

PROREFISH – Annex 24 – Carbon Accounting

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), 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 (CO₂), methane (CH₄) and nitrous oxide (N₂O), which once converted to CO₂ 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

OBJECTIVES OF THE PROJECT: **The project aims to build the resilience of the Gambian fisher folk against climate change and improve their livelihoods.** Throughout this proposal, fisher folk are defined as all the fisheries value chain actors, from fishermen, to traders, processors, providers of inputs, etc. – both

existing and new to the business, e.g. aquaculture producers. The project will scale up proven adaptation measures from the West Africa region and similar contexts, with a particular focus on value chain segments dominated by women (fish handling and processing). The project will also put particular emphasis on integration with the agriculture sector, particularly for the development of aquaculture.

BENEFICIARIES OF THE PROJECT: The project expects to have 167,643 direct beneficiaries and 250,000 indirect beneficiaries.

The GCF project “Climate Resilient Fishery Initiative for Livelihood Improvement in the Gambia (PROREFISH Gambia)” withholds 3 components:

- (1) Restoration of key fisheries habitats;
- (2) Climate resilient fisheries infrastructure and aquaculture development;
- (3) Improved climate change adaptive capacities.

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 ¹	Ex-ACT Module	Estimated net incremental emissions (t CO ₂ eq)
Activities 1.1.1 (Reforestation) and 1.1.2 (Assisted Natural Regeneration: These activities involve the restoration of 2,350ha of mangrove forest via a combination of full reforestation on 1,100ha and assisting natural regeneration on 1,250ha of mangroves. The activities will support selecting planting sites in targeted mangrove areas, train local planting teams from respective communities as well as finance and monitor planting campaigns.	Forest Degradation & Management and Coastal wetlands (rewetting and revegetation)	- 261,068 tCO ₂ -eq
Activities 1.2.3, 2.1.2 and 2.1.3: Focuses on introducing energy efficient technologies for fish processing across various project sites. This includes the introduction of improved fish smoking ovens (FTT ovens) to reduce the use of firewood and charcoal.	Inputs	- 77 tCO ₂ -eq
Activity 2.2.3: Supports the integration of African catfish production in fish tanks in 30 communal gardens. Each garden will get 10 fish tanks and will have two production cycles of catfish production.	Fisheries and Aquaculture (Inland and coastal aquaculture)	+89 tCO ₂ -eq
Activity 2.2.4: This activity introduces the cultivation of fish on 300ha of existing rice fields through a change in irrigation management. Rice plants will be planted in partly submerged fields where fish will also be included providing an additional source of income.	Cropland (Flooded rice systems) and Fisheries and aquaculture (Inland and coastal aquaculture)	+21,581 tCO ₂ -eq
Activity 2.2.5: This activity will scale up fish culture in earthen ponds. The project will support the development of 50 new units (400 sqm each) and the rehabilitation of 10 existing units.	Land use change (other land use change), Fisheries and aquaculture (Inland and coastal aquaculture) and, Inland wetlands (Inland Waterbodies	+939 tCO ₂ -eq
Activity 2.2.6: This activity involves scaling up and establishment of oyster culture in mangrove forests, and clam and cockle culture on mudflats in the Gambia.	Fisheries and aquaculture (Inland and coastal aquaculture) and Inputs	+17 tCO ₂ -eq
PROREFISH TOTAL:		-238,519 tCO ₂ -eq

¹ Reference: PROREFISH Funding Proposal (February 2022)

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 IPCC², 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.

Results of the EX-ACT analysis:

The detailed results obtained with EX-ACT can be disaggregated by components each reflecting a several different activities. The first component regarding restoration of fisheries habitats (activities 1.1.1 and 1.1.2) appears in the “forest degradation and management” module which account for the restoration activity and the “coastal wetlands” module which accounts for the revegetation activity. Given the computation of data (detailed below), the total carbon balance over 20 years of this activity is equal to **- 261,068 tCO₂-eq**. This result is the net difference between the carbon balance from the “without project” scenario (0 tCO₂-eq) and the carbon balance of the “with project” scenario (- 261,068 tCO₂-eq). The introduction of mangrove reforestation and natural regeneration activities contribute to further deepening the carbon sink of the mangrove forests.

The assessment of the introduction of FTT ovens and other fuel saving technologies (activities 1.2.3, 2.1.2 and 2.1.3) can be found under the “inputs” module. Introducing fuel saving technologies contributes to the **reduction of carbon emissions estimated at - 77 tCO₂-eq over 20 years**.

The project also supports the cultivation of African catfish (activity 2.2.3) which can be found under the “fisheries and aquaculture” module under “inland and coastal aquaculture”. Catfish aquaculture in the project contributes to an increase of **+89 tCO₂-eq** in the total carbon balance over the 20 years of this activity. The project aims to produce fish feed locally by the end of the implementation period. As a result, emissions number of +89 tCO₂-eq does not take into account the reduction of fish food miles that would have taken place from importing feed. The analysis also does not account for the reduction in emissions from the project offsetting marine catches, where emissions might be higher due to fuel and refrigeration usage.

Under activity 2.2.4, the project introduces the cultivation of fish on 300ha of existing rice fields through a change in irrigation management. The details of this activity can be found under “croplands” module which accounts for the emissions due to change in rice management practices and “fisheries and aquaculture” module to account for emissions from aquaculture production in the rice fields. The combined carbon balance of this activity is an increase of **+21,581 tCO₂-eq** in the total carbon balance over the 20 years of the activity.

The project also includes the rehabilitation of existing earthen ponds and creating new ones (activity 2.2.5), all of which will be used for aquaculture production. The details of the emissions for this activity can be found in the “land use change” module under “other land use changes”, “inland wetlands”

² IPCC recommends considering the timeframe between transitions states of natural systems and the period necessary to reach a new equilibrium for carbon stocks and suggests applying a 20 year time frame.

module under “inland waterbodies” and the “fisheries and aquaculture” module under “inland and coastal aquaculture”. The combined carbon balance of this activity is a positive carbon balance of **+939 tCO₂-eq** over the 20 years of the activity.

Finally, the project helps to scale up and establish oyster culture in mangrove forests, and clam and cockle culture on mudflats in the Gambia (activity 2.2.6). The details of the emission for this activity can be found in the “fisheries and aquaculture” module under “inland and coastal aquaculture” and the “inputs” module under “energy consumption”. From both the modules, the combined carbon balance of this activity is an increase of **+17 tCO₂-eq** over the 20 years of the activity.

Overall, **results show a positive environmental impact due to the implementation of the project’s activities, quantified at a total carbon balance of – 238,519 tCO₂-eq over 20 years.**

Computation of data in EX-ACT:

Activity 1.1.1 & Activity 1.1.2 - mangrove reforestation and assisted natural regeneration: Given the description of the activities (1,100 ha for mangrove reforestation and 1,250 ha for assisted natural regeneration) and practices implemented (finance planting campaigns, monitor and replace dead trees, enrichment planting, protective measures, etc), this activity best fits under the “5. Management” module and “7. Coastal wetlands” module of EX-ACT. The forest management module allows users to account for changes in GHG emission fluxes from forest management activities. Based on project site description, we assume a moderate forest degradation level with 40% biomass lost in the baseline and “without project” scenario. Within the tool, forested land with moderately degraded state is calculated as 40% of biomass lost compared to a non-degraded forest. Thus a moderately degraded mangrove could then hold 40% biomass less than a non-degraded mangrove system. The project’s objectives are to improve the state of these mangroves. Given the IPCC methodology, only an improvement of 20% of biomass restoration can be a realistic goal over an accounting period of 20 years. Therefore, we could expect an improvement to 20% biomass loss compared to a non-degraded mangrove system with the introduction of restoration activities with the “Climate Resilient Fishery Initiative for Livelihood Improvement in the Gambia (PROREFISH Gambia)” project.

The baseline scenario can be established through two assumptions: the first one being a stable state of degradation, meaning the system under focus would not further degrade over the 20 years accounting period, the second one being a further degradation of the system under focus, with a further loss of 60% of above ground biomass compared to a non-degraded mangrove system. Given the lack of quantitative information on degradation trends on mangrove lands in the Gambia, and to avoid overestimation of GHG impact induced by restoration activities, a conservative approach was preferred: the baseline scenario assumes the initial state of mangrove degradation over the entire period of the analysis.

Variables to include in EX-ACT also cover fire practices. However, there is no mention of fire being used on the project sites and thus it is not included within the analysis.

Similarly, we account of reforestation activities on 1100ha of mangroves in the “coastal wetlands” module. Here we estimate a 30% restoration of biomass based on values found for similar revegetation activities in Vietnam³.

³ The numbers are taken from the report titled “The economic value of the ecosystem services generated by Tokio Marine & Nichido’s mangrove planting activities”

The total balance is **a reduction in emissions of – 261,068 tCO₂-eq**, highlighting an additionality in GHG sinks introduced by the revegetation and restoration of mangrove lands.

Activities 1.2.3, 2.1.2 and 2.1.3 - introducing improved efficient FTT ovens for fish smoking: The project recognizes that smoking fish is a common practice in the Gambia used to preserve fish. This currently involved using firewood, charcoal or general waste to in conventional ovens. The project introduces improved fish smoking ovens (FTT ovens) which will reduce the use of firewood and improve fish processing operations. In EX-ACT, this activity is therefore referenced under the “9. Inputs” module.

Introduction of FTT ovens is expected to reduce firewood usage by approximately 80% from baseline values. As baseline firewood usage estimates for project sites were not available, estimation was carried out assuming 5kg of firewood needed to smoke 1kg of catfish⁴. Estimates for harvest were taken from the Economic and Financial Analysis (EFA) of the project, which are 6,650 kg/year of catfish. FTT ovens primarily use charcoal at the rate of 126kg to smoke 1 tonne of catfish. These values were included in the EX-ACT analysis.

The result of introducing improved efficient FTT ovens for fish smoking can be interpreted as the **reduction in emissions of –77 tCO₂-eq**.

Activity 2.2.3 - introduction of catfish aquaculture: Supports the integration of African catfish production in fish tanks in 30 communal gardens. Each garden is expected to get 10 fish tanks and will have two production cycles of catfish per year. Based on the Economic and Financial Analysis (EFA), we assume a mortality of 5%, leading to an estimated production of 6.6 tonnes of catfish per year. We use a tier 2 value of 0.00169 tonnes of nitrous oxide per tonne of production⁵.

This activity leads to a **net emission of +89 tCO₂-eq**, via the introduction of catfish aquaculture with the PROREFISH Gambia project⁶.

Activity 2.2.4 - management of rice through the introduction of irrigation and from tilapia aquaculture: This activity introduces fish cultivation in 300ha of existing rice fields, through a change in irrigation management. Based on the funding proposal, a new water management regime will be introduced on existing rice fields to control for water levels, making it suitable for rice-fish aquaculture activities. Based on EFA, we assume that the primary fish will be tilapia. In EX-ACT, this activity is therefore referenced under the “3. Cropland” module which accounts for changes in rice management from rainfed flooded rice to irrigated rice and “8. Fisheries and aquaculture” module which accounts for emissions from aquaculture.

The PROREFISH project will work alongside an existing IFAD project (Resilience of Organizations for Transformative Smallholder Agriculture Programme (ROOTS)). Therefore, we assume the rice is managed in a similar manner to that of the ROOTS project, except with a change in irrigation management as mentioned in the PROREFISH funding proposal. As a result, we account for the rice being irrigated and continuously flooded, with the organic amendment being compost. Finally, we account for the tilapia production in the fisheries and aquaculture module. Based on values from the economic and financial analysis, we estimate 490.5 tonnes of tilapia produced per year. We use a tier 2 value of 0.00169 tonnes of nitrous oxide per tonne of production⁷.

⁴ See table 4 of FAO’s technical paper highlighting Thiaroye processing technique (Mindjimba, K. ; Rosenthal, I. ; Diei Ouadi, Y. ; Bomfeh, K. ; Randrianantoandro 2020) which can be found at <https://www.fao.org/documents/card/en/c/ca4667en/>

⁵ This is based on the a review article on nitrous oxide emissions in aquaculture (Hu et al. 2012) which can be found here: <https://pubs-acsc-org.ezproxy.library.wur.nl/doi/full/10.1021/es300110x>

⁶ Because of a lack of available data, this number does not take into account the emissions reductions that would result from substituting inorganic fertilizer with fish droppings. Therefore, the real net emissions of this project activity would probably be lower

⁷ This is based on (Hu et al. 2012) and (Dullah, Malek, and Hanafiah 2020)

This activity leads to a **net emission of +21,581 tCO₂-eq**, via changes to the management of rice through the introduction of irrigation and from tilapia aquaculture.

Activity 2.2.5 - scale up fish culture in earthen ponds: The project will support the development of 50 new units (400 sqm each) and the rehabilitation of 10 existing units. In EX-ACT, this activity is therefore referenced under the “2. LUC” module which accounts for the land-use change and “8. Fisheries and aquaculture” module which accounts for emissions from aquaculture.

Based on the description of the activity, the project will have approximately 2ha of fallow land converted to earthen ponds. The earthen ponds will primarily have tilapia (based on EFA) which are herbivorous fish that need medium-high nutrient water⁸. Based on consultation with project managers, the analysis assumes the ponds’ trophic class will be mesotrophic. As in activity 2.2.4, we use a tier 2 value of 0.00169 tonnes of nitrous oxide per tonne of production.

This activity leads to a **net emission of +939 tCO₂-eq**, via the land-use change from fallow land to build earthen ponds and from tilapia aquaculture in the “Climate Resilient Fishery Initiative for Livelihood Improvement in the Gambia (PROREFISH Gambia)” project.

Activity 2.2.6 - scaling up and establishment of oyster culture in mangrove forests, and clam and cockle culture on mudflats: In EX-ACT, this activity is therefore referenced under the “8. Fisheries and aquaculture” module which accounts for emissions from aquaculture and “9. Inputs” module which accounts for fuel use.

Based on the economic and financial analysis, 1.129 tonnes of oyster, clam and cockles will be harvested via this activity. Similar to other aquaculture activities, we use a tier 2 value of 0.00169 tonnes of nitrous oxide per tonne of production, which is based on previously cited studies. The EFA also shows the use of 48 litres of fuel per year. We assume that to be gasoil/diesel oil as it is used in a boat.

As a result, **this activity leads to a net emission of +17 tCO₂-eq tCO₂-eq**, via oyster, clam and cockles aquaculture and fuel use in the “Climate Resilient Fishery Initiative for Livelihood Improvement in the Gambia (PROREFISH Gambia)” project.

Activities not taken into account: project documentation makes reference to activities that could be accounted for in EX-ACT, but could not be included in this analysis due to insufficient data information.

Activity 2.2.2: Expansion of the Jahally Aquaculture Center describes increasing the capacity of fish feed production through four small scale, private manufacturing units. It also describes expanding production of feed with alternative sources of protein which have a lower fish-meal content. As some feed and fingerlings are imported into the Gambia (based on project documents), expansion of feed production is likely to reduce emissions (via lower transport emissions). Migrating to feed which uses lower levels of fish-meal is also likely to reduce emissions as it reduces the emissions from feed. However, as the composition of feed and their emissions are unknown, this activity cannot be accounted for within the EX-ACT analysis.

Activity 1.2.3: In addition to the use of FTT ovens, the project also incorporates small solar powered equipment. However, currently there is no data available regarding the amount of energy generated by the solar equipment. As solar does not produce any GHG emissions in its use (not including emissions

⁸ See (El-Sayed 2020)

from production of solar equipment), it is likely to reduce carbon emissions from electricity usage. Currently its impact is not accounted for within this EX-ACT analysis due to lack of data.

Potential refinement of the analysis: Given the focus of the project on making improvements to aquaculture, more information on emissions from feed can be desirable⁹. As an example, this project aims to generate local feed production and use newer feed compositions with lower fishmeal content (such as replacing fishmeal with the use of moringa leaves). This is likely to further reduce emissions from aquaculture activities¹⁰ which the current EX-ACT analysis is unable to account for.

Additionally, the project document mentions that one of the motivations for expanding aquaculture activities is to make up for declining catches in marine fisheries. An element of refinement could be assessing the reduction in emissions from reducing marine fisheries (e.g., via changes in fuel and refrigeration emissions).

The project document mentions that in rice-fish aquaculture, there will be a lower need for fertilizers and pesticides. However, as no specific numbers are available, their impact on emission cannot be estimated. Including these values is likely to reduce emissions from pesticide and fertilizer usage.

Furthermore, the Ex-ACT analysis documents gross emissions and does not take into account the fact that The Gambia needs to increase food production because of its rapid population growth. If the PROREFISH activities would not be implemented, other food production or importation activities, potentially with higher greenhouse gas emissions, may need to be implemented in The Gambia.

⁹ See (MacLeod, Hasan, and Robb 2018).

¹⁰ Feed is likely to have otherwise been imported raising emissions from transport. Also, replacing fishmeal with moringa leaves likely reduces emissions from fishmeal production.

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