Methodology for GHG accounting

The Ex-Ante Carbon Balance Tool (EX-ACT) has been developed by the Food and Agriculture Organization of the United Nations (FAO) to evaluate impacts of the interventions in the Agriculture, Forestry and Other Land Use (AFOLU) sector on greenhouse gas (GHG) emissions. EX-ACT provides estimates of the mitigation potential of public or private investment projects, policies and national level programs. It helps the decision makers to understand whether the planned agricultural interventions contribute to meeting climate change mitigation objectives. The EX-ACT appraisals, initially designed for ex-ante analysis, can be also conducted during the project implementation as well as ex-post for comprehensive monitoring and evaluation, both at a project and at a country level. EX-ACT calculations are based on land use data.

The current version of EX-ACT is primarily based on *the IPCC 2019 Refinement to the 2006 Guidelines for National Greenhouse Gas Inventories* (IPCC 2019) and *IPCC 2013, 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands* (IPCC 2014), complemented by other scientific research. GHG emissions for farm operations, inputs, transport and irrigation systems implementation are based on Lal (2004). Emissions factors for the fishery sector are derived from Parker & Tyedmers (2014), Sciortino (2010), Winther et al. (2009) and Irribaren et al. (2010 & 2011). Soil carbon stock in mangroves is complemented by the review from Atwood et al. (2017). These references provide EX-ACT with recognized default values for emission factors and carbon values, the so-called Tier 1 level of precision.

The tool consists of seven topic modules that allow to analyze a range of agricultural and forestry activities including crop production, land rehabilitation, forest management, livestock and grassland production systems among others. The tool calculates changes in carbon stocks and GHG emissions including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), which once converted to CO_2 equivalent are used to derive the carbon balance that indicates the impact of the project: positive carbon balance indicates that the project leads to greater emissions, while negative carbon balance indicates that project contributes to emissions reduction.

The evaluation assesses how the impacts of an intervention compared to the business as usual (BAU) scenario. The calculator requires data for 3 specific points in time: initial situation, with project scenario, without project or BAU. In preparing this data a lot of work is required up front to determine the adequate modeling of activities/interventions in the tool. This takes into consideration technical specificities, conversations with national staff to determine current and future projections, literature reviews to assess availability of tier 2 or 3 coefficients to improve the accuracy of the assessment. Once all this information is gathered, a plan based on technical expertise is generated on how to best model the intervention in the tool along with the assumptions made. This is a crucial step as this is what really determines the measurement of the impact. All these aspects are discussed below to ensure a clear and transparent understanding of the assessment done for this project.

Project boundaries and data sources

The project should directly benefit 330,000 people.

The GCF project OCRI withholds 3 components:

(1) Climate Resilient Crop production enhanced and Ecosystem services restored in the Upper and Middle Ouéme;
(2) Climate-resilient and gender-sensitive value chains, supporting farmers' livelihoods in the Upper and Middle Ouémé;
(3) Strengthening Climate Change Governance, planning and institutional capacity for long term adaptation.

Detailed information on activities from each component were used to inform the GHG analysis, providing some basic data needed to shape the EX-ACT analysis. The assumptions and data used are presented in the consecutive sections.

Table 1: Project activities considered under EX-ACT analysis.

Activity description	Reference	Ex-ACT Module
Activity 1.1.1: Build Water Harvesting and retention infrastructures.	Logical Framework (07/2021)	Land Use Changes; Inputs
Activity 1.1.2: Strengthen degraded river banks and restore land with trees.	Logical Framework (07/2021)	Cropland and Forest; management
Activity 1.2.3: Implement CRA, including agroforestry and promotion of green manure utilization, to enhance agricultural productivity under climate change.	Logical Framework (07/2021)	Cropland

The estimation of emissions for this project considers the sequestration, reduction and or avoidance that result from the implementation of the activities summarized in Table 1. EX-ACT differentiates between two time periods: project implementation phase and capitalization phase. The implementation phase is the period during which the project activities are carried out. Yet, the period covered by the analysis does not necessarily end with the termination of the active project intervention. Further changes may occur as the result of the interventions (project activities) such as changes soil carbon content or biomass. This period defines the capitalization phase. In this analysis, following recommendations of the IPCC[1], we consider an overall 20-year period for implementation and capitalization phase. As in the current analysis the physical implementation of the project consists of 6 years, the benefits generated by the project will continue to capitalize for 14 more years to reach the 20-year period. In the specific case of soil organic carbon, a constant rate over a period of 20 years from the year of planting to reach the new equilibrium is assumed. The analysis further assumes the dynamics of change (from without (BAU) to "with project") to be linear over the duration of the project.

Project activities and mitigation potential

This evaluation considers the three main activities of the project that have direct impact on carbon emission (Table 1):

(i) **Construction of water harvesting and retention infrastructure on 1 ha:** This infrastructure will be built on a fallow land. The activity will induce a change of 1 ha from vegetated to non-vegetated land leading to an additional carbon emission of 115 tCO_2-e over 20 years.

(ii) **Improved agricultural practices and development of small irrigation system on 2 000 ha:** Currently, farmers in the project area practice full tillage, burn their crop residues and use low input. This production system results in low yield and high emission. With the project, the beneficiaries with be trained to adopt the technic of non-tillage on 2 000 ha and the residue will no longer be burned. In addition, to significantly increase the yield, there will be an increase in input use. As a result, the improved agronomic practices will avoid the emission of 52 587 tCO_2-e over the 20 years while the irrigation system will emit 623 tCO_2-e over 20 years. Additional reduction in emissions of approximately 29,383 tCO2eq over 20 years is expected from phasing out mineral fertilization.

[1] IPCC recommends considering the timeframe between transitions states of natural systems and the period necessary to reach a new equilibrium for carbon stocks and suggest to apply a 20 year long time frame. [IPCC, 2019 Refinements to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories]

(iii) **Establishment of agroforestry/forestry systems on 84 000 and sustainable land management on 9 000 ha:** The project aims also to restore 84 000 ha of parkland in Benin. Currently, this area is highly degraded and fire is used on 20 percent of the land (16 800ha). With the project, 15 percent of the total land (12 600ha) will be planted with perennial crops (cashew) with improved residue management. The project will also increase tree covers on 85 percent of total parkland (71 400 ha) (agroforestry combined with fruit trees). The improvement of tree density will increase carbon sequestration potential on this land. No residue will be burnt under the project. In addition, 9 000 ha of forest that is highly degraded will be restore to become a low degraded area. Thus, the agroforestry system on 84 000 ha will contribute to sequester 1 469 260 tCO_2-e over 20 years while the improved forest management on 9 000 ha will sequester 232 518 tCO_2-e during the same period.

Details on mitigation potential per activity

Activity 1.1.1: This activity is divided into sub-activities relevant to EX-ACT: (1.1.1.2) build new water collection structures, and (1.1.1.4) set up 2 000 ha of small irrigated plots.
The first sub activity is related to the construction of 15 micro-dams and dykes. In total, 1 ha would be impacted by the construction of new water infrastructures. This sub-activity can be found under the module "2.Land Use Changes". It is assumed that the new water infrastructures will be built on land that is currently unused and uncultivated (fallow land). The final land use is considered "Other (non-vegetated)" in EX-ACT. Given the small surface impacted by this activity, the carbon balance is an emission of GHG emissions of 115 tCO2-eq over 20 years.
The second sub-activity related to the installation of irrigation on small plots (total of 2 000 ha irrigated) will be found in the "8.Inputs" module in EX-ACT. It has been assumed that the project will introduce drip irrigation, characterized by a "trickle" irrigation system in EX-ACT. Total emissions from this sub-activity are quantified at 623 tCO2-eq over 20 years.

Activity 1.1.2: The sub-activity relevant in EX-ACT is the trees plantation to restore vegetation coverage (reforestation) along degraded riverbanks and fields (1.1.2.2). About 84 000 ha would be restored using replantation techniques. This activity can be found under the "3.Cropland" module, in the perennial section. Initial vegetation systems are degraded, meaning the in-situ biomass is low due to degradation. Management practices include no tillage, no carbon input and residues management other than fire. The initial agroforestry system has been entered as "Parkland" in EX-ACT, as it represents a low above-ground biomass, with low density mature and scattered trees. Without the project, the entirety of the area would remain under similar conditions and management practices.
With the project, it was assumed that 85 percent of the surface would be improved on riverbanks and 15 percent would be improved on fields. The difference stems from the combination of vegetation obtained after project's implementation: on river banks, it would be a mix of natural vegetation and agroforestry system (parkland) whereas improved fields would be a mix of different fruit-trees varieties and perennial crops. The restauration of vegetation through replanting and strengthening in-situ biomass would result in the sequestration of 1 469 260 tCO2-eq over 20 years. In addition, the project will improve the management of 9 000 ha of degraded forest resulting in 232 518 tCO_2-e avoided over 20 years. This sub-activity is described in the module "Forest Management" section 5.1.

Activity 1.2.3: The implementation of climate-resilient agriculture (CRA) by 2 000 farmers can be found under the "3.Cropland" module, in the "Annual Croplands" section. For data entry, it was assumed that 1 farmer owns 1 ha of cropland.
Initially, the prevalent type of agriculture is rainfed, with brunt residue management. Tillage practices are assumed to cause substantial soil disturbance (full tillage).
The project aims at introducing sustainable land management techniques: management practices will shift towards the use of compost as additional carbon input, crop rotations, use of cover crops, mulching, and the use of improved varieties. Tillage practices are assumed to be reduced to meet soil-

conservation practices. New, improved riverbanks and fields will be managed with reduced tillage, high carbon input (no manure) and residues will be retained on field. The improvements of land management introduced by the project results in a reduction of emissions from annual cropland, with a carbon balance of 52 587 tCO2-eq over 20 years. Green manure will contribute to phase out mineral fertilization, leading to a reduction of an additional 29,383 tCO2eq over 20 years.

<u>Adjustments in the tool:</u>
To account for the construction of water infrastructure, Soil Organic Carbon levels of "Other (non-vegetated)" had to be adjusted to 0, to reflect the introduction of retention infrastructures.

Results of the EX-ACT analysis:

Overall, the implementation of the project will increase the mitigation potential of the area. The total GHG sequestered is estimated at 1 783 633 tCO_2-eq over 20 years. With a total area of 95 001 ha, the carbon sequestered per hectare and per year increases from 2.1 to 3 tCO_2-e between the baseline scenario (without project intervention) and the planned scenario when the project is implemented. This corresponds to a carbon balance of 0.9 tCO_2-eq sequestered per hectare and per year. The detailed results obtained with EX-ACT can be disaggregated by components. The first activity (1.1.1) regarding the construction of water infrastructure and the introduction of irrigated plots has a total carbon balance of 115 and 623 tCO_2-eq emitted over 20 years respectively. The restoration of degraded riverbanks and fields with agroforestry systems (Activity 1.1.2) would contribute to deepen existing carbon sinks through the plantation of fruit trees and increase density of parkland. The results show an additional 1 469 260 tCO_2-eq sequestered over 20 years. The Improved management of degraded area contributes to carbon sequestration by 232 518 tCO_2-e. Introducing climate-resilient agriculture (CRA) through Activity 1.1.3 would shift cropping practices on a variety of crops. The carbon balance of this activity corresponds to an avoidance of 52 587 tCO_2-eq over 20 years, plus an additional 29,383 tCO2eq over 20 years from phasing out mineral fertilization.

Interpretation of results:

The total mitigation potential of the project is quantified by EX-ACT at 1 783 633 tCO2-eq to be sequestered over 20 years of analysis. The most impactful activity in the carbon balance is the improvement of vegetation on riverbanks and fields, which would further deepen existing GHG sinks by contributing to the sequestration potential at 1 469 260 tCO2-eq over 20 years. This is followed by the forest management that will sequester 232 518 tCO_2-e.
GHG emissions due to irrigation introduction (623 tCO2-eq emitted over 20 years) has to be put back into perspective with improved crops which seek the improvement of cropland management practices (52 587 tCO2-eq sequestered over 20 years). Reduction in emissions of approximately 29,383 tCO2eq over 20 years is expected from phasing out mineral fertilization.
The construction of water infrastructures would contribute to emissions by 115 tCO2-eq over 20 years. The total mitigation potential of the project is quantified by EX-ACT at 1 783 633 tCO2-eq over 20 years of analysis if deforestation-centered activity is implemented. This would bring the total area impacted by the project to 95 001 ha, and a carbon balance of 0.9 tCO2-eq sequestered per hectare and per year.

<u>Monitoring and evaluation using EX ACT</u>

Monitoring can be carried out using EX ACT tool. This is realized at different stage of the project Implementation. In collaboration the implementation and monitoring teams, the EX ACT analyst identifies all the activities that are already undertaken and the actual areas that have been improved or restored by the project. The assessment uses this information to quantify the effective carbon sequestered or emitted by the project so far compared to the planned sequestration potential estimated at the beginning of the project. If substantial difference persists, corrective actions could be taken to put the project in the planned path. Finally, at the end of project implementation (6 years), management strategy should be developed to ensure the stability of the forest restored and an adequate use of dam for irrigation. This management strategy should ensure that the areas of project intervention continuously sequesters carbon and increases resilience of beneficiaries for at least during the project lifetime of 20 years.