## Appendix 6

# Greenhouse Gas Accounting for the RECEM – Valles project in Boliva.
# *Upscaling Ecosystem Based Climate Resilience of Vulnerable Rural Communities in the Valles Macro-region of the Plurinational State of Bolivia (RECEM-Valles)*

## 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 proposed project has an adaptation approach where production systems can withstand climate change and enable restoration of ecosystems to further enhance socio-ecological resilience. The objective of this project will be achieved by implementing an integral and participatory micro-watershed management following these activities.

COMPONENTS OF THE PROJECT:

- *Component 1.* Strengthened food and income security in changing climate through climate resilient agricultural systems by improving the capacity of small-scale farmers to manage their agroecosystems sustainably,
- *Component 2.* Smallholder water resources secured to reduce the risks from droughts and low rainfall by on-farm capacity building for climate-proofed irrigation systems,
- *Component 3*. Restored and conserved micro-watersheds and ecosystem functions and services by participatory and integral watershed management to restore ecosystem functions, particularly water regulation and supply, reduction of erosion and disaster risk and
- *Component 4*. Enabling conditions created to implement and upscale climate-resilient agroecological management, climate-informed integral micro-watershed management, and access to financial mechanisms by strengthening the corresponding governance and institutional capacities at local level to support climate risk management by smallholder farmers and their communities

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.*

| ***Component 1*** | **Description** | **EX-ACT Module** |
|---|---|---|
| *Activity 1.1.1.* | Implement resilient agricultural management by deploying climate-resilient technologies, such as of communal solar tents, frost blankets, anti-hail nets, hydrogel. | N/A |
| *Activity 1.1.2* | Capacity building of the use of technologies and practices (conservation agriculture) | Cropland |
| *Activity 1.2.1* | Development and implementation of community and associative productive enterprises. Organic certification | Cropland |
| *Activity 1.2.2* | Technical support and implementation of collection and marketing centers | Inputs[1] |
| | Transport | Inputs[2] |
| *Activity 1.2.3* | Promotion of climate resilient value chain for livelihood diversification with honey producers | N/A[3] |
| ***Component 2*** | | |
| *Activity 2.1.1* | Construction of harvesting rainwater at community and family reservoirs. | Inputs<br>Inland wetlands |

[1] Construction and energy use was calculated using EX-ACT. Potential emissions due to refrigerant leakage were calculated separately and aggregated for the total carbon balance.

[2] Assumed transport fuel consumption was included in the carbon-balance, however the project is not supporting directly the use of transport.

[3] Not included directly in EX-ACT. An estimated was calculated for reference purposes and aggregated in the total carbon balance.

| | | |
|---|---|---|
| *Activity 2.1.3* | Implement irrigation systems: drip and sprinkler to be promoted. | Inputs |
| *Activity 2.2.1* | Strengthen capacities by farmer's field schools for the implementation of climate-proofed irrigation systems | Cropland |
| *Activity 3.1.2* | Implement restoration practices under agroecological and /or agroforestry management in public areas | Forest Management |

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[4], 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 de disaggregated by components each reflecting a different activity, see figure 1. The component regarding Activities 1.1.2, 1.2.1, and 2.2.1 appears in the Cropland module, in section annuals. Given the computation of data (detailed in Computation of data in EX-ACT), the total carbon balance over 20 years of this activity is equal to **-162,944 tCO2-eq**. This result is the net difference between the carbon balance from the baseline scenario (237,032 tCO2-eq) and the carbon balance of the "with project" scenario (74,089 tCO2-eq). The introduction of conservation agriculture practices (reduce tillage), and residue management are the main improvements, irrigation and manure application are considered too. The project foresees the implementation of activities that are net emitters, such as the construction of rainwater harvesting reservoirs, irrigation systems, and collection and marketing centers, and promotion of honey value chain. The sum of this activities produces **781,566 tCO2-eq** over 20 years period. Finally, the activity 3.1.2 aims for the restoration and conservation of watersheds to sustain and regulate the hydrological cycle. This component gives the highest potential carbon sink as: **-996,119 tCO2-eq** over 20 years. Overall, results show a positive environmental impact due to the implementation of the project's activities, quantified at a total carbon balance **of -377,497 tCO2-eq** over 20 years. Knowing the total area under focus, this would amount to a carbon balance of **-0.6 tCO2-eq** per hectare and per year.

[4] 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. [add reference to IPCC methodology]

***Figure 1. EX-ACT Detailed Results*[5]**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project name** | | | | | | | |
| **Continent** | South America | **Project duration (in years)** | | **Total area (ha)** | 40,913 | **Global warming potential** | |
| **Country** | Bolivia | Implementation Phase | 5 | Mineral soil | 40,910 | $CO_2$ | 1 |
| **Climate** | Tropical Montane | Capitalization Phase | 10 | Organic soil | 0 | $CH_4$ | 28 |
| **Moisture** | Moist | Total Duration of Accounting | 15 | Waterbodies | 3 | $N_2O$ | 265 |

Tier 2
Annual emissions

| | | **GROSS FLUXES** In tCO2-e over the whole period analysis | | | **SHARE PER GHG OF THE BALANCE** In tCO2-e over the whole period analysis | | | | | **AVERAGE ANNUAL EMISSIONS** In tCO2-e/yr | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PROJECT COMPONENTS** | | **WITHOUT** | **WITH** | **BALANCE** | **CO2 BIOMASS** | **CO2 SOIL** | **$N_2O$** | **$CH_4$** | **ALL NON-AFOLU EMISSIONS*** | **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 land-use | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 |
| Cropland | Annual | 237,032 | 74,089 | -162,944 | 0 | -142,774 | 23,024 | -43,194 | | 15,802 | 4,939 | -10,863 |
| | Perennial | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 |
| | Flooded rice | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 |
| Grasslands & Livestock | Grasslands | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 |
| | Livestock | 0 | 0 | 0 | | | 0 | 0 | | 0 | 0 | 0 |
| | Forest mngt. | 0 | -996,119 | -996,119 | -996,119 | 0 | 0 | 0 | | 0 | -66,408 | -66,408 |
| | Inland wetlands | 0 | 412 | 412 | 0 | 0 | 0 | 412 | | 0 | 27 | 27 |
| | Coastal wetlands | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 |
| | Fisheries and aquaculture | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Inputs & Invest. | 0 | 768,929 | 768,929 | | 0 | 0 | | 768,929 | 0 | 51,262 | 51,262 |
| **Total emissions, tCO2-e** | | **237,032** | **-152,690** | **-389,722** | **-996,119** | **-142,774** | **23,024** | **-42,782** | **768,929** | **15,802** | **-10,179** | **-25,981** |
| **Total emissions, tCO2-e/ha** | | **5.8** | **-3.7** | **-9.5** | **-24.3** | **-3.5** | **0.6** | **-1.0** | **18.8** | | | |
| **Total emissions, tCO2-e/ha/yr** | | **0.4** | **-0.2** | **-0.6** | **-1.6** | **-0.2** | **0.0** | **-0.1** | **1.3** | | | |

+ = Source / - = Sink
Results presented here include GHG fluxes on mineral and organic soils
See further down for detailed results on organic soils
* Includes fisheries, acquaculture and inputs & investments that are not included in the AFOLU definition.

| **Uncertainty level** | tCO2-e/yr | Percent |
|---|---|---|
| **WITHOUT** | 15,802 | 43% |
| **WITH** | -10,179 | 34% |
| **BALANCE** | -25,981 | 35% |

## Computation of data in EX-ACT:

Activity 1.1.2, 1.2.1, and 2.2.1: This activity foresees an improvement of agriculture management practices, in particular soil conservation, in an area of 23,400 ha. This will reduce tillage and avoid burning residue. Additionally, a shared of land will shift towards organic crop requiring the application of organic inputs; other section will show improvements by better irrigation practices. The activities are expected to be carried out by building capacities, such as Farmers' Field Schools. An adoption rate of 70% was applied[6], this means that it is assumed that 70% of farmers under building capacity will continue carrying out the improvements over a 20 years' time period.

Activity 1.2.2: This activity calculates the construction of four collection and marketing centers (200 $m^2$ each). The emission factor of 'food sales (retail or wholesale)' category was used which considers the building construction emissions via manufacture of materials used, transport and fuel used onsite[7]. Additionally, it is expected that the collection and marketing center provides a minimum requirement for cold and chill storage. Energy consumption was calculated based on Evans, et al, et al. (2015)[8] with specific energy consumption of 45 kWh/m3/year under chilled chambers. Furthermore, refrigerant leakage emissions were calculated based on IPCC[9] and EPA[10] equations, where average leakage rate is multiplied by the GWP of the refrigerant. It was assumed the use of R-134 refrigerant with a GWP of 1,300 and an average of 7.9% of leakage rate.

The analysis integrated emissions from transport to inform their contribution, however this is a component that the project is not funding directly. The approach is a fuel consumption based. It was assumed that two thirds of the producers own a vehicle to collect the product and travel an average of 141 km to collection center, this is an average in each area of the project. Additionally, it is assumed

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[5] The screenshot do not show emissions from refrigerant leakage and honey VC.

[6] FFS is recognized as a most suitable approach to shift agriculture practices into sustainable ones (Cai, et al. 2022, Jørs, et al. 2014, Jabbar, et al. 2022, Waddington, et al. 2014). The adoption rate of 70% is the standard recognized by FFS technical experts on the basis of 30 and more years of FFS implementation in over 100 countries around the world.

[7] Based on ADEME-Bilans database. https://bilans-ges.ademe.fr/en/accueil

[8] Evans, et al. 2015. Specific energy consumption values for various refrigereted food cold stores. ICR.

[9] IPCC. 2006. Volume 3. Chapter 7. Table 7.9

[10] EPA. 2014. Direct fugitive emissions form refrigeration, air conditioning, fire suppression and industrial gases.

that one third of the producer's product ends in the main city of La Paz with an average distance of 642 km. Fuel consumption is dependent by many factors such as driving method, age of fleet, road, etc. An average fuel consumption of 30 to 40 liters per kilometer was assumed. With this data it can be derived an annual consumption and multiplied by the implementation years of the project.

Activity 1.2.3 The project seeks for the diversification of goods to increase the income of farmers, the beekeeping value chain is prioritized. Several constrains exist to conduct an emissions estimation, to mention, number of hives, type of technology use, type of processing, etc. However, for purposes of this project an average carbon footprint (CFP) of honey production was retrived from literature. Based on Sillman, et al (2021)[11] the carbon footprint per kilogram of honey in Finland is of 0.65 kgCO2eq per kg of honey; Mujica, et al (2016)[12] was calculated on 2.5 kgCO2 per kg of honey in Argentina. Furthermore, Kendall et al (2013)[13] provided a range of 0.67 to 0-92 kgCO2-eq per kg of honey in the USA. Within the studies energy is used for the honey extraction (centrifugation), transport is assessed with different context-specific distances. A CFP average between the lowest and higher bound was calculated of 1.6 kgCO2-eq per kg of honey. Based on an UNDP project in honey production in Bolivia, it is expected that hives produce up to 100 kg of honey, and each farmer association has around 30 hives. The total amount of potential honey production was calculated as 60 tons per year. By multiplying the honey production to the CFP allow us to calculate the total emissions. However, it is important to acknowledge that it is common at rural stage that honey extraction is performed without energy with manual centrifugates.

Activity 2.1.1 and 2.1.3: This component aims to establish efficient water use. For this, 1,0000 new community, and 5,000 family reservoirs are expected to be constructed for rainwater catchment. In EX-ACT this has been included as construction of agriculture infrastructure. Dripping and sprinkler irrigation systems are also expected to be install. This has been computed in EX-ACT for the installation of new infrastructure in 4,448 ha. Additionally, energy use of pumping water from the source has been calculated, assuming gasoline-based powered pumps.

Methane (CH4) emissions can occur in reservoirs from the first 20 years. EX-ACT tool is equipped to assess methane emissions from inland waterbodies. IPCC provides emission factors based on climate zones, which was used to simulate the potential methane emissions from reservoirs.

Activity 3.1.2: Seeks to restoration processes in micro-watersheds to increase resilience and climate adaptation by enhancing ecosystem functions and services. An area of 17,510 ha is targeted to be managed and improved. The module of Forest Management was the best suited to avoid any overestimation of this component, and a conservative approach to reduce biomass loss of 10% is assumed.

The table below describe the emissions disaggregated to complement Figure 1.

| **COMPONENT** | **EMISSIONS** |
|---|---|
| CROPLAND | -162,943.53 |
| FOREST MANAGEMENT | -996,119.37 |
| INPUTS | 768,929.22 |
| INLAND WETLANDS | 411.92 |

[11] Sillman, et al. 2021. Contribution of honeybees towards the net environmental benefits of food. Science of the total environment. Volume 756. https://doi.org/10.1016/j.scitotenv.2020.143880

[12] Mujica, et al. 2016. Carbon footprint of honey produced in Argentina. 116, 50–60. https://doi.org/10.1016/j.jclepro.2015.12.086. *National Honey Board, 2011. Carbohydrates and the Sweetness of Honey*

[13] Kendall, et al. 2013. Carbon footprint and air emissions inventories for US honey production: case studies. Int. J. Life Cycle Ass. 18, 392–400. https://doi.org/10.1007/s11367-012-0487-7

| | | |
|---|---|---|
| REFRIGERANT LEAKAGE | 10,335.00 | |
| HONEY VC | 1,890.00 | |
| ***TOTAL CARBON BALANCE*** | **-377,497** | tCO2-eq over 20 years |