer, satellite image, external hard disk). - Hands-on LEDS modelling training between CCS and the Côte d'Ivoire national team. Selection and design of the integrated modelling system. - Familiarizing the integrated model with stakeholders (Academic, sector ministries and development agencies) through facilitating training forum.

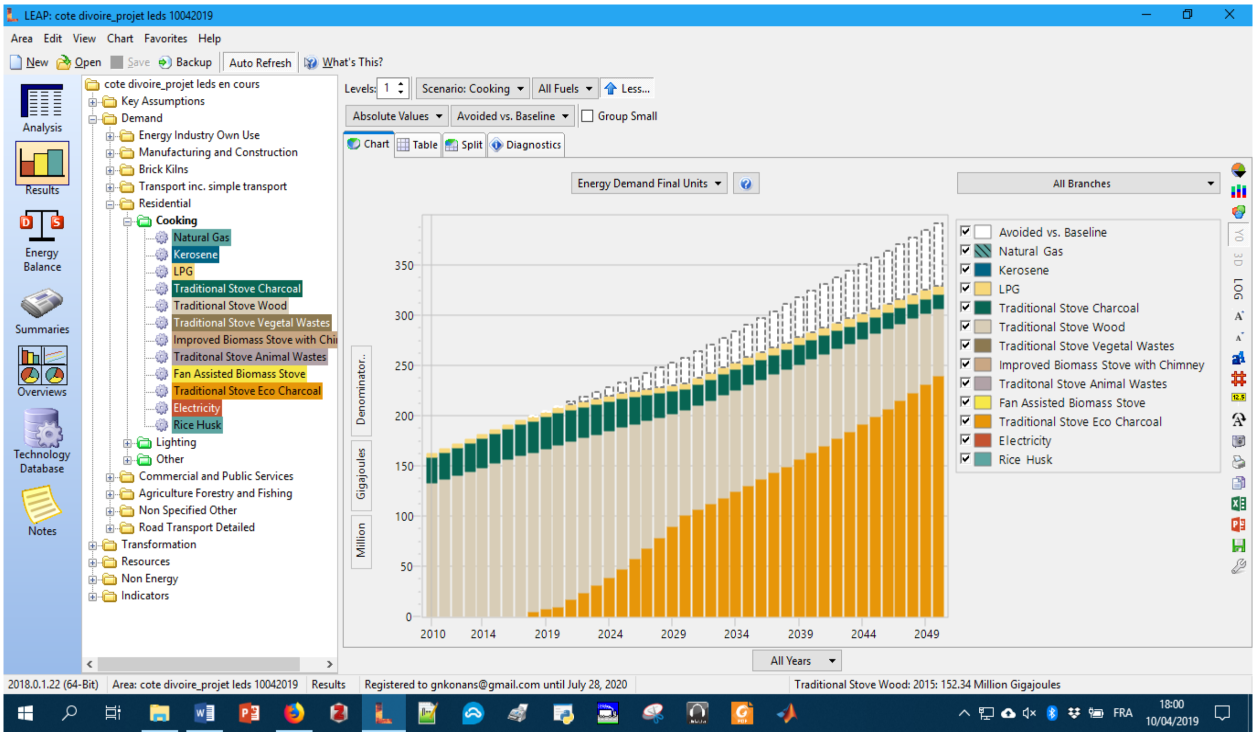
[26] LEAP-IBC website: *https://www.sei.org/publications/leap-ibc/*.
[27] EX-ACT website: *http://www.fao.org/tc/exact/ex-act-home/en/*.
[28] Link to CCS website description of step-wise action planning and the associated analytical toolkit.

Activity	Sub-activities and Related Results
	- Data gathering to support modelling of both ground demonstrations: field missions and literature searches. - Review of draft interim results with CCS and the Côte d'Ivoire national team.
Coordination of modelling activities.	- Coordination of modelling work (Ministry of Environment, Modelling Team, Political Task Force). - Final team workshop to review final results of direct and indirect impacts at the demonstration and national scale-up levels. - Project close-out workshop to present results to policy actors.

A summary is provided below for each of the 3 primary tools to describe how they were applied, and the results obtained:

LEAP-IBC: Over the long-term, the model developed for application in this project is expected to become the central tool within the modelling system, providing integrated impacts assessment across the energy and non-energy sectors. Although LEAP-IBC is generally known and applied as a system to develop models of the energy system of a jurisdiction, advanced users can extend to incorporate data from the non-energy sectors (agriculture, FOLU and waste management) either directly or through linkages to the other tools allowing for complete economy-wide tracking of energy, resource and emissions impacts. Currently, the Africa LEDS team is establishing linkages to the EX-ACT tool and to tools within the CCS toolkit to allow for assessments of both direct (micro-) and indirect (macro-) impacts across the energy and non-energy sectors.

Figure A-2. Sample Screenshot from the LEAP-IBC Cote d'Ivoire Model. This screenshot indicates the expected avoided GHG emissions at the national level for production and use of rice husk briquettes as a cooking fuel.



EX-ACT: this MS-Excel based tool was applied to assess GHG reductions for Pilot 2 (climate smart rice cultivation). The Figure below provides a screenshot with summary results.

Figure A-3. Sample Screenshot from the Application of EX-ACT for the Pilot 2 Analysis of Climate Smart Rice Cultivation. These results indicate total GHG reductions of 264 tCO_2e/yr for the two 50 ha pilot projects.

Project Name	0	Climate	*Tropical (Moist)*	Duration of the Project (Years)	32
Continent	*Africa*	Dominant Regional Soil Type	*LAC Soils*	Total area (ha)	100

Components of the project	Gross fluxes Without All GHG in tCO2eq Positive = source / negative = sink	With	Balance	Share per GHG of the Balance All GHG in tCO2eq CO_2 Biomass	Soil	Other	N_2O	CH_4	Result per year Without	With	Balance
Land use changes											
Deforestation	0	0	0	0	0		0	0	0	0	0
Afforestation	0	0	0	0	0		0	0	0	0	0
Other LUC	0	0	0	0	0		0	0	0	0	0
Agriculture											
Annual	0	0	0	0	0		0	0	0	0	0
Perennial	0	0	0	0	0		0	0	0	0	0
Rice	12,949	4,592	-8,357	0	-1,898		-111	-6,349	405	144	-261
Grassland & Livestocks											
Grassland	0	0	0	0	0		0	0	0	0	0
Livestocks	0	0	0				0	0	0	0	0
Degradation & Management	0	0	0	0	0		0	0	0	0	0
Coastal wetlands	0	0	0	0	0		0	0	0	0	0
Inputs & Investments	1,902	1,816	-86			-67	-20	0	59	57	-3
Fishery & Aquaculture	0	0	0			0	0	0	0	0	0
Total	14,851	6,408	**-8,443**	0	-1,898	-67	-130	-6,349	464	200	-264
Per hectare	149	64	-84	-0.7	-19.0	-0.7	-1.3	-63.5			
Per hectare per year	4.6	2.0	-2.6	0.0	-0.6	0.0	0.0	-2.0	4.6	2.0	-2.6

CCS Toolkit: two MS-Excel based tools were selected to assess:

1. Cost impacts (micro-economic or direct impacts) for both pilots and then to also assess the combined impacts for implementing both ground demonstrations simultaneously; and

2. The potential for positive socio-economic (macro-economic or indirect) impacts resulting from implementing one or both ground demonstrations.

The CCS micro-analysis tool served two purposes: 1. assessing energy and non-energy impacts and costs for both pilots (in the future, the Africa LEDS team plans to conduct these combined energy and non-energy assessments within LEAP-IBC); and 2. As a quality assurance (QA) check against the application of both LEAP-IBC and EX-ACT (the CCS tools are completely transparent allowing for an analyst to follow the calculation of each result back to the initial inputs). As of the writing of this report, the Africa LEDS team is still conducting this QA check.

Annex B. Field Activities Carried Out by the Côte d'Ivoire Africa LEDS Team

The following table summarizes the activities undertaken:

Activity	Sub-activities and Related Results
Activity 1: feasibility study, farmer capacity building for climate- smart agriculture application of intensive rice farming systems	- Identification missions for beneficiary rice farmers and mapping of local stakeholders - surveying about 100 households and restaurants to establish energy partners and current market sentiment on rice husk briquettes to establish market gap - cash flows and business plan analysis for returns to rice mill operator for adding in the rice husk briquetting process as compared to business as usual (BAU) treatment of rice husk as low value animal bedding or waste material - Rehabilitation of rice farms to implement climate smart rice cultivation practices: land preparation – bush clearing and levelling (two project sites: Tipadipa and Tiétiékou) rehabilitation of irrigation water channels – cleaning and desilting acquisition and distribution of rice seedlings and fertiliser preparation and maintenance of rice seedling beds harvesting and storage of rice straw from 100ha rice farm composting of rice straw with manure re-application of composted rice straw as an organic fertilizer - Training, supervision and monitoring of beneficiary farmers on Sustainable Rice Intensification application, rice marketing, production of biofertilizer from composted rice straw, water management infrastructure, sustainable agricultural practices, - 87 rice growers and other professionals trained
Activity 2: support production and trade of fuel briquettes made from rice husks	- Facilitate construction of the pyrolysis reactor for fuel briquettes production - Facilitate rehabilitation of briquette making machines by the Africa Business Group - Facilitate marketing of briquettes by the Africa Business Group - Facilitate testing of briquettes in clean cookstoves and collect data - Facilitate laboratory testing towards improving the quality of fuel briquettes - Training on socioeconomic aspects and marketing of briquettes and development of business plan studies
Activity 3: coordination of field activities	- Coordination of activities (Ministry of the Environment, ANADER) - Development of case study based on the demonstration project - Modelling of the impacts of each pilot implemented separately and together. Scale-up of those results to the national level.

Annex C. Data Inputs for Climate Smart Rice Cultivation

Paramètre Parameter	**Valeur** Value	**des unités** Units	**Parameter**	**Remarques** Notes
Taille du programme pilote	150.5	Ha	Pilot Program size: one 89.5 ha pilot and one 61 ha pilot.	Taken from Local Team Progress Report
Cycle de production de riz par an	1.0	sans unité	Rice production cycles/year	Taken from Scenario 1
Conditions habituelles: nombre de jours par cycle de production de riz	120	jours/cycle	BAU days per rice production cycle	Assumed based on typical length in tropical areas.
Conditions de program pilote: nombre de jours par cycle de production de riz	120	jours/cycle	Pilot program days per rice production cycle	Assumed based on typical length in tropical areas.
Conditions habituelles: additions d'engrais azotés chimiques	94.0	kg N/Ha/cycle	Business as usual chemical nitrogen fertilizer additions	From local team report: 100 kg/Ha of urea (46% N) and 200 kg of NPK (assumed at 24% N) per cycle.
Conditions habituelles: additions d'engrais azotés résidus de récolte	2.9	kg N/Ha/cycle	Business as usual nitrogen additions from crop residue	Calculated using paddy rice yield and IPCC defaults for rice cultivation
Conditions habituelles: additions d'engrais azotés ajout d'azote provenant d'engrais organiques	0.0	kg N/Ha/cycle	Business as usual nitrogen additions from organic fertilizers	Based on reports from the field.
Conditions de programme pilote: additions d'engrais azotés chimiques	0.0	kg N/Ha/cycle	Pilot program chemical nitrogen fertilizer additions	Based on reports from the field, 100% chemical N additions were replaced by composted straw/manure.
Conditions de programme pilote: additions d'engrais azotés résidus de récolte	7.3	kg N/Ha/cycle	Pilot program nitrogen additions from crop residue	Assumes total N additions are kept constant with BAU conditions
Conditions de programme pilote: additions d'engrais azotés ajout d'azote provenant d'engrais organiques	89.6	kg N/Ha/cycle	Pilot program nitrogen additions from organic fertilizers	Assumes total N additions are kept constant with BAU conditions
Facteur de combustion pour la paille de riz	0.80	sans unité	Combustion factor for rice straw	IPCC default

Paramètre Parameter	**Valeur** Value	**des unités** Units	**Parameter**	**Remarques** Notes
Teneur en azote des résidus hors sol	0.007	kg N/kg matière sèche	Nitrogen content of above-ground residues	IPCC default
Facteur d'émission directe d'oxyde nitreux pour le riz inondé	0.003	kg N2O-N/kg N	Direct nitrous oxide emission factor for flooded rice	Emission factor for flooded rice fields
Facteur d'émission de méthane pour le riz inondé	1.30	kg CH4/Ha-jour	Daily baseline CH4 EF for continuously flooded rice	No flooding prior to cultivation, continuous flooding during cultivation, no organic amendments.
Facteur d'échelle des émissions de méthane en cas d'inondation intermittente: aération multiple	0.52	sans unité	Methane EF scaling factor for intermittent flooding: multiple aeration	Assumed change for the pilot program.
Conditions habituelles: enlèvement de paille de riz pour utilisation comme litière ou autre	0.00	sans unité	BAU fraction of rice straw removed for use as bedding or other purpose	Assumed; replace with an estimate from field data.
Conditions de program pilote: enlèvement de paille de riz pour utilisation comme litière ou autre	0.80	sans unité	Pilot program fraction of rice straw removed for use as bedding or other purpose	Assumed; replace with an estimate from field data.
Conditions habituelles: rendement du riz paddy	2,450	kg/Ha	BAU rice yield of paddy rice	USDA 2018 Rice Annual report for Cote d'Ivoire.
Conditions habituelles: Rendement en matière sèche	2,181	kg matière sèche/hectare	BAU dry matter yield for paddy rice	Calculated
Conditions habituelles: Matière sèche résiduelle en surface	2,074	kg matière sèche/hectare	BAU above-ground residue dry matter yield	Calculated
Teneur en matière sèche du riz paddy	0.89	sans unité	Dry matter content of paddy rice	IPCC default
Augmentation du rendement du riz paddy grâce à l'amélioration des semis et d'autres pratiques de culture	150%	%	Increase in paddy rice yield from improved seedling and other cultivation practices	100% increase from BAU yield.

Paramètre Parameter	**Valeur** Value	**des unités** Units	**Parameter**	**Remarques** Notes
Conditions de programme pilote: rendement du riz paddy	6,125	kg/Ha	Pilot program rice yield of paddy rice	Calculated
Conditions de programme pilote: Rendement en matière sèche	5,451	kg matière sèche/hectare	Pilot program dry matter yield for crop	Calculated
Conditions de programme pilote: Matière sèche résiduelle en surface	5,181	kg matière sèche/hectare	Pilot program above-ground residue dry matter yield	Calculated
Accumulation de carbone du sol dans les rizières inondées	0.00	tC/Ha-an	Soil carbon accumulation in flooded rice fields with straw burning	Assumed to remain constant due to residue burning
Accumulation de carbone dans le sol dans les rizières inondées par intermittence sans combustion de la paille; toute la paille reste sur la terrain	(0.863)	tC/Ha-an	Soil carbon accumulation in intermittently flooded rice fields with no straw burning; all straw remains on the field	Average of 3 studies for the amount of soil carbon retained per unit of straw left on the field (0.421 kg soil C/kg C biomass). The cited Minamikawa study found carbon content of rice straw to be 39.6%.
Conditions habituelles: consommation de carburant diesel pendant la culture du riz (par exemple pendant la fertilisation, les récoltes, etc.)	0.00	L/Ha	BAU: Diesel fuel consumption during BAU rice cultivation (e.g. during fertilization, harvests, etc.)	Confirmed with local team that this is all done by hand labor.
Conditions de programme pilot: consommation de carburant diesel pendant la culture en plus de l'enlèvement de la paille de riz pour le compostage et la réapplication du compost.	0.00	L/Ha	Pilot Program: diesel fuel consumption during cultivation in addition to rice straw removal for composting and re-application of compost.	Confirmed with local team that this is all done by hand labor.
Facteur d'émission de GES de la combustion de carburant diesel	2.66	kg CO2e/L	Diesel fuel combustion GHG emission factor	2006 IPCC Guidelines; volume 2. Energy
Période d'accumulation de carbone dans le sol pour les systèmes où la paille est laissée sur le terrain	12	an	Soil carbon accumulation period for systems where straw is left on field	Number of years until soil reaches saturation in soil carbon level

Paramètre Parameter	**Valeur** Value	**des unités** Units	**Parameter**	**Remarques** Notes
Potentiel de réchauffement global de l'oxyde nitreux	265	sans unité	Nitrous oxide global warming potential	IPCC AR5
Potentiel de réchauffement global du méthane	28	sans unité	Methane global warming potential	IPCC AR5
Facteur d'émission de méthane pour la combustion de la paille de riz	2.7	g CH4/kg matière sèche	Methane emission factor for rice straw burning	2006 IPCC Guidelines, Volume 4, Chapter 2 "Generic Methodologies Applicable to Multiple Land Use Categories"
Facteur d'émission d'oxyde nitreux pour la combustion de la paille de riz	0.007	g N2O/kg matière sèche	Nitrous oxide emission factor for rice straw burning	2006 IPCC Guidelines, Volume 4, Chapter 2 "Generic Methodologies Applicable to Multiple Land Use Categories"

Paramètre Parameter	**Valeur** Value	**des unités** Units	**Parameter**	**Remarques** Notes
Conditions habituelles: coûts de semences de riz	41,500	CFA/Ha	BAU rice seed costs	Table 3 from the data source. $29/acre for conventional variety (~41,500CFA/Ha). These are US prices and should be updated with local data.
Coût du semis du riz dans le programme pilote	124,500	CFA/Ha	Pilot improved rice seed costs	Table 3 from the data source. An increase in cost by a factor of 3 to adopt the hybrid variety seed.
Coûts d'engrais azotés organiques	76	CFA/kg N	Organic N fertilizer costs	Assumed at half the cost of chemical N fertilizer. Covers purchase and transport of manure.
Coûts d'engrais azotés chimiques	151	CFA/kg N	Chemical N fertilizer costs	Calculated from the data in Table A1.26 in the data source. Average for Ghana Volta and northern growing regions.
Coûts du carburant diesel	725	CFA/L	Diesel fuel costs	Assumed; since all cultivation occurs via hand labor, this value has not been applied in the analysis.
Coûts de la main d'œuvre agricole	214	CFA/heure	Farm labor costs	Calculated from the value in the data source for Ghana minimum wage levels (Table A1.25): $245/day (8 hours/day) and an exchange rate of 580CFA/USD. Escalated by 20% to better reflect current labor rates.

Paramètre Parameter	**Valeur** Value	**des unités** Units	**Parameter**	**Remarques** Notes
Conditions habituelles: travail pour la plantation	24.0	heure/Ha	BAU planting labor	Approximated from the data provided for Ghana irrigated systems (Figure A1.27) in the data source (~3 days/Ha at an assumed 8 hours/day). Note that any land preparation labor is assumed to be the same under BAU and pilot scenarios and therefore not included here.
Conditions de programme pilote: travail pour la plantation	31.2	heure/Ha	Pilot program planting labor	Assumed to be 30% higher than BAU labor due to the need to establish a seedling nursery and transplant seedlings from the nursery to the cultivation plot.
Conditions habituelles: travail de culture	400	heure/Ha	BAU cultivation and harvest labor	
Conditions de programme pilote: travail de culture et récolte	440	heure/Ha	Pilot program cultivation and harvest labor	Assumes an additional 5 days of labor for rice straw management (removal from field, composting, re-application to field).
Bénéfice paysan	7.5%	% of paddy rice value	Farmer profit	Estimated from Figure !.28 in the data source. Build-up of production costs for irrigated white rice in Ghana.
Valeur du riz paddy	(184)	CFA/kg	Value of paddy rice	Value assumed to be two-thirds of finished rice documented for Senegal in the World Bank citation (Fig. A1.22). Based on production cost and farmer margin provided for Ghana in Figure A1.28.
Frais de support technique	1,799,700	CFA	Technical support costs	Covers a wide array of costs: identification of beneficiary farmers, land and irrigation preparation, seed acquisition and seedling nursery prep., and training, supervision and monitoring of farmers.
Taux d'inflation annuel	2.0%	%/an	Annual rate of inflation	Assumed
Taux d'actualisation sociétal	5.0%	%/an	Societal discount rate	Assumed
Capital Recovery Factor (CRF)	0.087	sans unité	Assumed	Not applicable for this analysis
Equipment Life	15	years	Assumed	Not applicable for this analysis

Paramètre Parameter	**Valeur** Value	**des unités** Units	**Parameter**	**Remarques** Notes
Interest Rate	3.5%	%	Assumed	Not applicable for this analysis

Annex D. CCS Macro-Indicators Tool Guide

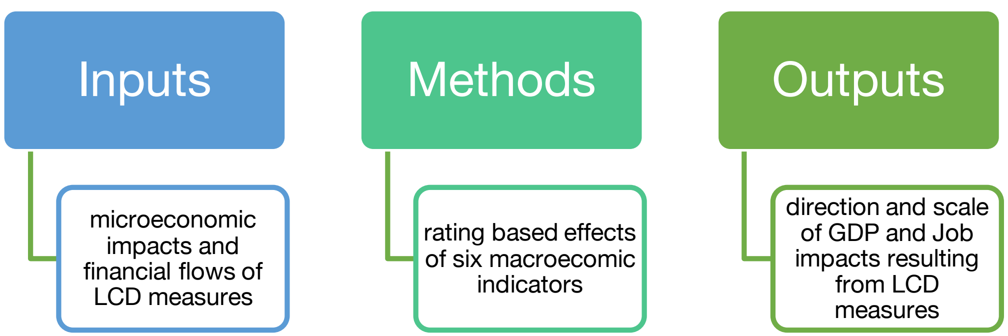
Côte d'Ivoire Low Carbon Development Macroeconomic Indicator Tool

(September 2019 Version)

User Guide

Background

This indicator tool allows users to visualize the role of policy implementation design parameters and estimated microeconomic performance (including financial flows) of specific policies and measures in all sectors on broader macroeconomic conditions (GDP and jobs). It does so through rating the influence of six key indicators that drive the direction and scale of macroeconomic impacts. This use of broad indicators to assess a policy or measure is intended as a *structured learning and evaluation* process, to provide a framework for thinking about the broader economic impacts of a policy option or measure, and to see the potential for that option or measure's direct spending and savings consequences to have not just one impact but possibly various distinct influences on different parts of the economy.



These six key indicators were developed through generally accepted procedures for economic and statistical analysis, including multivariate regression analysis, of results from advanced macroeconomic modeling (using the REMI model) of a wide range of low carbon policies and measures in all sectors contained in several US states climate action plans. A detailed report of this study is available at www.climatestrategies.us/library/library/download/905.

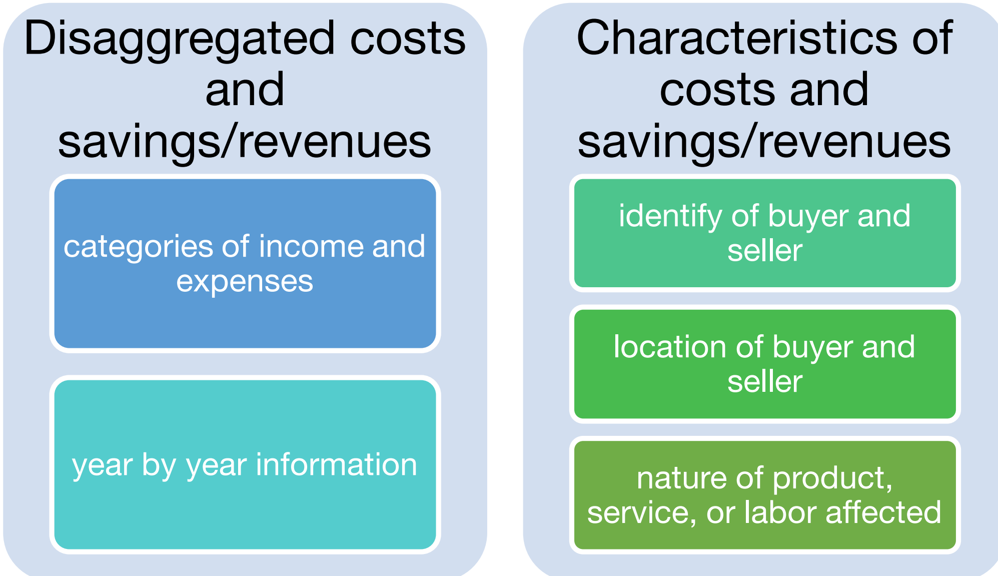
The six indicators associated with projected macroeconomic gains are:

1. Policy-induced shifts to technologies and practices with lower net implementation costs than those in the BAU scenario
2. shifts that generate overall savings on energy spending
3. shifts toward greater use of locally produced energy from local supply chains (solar and wind, with no fuel supply chains to speak of, do not qualify under this indicator)
4. stimulus provided to local supply chains
5. shifts to activities that require greater direct spending on labor
6. shifts to greater use of external versus domestic investment and/or greater net exports

The GDP and employment effects associated with these indicators result from shifts or changes in the pattern of spending (expenses) and savings and revenues (income) caused by adoption of new policy measures, as estimated by macroeconomic modeling using the REMI model. Using these indicators can provide insight on the direction and general scale of pressure an individual policy action can apply to the broader economy based on statistical analysis of empirical modeling. However, this tool does not produce numeric projections of overall impact on key economic indicators, and it does not substitute for macroeconomic modeling and the greater level of detail it provides.

Results of the macro indicator tool can help policy makers assess the potential positive or negative macroeconomic implications of policy design choices and microeconomic impacts (e.g. cost effectiveness and cash flow) and iterate toward better solutions that can be confirmed through more detailed modeling. In the process these indicator-based results can improve the quality of policy design choices and reduce the cost of later stage macroeconomic modeling analysis that may be time consuming and expensive.

Key Data and Required Information for Use

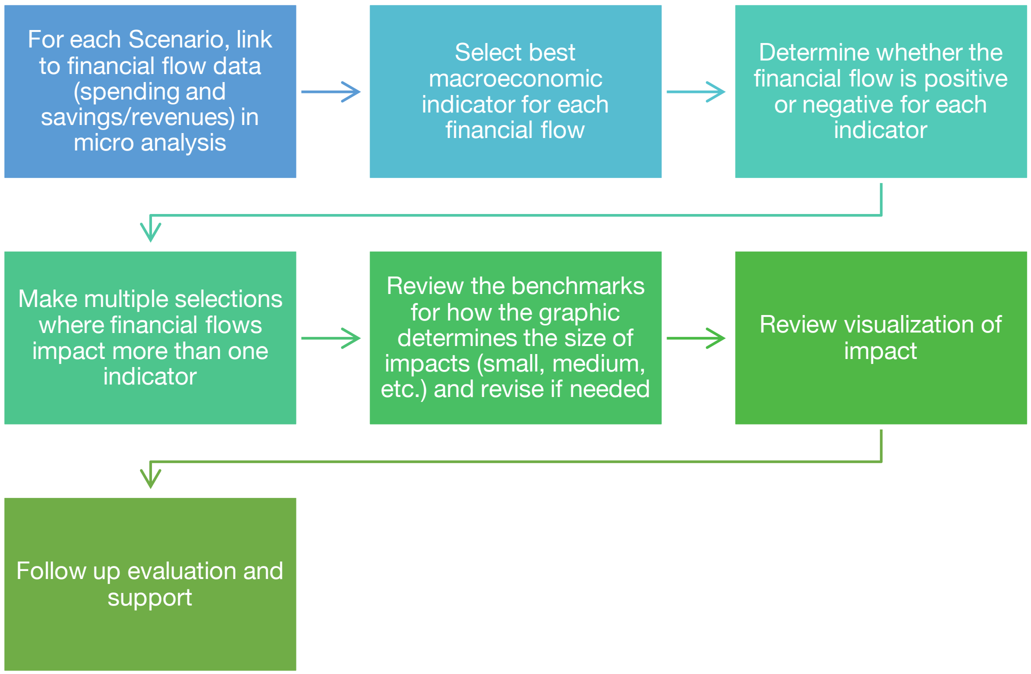


The crucial inputs to this tool are of two categories:

- The *disaggregated costs and savings* (monetary) to be produced by each policy measure, or option. These data are derived from the results of a direct impacts analysis of individual policy measures.
    - Ideally, this is detailed, year-by-year information on each individual cost and savings stream
    - This information is far more informative if the costs and savings are separated from each other, rather than collected into a net effect.
    - Collect this information for future years out through the life of the project, or for the entire period to the future year of interest (such as 2050, the ultimates key year for NDC compliance).
    - In the absence of detailed year-by-year costs and savings projections, this tool can use aggregate level results of cost benefit analysis in combination with policy design structure and expert judgment to estimate rated effects of relevant indicators for a policy measure.
    - This information should not be modified by discount rates or accrual-based accounting valuations but should reflect actual dollars. If inflation is applied, it should be applied equally to all financial flows to ensure ratios of relative sizes remain accurate over time.
- The *nature of each identified cost and savings* anticipated to result from the policy option. This is effectively a detailed understanding of the economic transaction involved. It includes:
    - The identity of the buyer and seller and an understanding of which part of the economy both occupy (i.e. households, government, industry, commercial, institutional, etc.)

- The location of the buyer and seller, and particularly whether or not either party is outside the country (to accurately assess whether activity is domestic or external, and whether changes affect imports, exports, or international capital flows across borders)
- The nature of the product, service or labor affected by this spending change

Steps to Use this Indicator Tool



Step 1: Link to Financial Flow Data

For each policy option, the key inputs to the macroeconomic assessment are the *cumulative values* for each of the financial flows (i.e. the costs and savings) identified in the direct impacts analysis.

These values should be added by formula, rather than manual entry, to preserve accuracy in case the direct analysis is changed later. This is true even of the cells containing names of financial flows, which may also be changed in later revisions. See the example below:

Microeconomic Data of Policy Scenario Impacts

Scénario du programme pilote: coûts directs Pilot Program Scenario (PS): Direct Costs				
	1-2. Coûts matériels: semis et engrais	**4. Main d'oeuvre de plantation**	**5. Main d'oeuvre de culture et de récolte**	**6. Valeur du riz paddy**
	1-2. Material costs: seedlings and fertilizer	4. Planting Labor	5. Cultivation and harvesting labor	6. Value of Paddy Rice
Valeur Cumulee du flux financier **Cumulative Value of Financial flow**	**-1,004,184,012 CFA**	**3,993,701 CFA**	**0 CFA**	**-4,892,283,447 CFA**

Step 2: Select the Most Appropriate Macroeconomic Indicator

For each financial flow, the analyst assesses that financial flow for whether it represents any of the following:

- Avoiding or reducing energy spending
- Shifting energy purchases to locally produce sources
- Stimulating or increasing demand for products of local supply chains
- A requirement for new direct hiring
- Attraction of outside capital to cover investment needs, or a positive shift in the balance of exports and imports (positive being in favor of higher exports or lower imports)

The cost-effectiveness of the overall policy option is also a factor; a net savings is a positive indicator of possible overall economic benefit, and a net cost is a cause for concern. However, this factor is self-identified and the positive or negative assessment is based entirely on its value, so the tool is intended to simplify this for the analyst.

Step 3: Determine whether the Macroeconomic Indicator is Positive or Negatively Represented for Each Financial Flow

The assessment should also look for the reverse of any of the factors, such as:

- an increase in energy spending
- reductions in demand for local energy or other sector output
- reduced need for labor, or
- a decrease in net exports.

These are equally significant observations, and the tool is equipped for the analyst to select findings that a financial flow is related to a key indicator, but in the reverse direction.

In the example below, the analyst has identified that the first stream of net change in direct costs results in a dramatically lower cost of crop inputs (seeds, fertilizer) as compared to BAU. Much of this cost reduction derives from lower purchases of nitrogen fertilizers produced outside of the local region (and likely outside of the country). The macro-indicator selected is therefore a strengthening in _net_ exports (which includes an accounting of the need to import less from outside the region). It was not considered to be an example of any of the other factors.

The second indicator relates to the higher cost of paying workers. Therefore, it is related to the "direct hiring of labor" factor, and that the example – wherein more money is spent for additional labor – is a positive example of that factor. It was not considered an example of any of the other factors.

	1-2. Coûts matériels: semis et engrais	4. Main d'oeuvre de plantation
	1-2. Material costs: seedlings and fertilizer	4. Planting Labor
Valeur Cumulee du flux financier Cumulative Value of Financial flow	-1,004,184,012 CFA	3,993,701 CFA
Nature de l'influence sur l'economie		
Influence sur le cout total de l'energie	↓ Selectionnez ↓	↓ Selectionnez ↓
Influence sur la production locale de carburant	↓ Selectionnez ↓	↓ Selectionnez ↓
Influence sur les secteurs productifs locaux	↓ Selectionnez ↓	↓ Selectionnez ↓
Influence sur les investissements etrangers ou les exportations / Influence on Foreign Capital or Exports	Attire des fonds exterieurs ou augmente les exportations nettes	↓ Selectionnez ↓
Influence sur l'emploi de travailleurs	↓ Selectionnez ↓	Implique l'emploi de travailleurs

Step 4: Make Multiple Selections where More than One Indicator is Associated with a Financial Flow

Each cost or savings is distinct, and the analyst may find that a single cost or savings appears related to more than one of the indicators in question. In this case, the tool simply requires the analyst to select the select the appropriate positive or negative association with each indicator that appears related to the cost or savings in question.

In the example below from a different pilot program, the analyst has determined that the program reduces demand for kerosene and is both a positive example of reducing energy spending, while also having a negative impact on a local sector of the economy – the kerosene distribution operators, specifically. Both have been selected, and the tool will incorporate both impacts.

	7. Coût évité du kérosène
	7. Avoided Cost of Kerosene
	CFA
Valeur Cumulee du flux financier Cumulative Value of Financial flow	**-276,847,053 CFA**
Nature de l'influence sur l'economie	
Influence sur le cout total de l'energie	Reduction des depenses energetiques
Influence sur la production locale de carburant	↓ Selectionnez ↓
Influence sur les secteurs productifs locaux	Reduit la demande pour les secteurs locaux
Influence sur les investissements etrangers ou les exportations / Influence on Foreign Capital or Exports	↓ Selectionnez ↓
Influence sur l'emploi de travailleurs	↓ Selectionnez ↓

<u>Step 5: Review the Benchmarks for How the Graphic Determines the Size of Impacts</u>

Financial flows can vary by several orders of magnitude in scale, from thousands of dollars or francs for small impacts to tens or hundreds of billions in the case of major policy endeavors. To show such widely varying values in a single graphic, the output is currently set to display five different sizes of impact on an exponential scale (each 10 times larger than the previous). The smallest of five levels of impact is currently set for amounts below 10 million francs, while the largest is set for values above 10 billion francs.

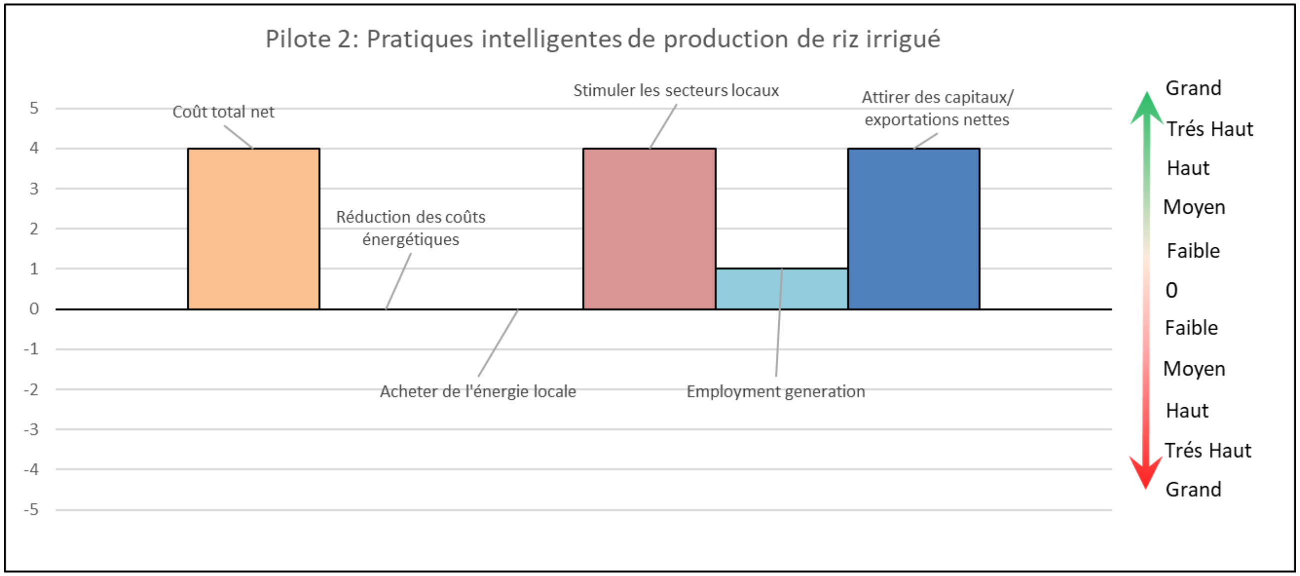
Based on the costs and savings involved, this scale may be appropriate, and be quite helpful in quickly showing the difference between the smaller and larger amounts in question. It may, however, be calibrated too low or too high to be helpful (such as in cases where all values are displayed as large, or all are displayed as small).

To adjust these, choose values that meaningfully distinguish between the smaller and larger sizes present in the analysis in question, and change the entered values in the table to the right of the graph accordingly:

Great dividing line	-XOF 10,000,000,000
Large-Major dividing line	-XOF 1,000,000,000
Med-large dividing line	-XOF 100,000,000
Small-med dividing line	-XOF 10,000,000
Small-med dividing line	XOF 10,000,000
Med-large dividing line	XOF 100,000,000
Large-Major dividing line	XOF 1,000,000,000
Great dividing line	XOF 10,000,000,000

Final Step: Review and Understanding of Final Graphic

Finally, the analyst should review the resulting graphic and the resulting outcome for each of the indicators. At this point, the task is to consider whether or not the displayed results are consistent with expectations, given the factors identified and the negative or positive directions selected. The tool will produce net results in cases where a factor is identified more than once. In the case of the Climate Smart Rice Cultivation Pilot Program in Côte d'Ivoire, each of the net direct cost stream was associated with positive macro-economic outcomes (positive associations with GRP), as indicated in the figure below.



The first indicator corresponds to overall net implementation costs and since those indicated a strong savings to society, the macro-indicator is shown as being very high. The next indicator corresponds to a change in local energy costs. There were no energy impacts for this pilot, so this indicator, as well as the next indicator regarding purchases of local energy sources, is zero. The next indicator corresponds to stimulation of local sectors. The direct cost stream corresponding to this indicator is the increase in value of paddy rice to the farmer. This is a significantly positive impact due to the increase in yields (~a factor of 2.5 times greater than BAU). The employment generator is also positive due to the overall increase in labor costs for rice cultivation. Finally, the indicator for attraction of foreign capital/increase in net exports is highly positive. The corresponding net direct cost stream is the net cost of crop inputs. Specifically, there is significant savings to the farmer for substituting locally-derive compost for chemical fertilizers used in the BAU scenario. All around, the macro-indicators assessment indicates that smart rice cultivation practices are likely to highly stimulate the local economy.

Follow-up and Support

CCS welcomes questions regarding the use of this tool, and also welcomes feedback toward its improvement. This tool, like many tools, is continually under enhancement based on the experiences of its users, and so user insight is welcome.

Annex E. Data Inputs for Rice Husk Briquetting

Paramètre Parameter	**Valeur** Value	**des unités** Units	**Parameter**	**Remarques** Notes
Taille du programme pilote	1,000	kg riz paddy/jour	Pilot Program size	Rice mill capacity: paddy rice/day
Calendrier d'exploitation des moulins à riz	180	jours/an	Rice mill operating schedule	Assumed
Cycle de production de riz par an	1.0	sans unité	Rice production cycles/year	Not used in this analysis
Balle de riz produites par tonne de riz paddy	0.20	t/t	Rice husk produced per tonne of paddy rice	International default value; update as needed.
Facteur de GES pour la gestion de la balle de riz par le BAU: utilisation comme litière pour animaux	0.00	kg CO2e/kg balle de riz	GHG emission factor for BAU management of rice husk: use as animal bedding	Rice mill operator during site visit to Gagnoa mentioned this as the most common use of rice husk. It is assumed to decompose aerobically with little/no methane emissions.
Quantité de autre produit de balle de riz produite par tonne de balle de riz	1.00	t produit/t balle de riz	Amount of rice husk product produced (animal bedding) per tonne of rice husk	Assumed
Quantité de briquettes produite par tonne de balle de riz	0.46	t briquette/t balle de riz	Amount of briquette produced per ton of rice husk	Based on reduction from rice husk to carbonized rice husk; excludes binders
Rapport de compensation: bio-briquette au charbon	1.00	kg briquette/kg charbon de bois	Offset ratio: bio-briquette to charcoal	Assumed; should match value used in LEAP
Quantité de biomasse forestière sèche nécessaire pour produire du charbon de bois	0.20	kg charbon/kg biomass sèche	Amount of dry forest biomass needed to produce charcoal	FAO indicates a 5:1 ratio of dry forest biomass to charcoal during production and transport.
Facteur de conversion: biomasse forestière sèche en carbone forestier	0.47	kg carbone forestier/kg biomass sèche	Conversion factor: dry forest biomass to forest carbon	Default value for forest biomass
Production de briquettes: consommation d'électricité	0.179	kWh/kg briquette	Briquette Production: Electricity Consumption	Traditional briquetting machine (no added heat)

Paramètre Parameter	**Valeur** Value	**des unités** Units	**Parameter**	**Remarques** Notes
Utilisation de charbon de bois compensée par des briquettes biologiques	1.00	kg charbon/kg briquette	Charcoal use offset by bio-briquettes	A 1:1 ratio is assumed.
Intensité de carbone de l'approvisionnement en électricité	1.18	kg CO2e/kWh	Carbon intensity of electricity supply	Assumed value for diesel-based generation for the electrical grid. Based on a heat rate of 13,000 kJ/kWh; an emission factor of 74,336 tCO2e/TJ; and a T&D loss rate of 23%; the emission factor should be 1.177 kgCO2e/kWh.
Fraction de combustible de cuisson compensée sous forme de GPL	0.10	sans unité	Fraction of cooking fuel offset that is LPG	Local market assessment needed for verification and update.
Facteur de GES: Gaz de pétrole liquéfié (GPL)	63.1	kg CO2e/GJ	GHG emission factor: LPG	LPG is the fossil fuel used locally along with charcoal/fuelwood for cooking which could be offset by the introduction of bio-briquettes.
Facteur de GES: combustion de charbon de bois	9.87	kg CO2e/GJ	GHG emission factor: charcoal combustion	CH4 and N2O only
Facteur de GES: combustion de briquette biologique	9.87	kg CO2e/GJ	GHG emission factor: bio-briquette combustion	Assumed to be the same as charcoal; CH4 and N2C only.
Facteur de GES pour la carbonization de balle de riz	1.30	kg CO2e/kg balle de riz	GHG emission factor for rice husk carbonization	This addresses CH4 (N2O has net been measured in identified studies) with a GWP of 25 and based on the average of the two studies listed; carbonization also produces lots of volatile organic compound emissions.
Teneur en chaleur du charbon de bois	30.0	MJ/kg	Heat content of charcoal	From listed data source.
Teneur en chaleur des briquettes biologiques	27.0	MJ/kg	Heat content of bio-briquettes	Assumed to be 10% lower than charcoal, since some clay binder is also included. Update with more specific data, if available.
Teneur en chaleur de la biomasse forestière	19.0	MJ/kg	Heat content of forest biomass	
Densité de carbone des forêts en surface pour les forêts dégradées	165	t biomass/Ha	Above-ground forest carbon density for degraded forests.	FAO study from 1980 on potential vs. actual carbor stocks - need more recent data

Paramètre Parameter	**Valeur** Value	**des unités** Units	**Parameter**	**Remarques** Notes
Densité de carbone des forêts en surface pour une forêt en bonne santé.	276	t biomass/Ha	Above-ground forest carbon density for healthy forest.	FAO study from 1980 on potential vs. actual carbon stocks. 276 t biomass/ha is potential density for Cote D'Ivoire
Taux de croissance de la biomasse forestière en surface pour les forêts dégradées à la suite de récoltes réduites de bois de feu.	2.24	t biomass/Ha-an	Above-ground forest biomass growth rate for degraded forests following reduced fuelwood harvests.	Estimated as the difference between the natural control forest and the thinned + logged forest values cited in this study in the Central African Republic
Taux de croissance de la biomasse forestière en surface pour des forêts en santé.	4.67	t biomass/Ha-an	Above-ground forest biomass growth rate for healthy forests.	Assumed, needs additional research. See note below in this column for calculation of Forest area affected by the Program.
Facteur d'expansion de la biomasse liée à la récolte de combustible ligneux	1.32	sans unité	Wood fuel harvesting biomass expansion factor	An expansion factor of 1.32 conservatively estimates the total biomass that is emitted as a result of wood fuel harvesting that results in forest degradation. This factor was taken from the American Carbon Registry's Energy efficiency measures in thermal applications of non-renewable biomass methodology, based on the CDM-approved methodology AMS-II.G, Version 05.0. This factor of 1.32 was based on the assumption that for every unit of biomass extracted from the forest, an additional 10% is left in the field from uncollected aboveground biomass. A further 20% was conservatively estimated to remain from root biomass. These factors, multiplied together, produced a 1.32 expansion factor.
Zone forestière affectée par la mise en œuvre du programme (pour chaque kg de briquettes qui déplace le charbon de bois)	0.0011	Ha/kg briquette	Forest area affected by Program implementation (for each kg briquette that displaces charcoal)	IPCC Guidelines for forests: 140 t dm/Ha above-ground for subtopical dry forests in Africa; assume forest accumulates over 30 years = 4.67 t above-ground dm/Ha-yr. Each kg briquette offsets 1 kg of charcoal. Removals above this level lead to degradation/deforestation

Paramètre Parameter	**Valeur** Value	**des unités** Units	**Parameter**	**Remarques** Notes
Valeur du produit en balle de riz (litière pour animaux)	(10)	CFA/kg produit de balle de riz	BAU value of rice husk product (animal bedding)	Assumed value; it could also be zero, if the materia is given away.
Coûts d'équipement de production de briquettes	4,934,800	CFA	Briquette production equipment costs	Briquette press cost portion is from the source linked (local team's cost was based on re-habilitating an old press); it is a small press rated a 200 kg/hr. In addition, the other equipment costs are taken from the local team's cost assessment: carbonizer (800,000 CFA, mixer (600,000 CFA), dryer (500,000 CFA).
Subvention gouvernementale pour l'achat et l'installation d'équipements; source nationale ou internationale	0%	%	National or international government grant for purchase and installation of equipment.	Assumed; update as needed
Production de briquettes: taux de travail moyen	517	CFA/heure	Briquette production: average labor rate	Calculated from mean monthly minimum wage value provided in the reference for west Africa (~$150/month); assuming 168 hours/month and ar exchange rate of 580CFA/USD.
Production de briquettes: travail	19.4	heure/t briquette	Briquette production: labor	Derived from local team assessment of annual costs: 2 man-months assumed to equal 336 hours (needed to produced 17.3 t briquette).
Autres intrants de production de briquettes	130,080	CFA/t briquette	Other briquette production input costs	From local team assessment of annual costs. This includes process inputs: water, clay and starch (powedered cassava); and insurance (2.5% of equipment costs).

Paramètre Parameter	**Valeur** Value	**des unités** Units	**Parameter**	**Remarques** Notes
Coûts d'électricité	112.15	CFA/kWh	Electricity costs	From local team assessment of annual costs.
Prix du PLG	13.5	CFA/MJ	LPG price	Assumed based on a price of 333CFA/liter cited for Cote d'Ivoire in the data source cited.
Prix du charbon de bois	70,000	CFA/ t charcoal	Charcoal price	Local team data; 6,000 - 8,000 CFA/100 kg bag.
Bénéfice de l'opérateur d'une rizière sur les ventes de briquettes	35%	%	Rice mill operator profit on bio-briquettes	Assumed; adjust based on field data.
Coût de la production de briquettes, y compris les coûts d'équipement annualisés	192,903	CFA/t briquette	Cost of briquette production, including annualized equipment costs	Calculated from the sum of annualized costs (equipment, labor, electricity and other inputs).
Coût de la production de briquettes, hors coûts d'équipement annualisés	160,185	CFA/t briquette	Cost of briquette production, excluding annualized equipment costs	
Frais de support technique	19,037,180	CFA	Technical Support Costs	Costs for government technical support: briquetting process (non-equipment costs; local market studies and promotional programs, including acquisition of clean cookstoves for promotional activities; laboratory testing of briquettes; business plan preparation and training.

Paramètre Parameter	**Valeur** Value	**des unités** Units	**Parameter**	**Remarques** Notes
Taux d'inflation annuel	2.0%	%/an	Annual rate of inflation	Assumed
Taux d'actualisation sociétal	5.0%	%/an	Societal discount rate	Assumed
Facteur de récupération du capital	0.110		Capital Recovery Factor (CRF)	Calculated; this factor is used to annualize the tota investment costs.
Durée du prêt pour l'achat d'équipement	15	years	Length of the loan for equipment purchases	Assumed based on expected equipment life.
Taux d'intérêt du prêteur	7.0%	%	Interest Rate of lender	Assumed; 100% financing (no downpayment) is assumed.