Resilient Puna: Ecosystem-based approaches for sustainable High Andean communities and ecosystems in Peru

Annex 22: GHG emissions reduction

Version 2

Content

1. Methodology for calculation GHG emission reductions

1.1 Methodology

The project recognizes as a valuable co-benefit the reduction of GHG emissions. The proposed intervention measures aim to prevent emissions from existing carbon sources, like livestock, crops, and pasture management, and contribute to carbon sequestration in soil and vegetation, through pasture and forest management, and wetland restauration.

GHG reductions are calculated using the methodology presented in the IPCC Good Practice Guidance for LULUCF, applied though the tool EX-ACT (version 9.4) developed by FAO. This methodology was chosen due to its widespread recognition, general applicability in both the baseline and with-project scenarios, and the availability of relevant data.

In order to assume a potential budget distribution for the different EbA measures in the selected districts, the data collected by the cartographic analysis was used to determine the probability of implementation. Even though the sub-projects that will get funded by the Puna Resilience facility are not yet determined, a methodology is proposed to reach assumptions on a distribution that is likely to happen, based on the data available.

The aim of this exercise was to generate the data required to perform the impact assessment and GHG calculations resulting from the application of the EbA measures. The analysis determined the potential units per EbA measure and the associated costs of implementation.

Table 1 shows an overview of the total area catalogued with “high-suitability” of implementation of each EbA measures in the selected departments, and the probability of implementation, understood as the total area with “high-suitability” per EbA measure divided by the total area with “high-likelihood” of all EbA measures.

The calculations performed can be resumed as:

Ha per EbA measure = Budget per Eba measure / Unitary cost per ha for each EbA

Budget per Eba measure = Available budget * probability of implementation

Probability of implementation = Area characterized as highly suitable per EbA measure/Total are characterized as High suitable for at least one EbA

Table 1 – Overview of EbA’s probability of implementation and areas with “high-likelihood” of implementation, in hectares.

EbA measures	Apurimac (ha)	Arequipa (ha)	Cusco (ha)	Lima (ha)	Puno (ha)	Total (ha)	Probability of implementation (%)
EbA 1: Bodefal restauration and conservation	5,021	18,041	17,316	1,191	20,781	**62,350**	3.3%
EbA 2: Family Qochas	371	2,168	5,262	389	2,912	**11,101**	0.6%
EbA 3: Integrated Soil fertility management	31,168	11,793	81,663	1,161	25,056	**150,840**	7.9%
EbA 4: Contour farming	400	882	17,163	14	4,942	**23,400**	1.2%
EbA 5: Infiltration ditches	22,016	5,672	4,706	1,296	1,687	**35,378**	1.8%
EbA 6: Sustainable grassland management[1]	285,106	399,719	274,604	66,197	454,140	**1,479,766**	77.2%
EbA 7: Conservation Agriculture	14,699	3,567	20,119	895	12	**39,293**	2.0%
EbA 8: Agroforestry	15,979	6,076	50,694	846	24,937	**98,532**	5.1%
EbA 9: Reforestation with native species	0	4,403	534	1,606	0	**6,542**	0.3%
EbA 10: Andenes/ Terraces restauration	2,867	1,260	5,595	702	100	**10,524**	0.5%

Once determined the probability of implementation, the total investment assigned to EbA measures (14,400,000 EUR), was distributed using the probability number, to obtain the expected budget to be utilized in each EbA measure implementation. In order to obtain the impact of each EbA measure, the investment available per measure was divided by the unitary cost, determining how many units of each measure could be achieved with the budget assigned. The results are displayed on Table 2.

Table 2 – Overview of EbA's probability of implementation and areas with "high-likelihood" of implementation, in hectares.

EbA measures	Probability of implementation	Total investment per EbA (EUR)	Cost per unit		Value
			Soles	EUR	
EbA 1: Bodefal restauration and conservation	3.3%	468,180	1,880	470.00	996 ha
EbA 2: Family Qochas	0.6%	83,360	20,000	5,000.00	17 qochas
EbA 3: Integrated Soil fertility management	7.9%	1,132,643	6,844	1,710.94	662 ha
EbA 4: Contour farming	1.2%	175,708	1,041	260.25	675 ha
EbA 5: Infiltration ditches	1.8%	265,648	5,000	1,250.00	213 ha
EbA 6: Sustainable grassland management	77.2%	11,111,397	2,286	571.50	19,443 ha
EbA 7: Conservation Agriculture	2.0%	295,049	6,113	1,528.13	193 ha
EbA 8: Agroforestry	5.1%	739,867	1,898	474.50	1,559 ha
EbA 9: Reforestation with native species	0.3%	49,126	4,500	1,125.00	44 ha
EbA 10: Andenes/Terraces restauration	0.5%	79,023	2,441	610.21	130 ha

[1] Includes areas with medium and high-suitability of implementation.

TOTAL	**23,914 ha**

1.2 Scope

The timeframe considered for the analysis is 15 years, which includes five years of implementation phase and ten years of capitalisation phase. All project activities considered inside the scope of the calculation belong to Output 1.1: Public and Private investment for the scale up of Ecosystem based Adaptation (EbA) measures. The initial assumptions are displayed in Table 3.

Table 3 – Project activities included inside the scope for the GHG calculation

Value chain	Activity	Implementation probability (%)	Units	Mitigation impact	EX-ACT Module
Ecosystem based Adaptation	EbA 1: Bodefal restauration and conservation	3.3%	996 ha	Increase of carbon in soils (capture).	6.Inland wetlands
	EbA 2: Family Qochas	0.6%	17 qochas	No direct mitigation impacts.	
	EbA 3: Integrated Soil fertility management	7.9%	662 ha	Increase of carbon in vegetation and soils (capture).	3. Cropland management
	EbA 4: Contour farming	1.2%	675 ha	No direct mitigation impacts.	
	EbA 5: Infiltration ditches	1.8%	213 ha	Considered together with EbA 6.	
	EbA 6: Sustainable grassland management	77.2%	19,443 ha	No direct mitigation impacts in carbon soil for reduction of overgrazing.	4.Grassland and livestock
	EbA 7: Conservation Agriculture	2.0%	193 ha	No direct mitigation impacts.	
	EbA 8: Agroforestry	5.1%	1,559 ha	Increase of carbon in vegetation and soils (capture).	2. Land use changes 3. Cropland management
	EbA 9: Reforestation with native species	0.3%	44 ha	Increase of carbon in vegetation and soils (capture).	
	EbA 10: Andenes/Terraces restauration	0.5%	130 ha	No direct mitigation impacts.	
Value Chain 1: Camelids (vicuñas and alpacas)			6,416 heads	Reduction of emission sources due to less emitting livestock species.	4. Grassland and livestock
Value Chain 2: Andean crops			6,041 ha	Increase of carbon in vegetation and soils (capture).	3. Cropland management

1.3 Summary of parameters, values, and data sources

GHG sequestration figures are estimated according to the following parameters:

Table 4 – Inputs required to perform the GHG calculations in EX-ACT according to the project proposed activities.

Category	Sub-category	Variable	Value	Source
1. General parameters	Project site and duration	Climate	Warm temperature	IPCC Guidelines for National Greenhouse Gas Inventories (2016), Climate zones
		Moisture	Moist	
		Soil type	Wetlands soils	Harmonised World Soil database
		Implementation phase	5 years	Concept Note
		Capitalization phase	10 years	
2. Land-use changes	1.2.Other land use changes	Initial land-use	Annual cropland: 1,559 ha	Field research/ cartography
		Final land use	Agroforestry: 1,559 ha	EbA measures
		Fired used?	No	Assumption
3. Cropland management	3.1. Annual crop systems	Main season crop – baseline/ without project	Potatoes: 662 ha	Field research/ cartography
		Main season crop – with project	Potatoes + Quinoa (minor crop): 331 ha Potatoes + Legumes (minor crop): 331 ha	EbA measures
		Tillage management – Baseline, without project	Reduced tillage	Field research
		Tillage management – with project	No tillage	EbA measures
		Input of organic material – baseline/ without project	Low C input	Field research
		Input of organic material – with project	High C input, with manure	EbA measures
		Residue management	Retained	Field research/ EbA measures
		Yield – baseline/ without project	Potatoes: 7.73 t/ha.yr	Field research
		Yield – with project	Potatoes: 10 t/ha.yr Quinoa: 18 t/ha.yr Legumes: 16.8 t/ha.yr	EbA measures
	3.2. Perennial crop systems	Agroforestry systems	Agroforestry	EbA measures
		Tillage management – Baseline, with/ without project	No tillage	Field research/ EbA measures
		Input of organic material – with project	High C input, with manure	EbA measures
		Residue management	Retained	Field research/ EbA measures
		Residue/ biomass burning	No	Assumption
4.1 Grassland		Grassland management – start	Severely degraded	Field research

and Livestock	4.1.2. Grassland management	Grassland management -without project	Severely degraded	Field research
		Grassland management - with project	Severely degraded	EbA measures
		Area	19,443 ha	EbA measures
		Fire management and periodicity - without/ with project	No	Assumption
		Yield at - start	0.16533 t/ha.yr	Field research
		Yield at - without project	0.085 t/ha.yr	Field research
		Yield at - with project	0.5 t/ha.yr	EbA measures
	4.2. Livestock and manure management	Livestock categories/species - start/ without project	Llamas and Alpacas - Low productivity 19,443 heads	Field research
		Livestock categories/species - with project	Llamas and Alpacas - High productivity: 6,416 heads	EbA measures
5. Forest management	5.1. Forest degradation & management	Type of forest vegetation that will be managed	Subtropical mountain systems	Global ecological zones. FAO (2015)
		Forest degradation level - Start	Large	Field research
		Forest degradation level -Without project	Extreme	Assumption
		Forest degradation level - With project	Moderate	EbA measures
		Fire occurrence, periodicity, impact - Start/ Without/ With project	No	Assumption
		Forested area (ha)	44 ha	Field research/ cartography
6. Inland wetlands	6.1.3. Organic soil management practices associated with other LUC	Land use cover - Start/ without project	Degraded land: 996 ha (SOC: 85 tC/ha)	Field research/ cartography
		Land use cover - With project	Grassland: 996 ha (SOC: 124 tC/ha)	EbA measures
		Fire used?	No	Assumption
		Burning of biomass	No	Assumption
		Area under drainage - Start/ without/ with project	0 ha	Assumption
		Fire on soil	No	Assumption

The emission factors used for this calculation are:

Category	Sub-category	Variable	Factors used	Value	Source
2. Land-use changes	1.3. Other land use changes	Annual cropland	Biomass	4.7 tC/ha	EX-ACT database
			Soil carbon	135.0 tC/ha	EX-ACT database
			Flu	0.7 tC/ha	EX-ACT database
		Grassland	Biomass	6.3 tC/ha	EX-ACT database

			Soil carbon	135.0 tC/ha	EX-ACT database
			Flu	1.0 tC/ha	EX-ACT database
		Agroforestry	Biomass	1.8 tC/ha	EX-ACT database
			Soil carbon	135.0 tC/ha	EX-ACT database
			Flu	0.7 tC/ha	EX-ACT database
3. Cropland management	3.1.1 Annual crop systems	Annual converted to non-forest LUs	Soil carbon	93.2 tC/ha	EX-ACT database
			Tillage factor	1.10	EX-ACT database
			Input factor	0.92	EX-ACT database
			Residue/Biomass available	10.90 t dm/ha	EX-ACT database
	3.1.2 Annual cropping systems remaining cropping systems	Potatoes (baseline)	Soil carbon	135.0 tC/ha	EX-ACT database
			Land-use factor	0.69	EX-ACT database
			Tillage factor	1.05	EX-ACT database
			Input factor	0.92	EX-ACT database
			Residue/Biomass available	0.77 t dm/ha	EX-ACT database
		Potatoes (with project)	Soil carbon	135.0 tC/ha	EX-ACT database
			Land-use factor	0.69	EX-ACT database
			Tillage factor	1.10	EX-ACT database
			Input factor	1.44	EX-ACT database
			Residue/Biomass available	1.0 t dm/ha	EX-ACT database
		Quinoa (with project)	Soil carbon	135.0 tC/ha	EX-ACT database
			Land-use factor	0.69	EX-ACT database
			Tillage factor	1.10	EX-ACT database
			Input factor	1.44	EX-ACT database
			Residue/Biomass available	19.62 t dm/ha	EX-ACT database
		Legumes (with project)	Soil carbon	135.0 tC/ha	EX-ACT database
			Land-use factor	0.69	EX-ACT database
			Tillage factor	1.10	EX-ACT database
			Input factor	1.44	EX-ACT database
			Residue/Biomass available	18.98 t dm/ha	EX-ACT database
	3.2. Perennial crop systems	Perennias converted from non-forest to LUs	Above-ground	1.37 tC/ha/yr	EX-ACT database
			Below-ground	0.39 tC/ha/yr	EX-ACT database
			Max AGB in IPCC	39.7 tC/ha	EX-ACT database
			Soil carbon	97.2 tC/ha	EX-ACT database
4. Grassland and Livestock	4.1.2. Grassland management	Remaining grassland systems	Soil carbon stocks - start	94.5 tC/ha	EX-ACT database
			Soil carbon stocks - without project	94.5 tC/ha	EX-ACT database

			Soil carbon stocks – with project	94.5 tC/ha	EX-ACT database
			AGB	2.7 t d.m./ha	EX-ACT database
	4.2. Livestock and manure management	Alpacas	Enteric fermentation	8 kgCH4/head/year	EX-ACT database
			% corresponding to pasture	80%	EX-ACT database
5. Forest management	5.1. Forest degradation & management	Subtropical mountain systems	Above-ground	35.1 tC/ha	EX-ACT database
			Below-ground	9.5 tC/ha	EX-ACT database
			Litter	0.0 tC/ha	EX-ACT database
			Dead wood	11.8 tC/ha	EX-ACT database
6. Inland wetlands	6.1.3. Organic soil management practices associated with other LUC	Bofedal restauration	Above and below ground – baseline/without project	1.0 tC/ha	EX-ACT database
			Above and below ground – with project	6.3 tC/ha	EX-ACT database

2. Description of baseline scenario and results of emission reduction calculations

The area of intervention of the Resilient Puna Project includes territories located in the highest region of the Andes Mountains, where hydrographic basins that discharge into the large basins of the West Pacific and Amazon (W. Atlantic) are born. It contains fragile ecosystems that provide very important services for the sustenance of both the population that inhabits this region, and for those located in the lower areas of the mountain range. These ecosystem services, which are very necessary to sustain the quality of life and the capacity to produce goods and services for the entire population include water regulation in the headwaters of the basins, the maintenance of biodiversity, the capture and storage of carbon, the provision and conservation of genetic resources, the harmony of nature and scenic beauty, among others.

Ecosystems are the basis for the livelihood of the population located in their surroundings because they facilitate the provision of renewable resources for the production of food and fodder, through family farming, raising and/or grazing animals, as well as energy and shelter, necessary for their homes. However, the main puna ecosystems, such as wetlands, bofedales[2] (peat bogs) and pajonales (natural grasslands) are in the process of frank deterioration due to different causes, the main ones being prolonged droughts and overgrazing.

In this region, especially in the South Puna, which is covers the regions of Apurimac, Arequipa, Cusco and Puno, climate change manifests itself with significant variations in the presence and volume of rainfall, as well as atypical changes in temperature, which cause periods excessively rainy and years with no rain or meteorological droughts. These variations result in significant loss of crops, pastures, and animals. The regions also experience sudden drops in temperature, which are almost always associated with snowfall, which causes the death of animals that graze in the open air and lack protection against the cold. These phenomena gradually deteriorate Puna ecosystems, restricting their ability to regulate water and forage production consumed by domestic and wild animals, causing an increase in overgrazing of the weak grasslands and of the vegetation that grows in the bogs.

The Resilient Puna project will be distributed among the departments of Apurimac, Arequipa, Cusco, Lima, and Puno. Given that the Resilient Puna Project is articulated in a financial scheme, the Puna Facility, the interventions that supported will belong to a given set of options, but its distribution is still unknown. The scope proposed is at sub-project level, based on the "implementation probability" that an intervention will happen in the defined territory. To determine the probability, a cartographic analysis has been performed, including all districts and measures, defining the areas with high potential to apply each of the measures and distributing the total budget among the likelihood.

[2] The bofedales are high altitude wetlands composed by dense vegetation grasslands, arranged as compact grass carpets, and developed on saturated peaty or permanently wet organic soils along the year (Helvetas Swiss Intercooperation, 2017 et al, citado por UNU CONDESAN en el Eba Catalogue.

The emissions in the business-as-usual scenario in the designated area are associated to activities as agriculture and livestock production. The total emissions calculated for without project have been estimated to be 1,296,911 tCO2e, in the period analysed of 15 years.

2.1 Analysis of Output 1.1

Output 1.1 activities include investments for EbA measures and climate resilient value chains are implemented at the local landscape level. It will contribute to creating the basis for financing and implementing EbA measures and climate resilient value chains (CRVC) and providing financial support for climate-focused sub-projects through the Puna Facility and public resources.

The different measures included in the sub-projects portfolio consider the following parameters:

Measure	Area (ha)	Current land use	Assumption – without project	Assumption – with project	EX-ACT Module	Reference sources
EbA 1: Bodefal restauration and conservation	996 ha	Degraded land of organic soil wetlands.	Degradation increase on bofedales, releasing oil carbon.	Restauration through bofedal patches planting, water management using ditches, limited rotational grazing of camelids, and maintenance of fences.	6.1.3 Inland wetlands, Organic soil management practices associated with other land-use changes	IPCC 2006: Volume 4 – AFOLU, Chapter 7: Wetlands
EbA 2: Family Qochas	No direct mitigation impacts, integrated to EbA1: bofedal restauration.					
EbA 3: Integrated soil fertility management	662 ha	Annual cropping system: ▪ Potatoes 662 ha (yield: 7.73 t/ha.yr)	Annual cropping system: Potatoes 662 ha (yield: 7.73 t/ha.yr)	Crop diversification and yield increase, due to changes in the management options: reduced tillage to no tillage, and low C input to high C input with manure. Annual cropping system: ▪Potatoes 331 ha (yield: 10 t/ha.yr) + Quinoa (minor season crop) (yield: 18 t/ha.yr) ▪Potatoes 331 ha (yield: 10 t/ha.yr) ▪+ Legumes (minor season crop) (yield: 16.8 t/ha.yr)	3.1.2.Cropland management, Annual cropping systems remaining annual cropping systems	IPCC 2006: Volume 4 – AFOLU, Chapter 5: Cropland
EbA 4: Contour agriculture (TA)	No direct mitigation impacts.					
EbA 5: Infiltration ditches	No direct mitigation impacts, integrated to EbA1: bofedal restauration.					

EbA 6: Sustainable grassland management	19,443 ha	19,443 ha Grassland severely degraded	19,443 ha Grassland severely degraded	19,443 ha Grassland severely degraded[3]. Sustainable grassland management and limited rotational grazing of camelids.	4.1.2 Grassland management, Grassland systems remaining grassland systems.	IPCC 2006: Volume 4 – AFOLU, Chapter 6: Grassland
EbA 7: Conservation Agriculture	No direct mitigation impacts.					
EbA 8: Agroforestry	1,559 ha	1,559 ha of annual crops	1,559 ha of annual crops	Introduction of perennial species into agricultural systems and livestock productive units. Plantation of trees for agroforestry in the 1,559 ha.	2.3 Land-use changes, Other land use changes 3.1.1 Cropland management, annual cropping systems from other LU 3.2.1. Cropland management, perennial systems from other LU	IPCC 2006: Volume 4 – AFOLU, Chapter 5: Cropland
EbA 9: Reforestation with native trees	44ha	44 ha of forest with large degradation level (60%).	44 ha of forest with extreme degradation level (80%).	Re-establishing native forest by planting and diversifying forest species similar to the original cover. 44 ha of forest with moderate level (40%).	5.1. Forest management, Forest degradation & management	IPCC 2006: Volume 4 – AFOLU, Chapter 4: Forest land
EbA 10: Andenes/Terraces restauration	No direct mitigation impacts.					
Value Chain 1: Andean Camelids (vicuñas and alpacas)	19,443ha	19,443 alpacas Density: 1 alpaca/ha	19,443 alpacas Density: 1 alpaca/ha	6,416 alpacas Limitation of other species of livestock in the grassland and increase in the camelids population. Density: 0.33 alpaca/ha	4.2 Livestock and manure management	IPCC 2006: Volume 4 – AFOLU, Chapter 10: Emissions from Livestock and manure management
Value Chain 2: High Andean crops	Considered in EBA 3- Integrated Soil Fertility Management					
Value Chain 3: Community tourism	No direct mitigation impacts.					

[3] The situation is expected to improve from severely degraded to non-degraded. However, there is no local data available to predict changes over time for the project, so the condition remains severely degraded for this estimation. The project will seek to measure the changes in soil carbon content resulting from this EbA under the project in activity 1.2.2.

2.2 Analysis of Output 1.2

Output 1.2 activities involve the recovery and dissemination of EbA knowledge, and local monitoring committee and observation systems are implemented. It will ensure that the use of EbA knowledge is recovered, disseminated and that local monitoring committees and observation systems are implemented. This will be achieved through facilitating intergenerational dialogues on ancestral practices, capacity building of local experts for ancestral and innovative knowledge linked to EbA and climate-resilient value chains.

No direct emission reductions are associated to Output 1.2.

2.3 Analysis of Output 2.1

Output 2.1 includes different financial mechanisms for the implementation of EbA measures and the improvement of climate resilient livelihoods, to make them accessible to vulnerable communities in the Puna ecosystem. The mobilisation of private and public financing through new financial mechanisms:

- Improvement of MERESE (PES) Schemes
- Grants and repayable grants to the community
- Development of new financial products such as microcredit.

No direct emission reductions are associated to Output 2.1.

2.4 Analysis of Output 3.1

Output 3.1 involves multilevel landscape governance improvement through capacity building, stakeholder engagement and management of climate information for decision making. Under Output 3.1, activities will ensure the incorporation of experiences from local planning processes in dialogue and consensus-building platforms at the watershed (meso) level to influence regional planning and budget allocation for EbA practices.

No direct emission reductions are associated to Output 3.1.

2.5 Summary of project emission reduction potential

The overall mitigation impact from the project quantified by EX-ACT is a reduction of 407,657 tCO2e in the 15 years analysed, which include five years of implementation phase and ten years of capitalisation phase. It is measured against a scenario without project that would have increased by 93,905 tCO2e the GHG emissions in the areas of intervention.

The gross fluxes corresponding to the different activities with a direct mitigation impact are presented in Table 5. The numbers reflected correspond to the impact during the 15 years considered for analysis in a total area of intervention of 23,914 ha.

Table 5. Summary of project emission reductions

Value chain	Activity	Scenario without project	Scenario with project	Balance
Ecosystem based Adaptation	EbA 1: Bodefal restauration and conservation	0	-142,447	-142,447

	EbA 2: Family Qochas	No direct mitigation impacts, considered together with EbA 1.		
	EbA 3: Integrated soil fertility management	11,373	-77,734	-89,107
	EbA 4: Contour agriculture (TA)	No direct mitigation impacts.		
	EbA 5: Infiltration ditches	No direct mitigation impacts, considered together with EbA 1.		
	EbA 6: Sustainable grassland management	No direct mitigation impacts in carbon soil stocks.		
	EbA 7: Conservation Agriculture	No direct mitigation impacts.		
	EbA 8: Agroforestry	15,401	-120,619	-136,020
	EbA 9: Reforestation with native Species	1,804	-1,804	-3,608
	EbA 10: Andenes/Terraces restauration	No direct mitigation impacts.		
Value Chain 1: Camelids (vicuñas and alpacas)		65,327	28,853	-36,474
Value Chain 2: high Andean Crops		Considered in EBA 3- Integrated Soil Fertility Management		
Value Chain 2: high Andean Crops		No direct mitigation impacts.		
Total emissions, tCO2-e		**93,905**	**-313,751**	**-407,657**
Total emissions, tCO2-e/ha		**4.1**	**-13.8**	**-18.0**
Total emissions, tCO2-e/ha/yr		**0.3**	**-0.9**	**-1.2**