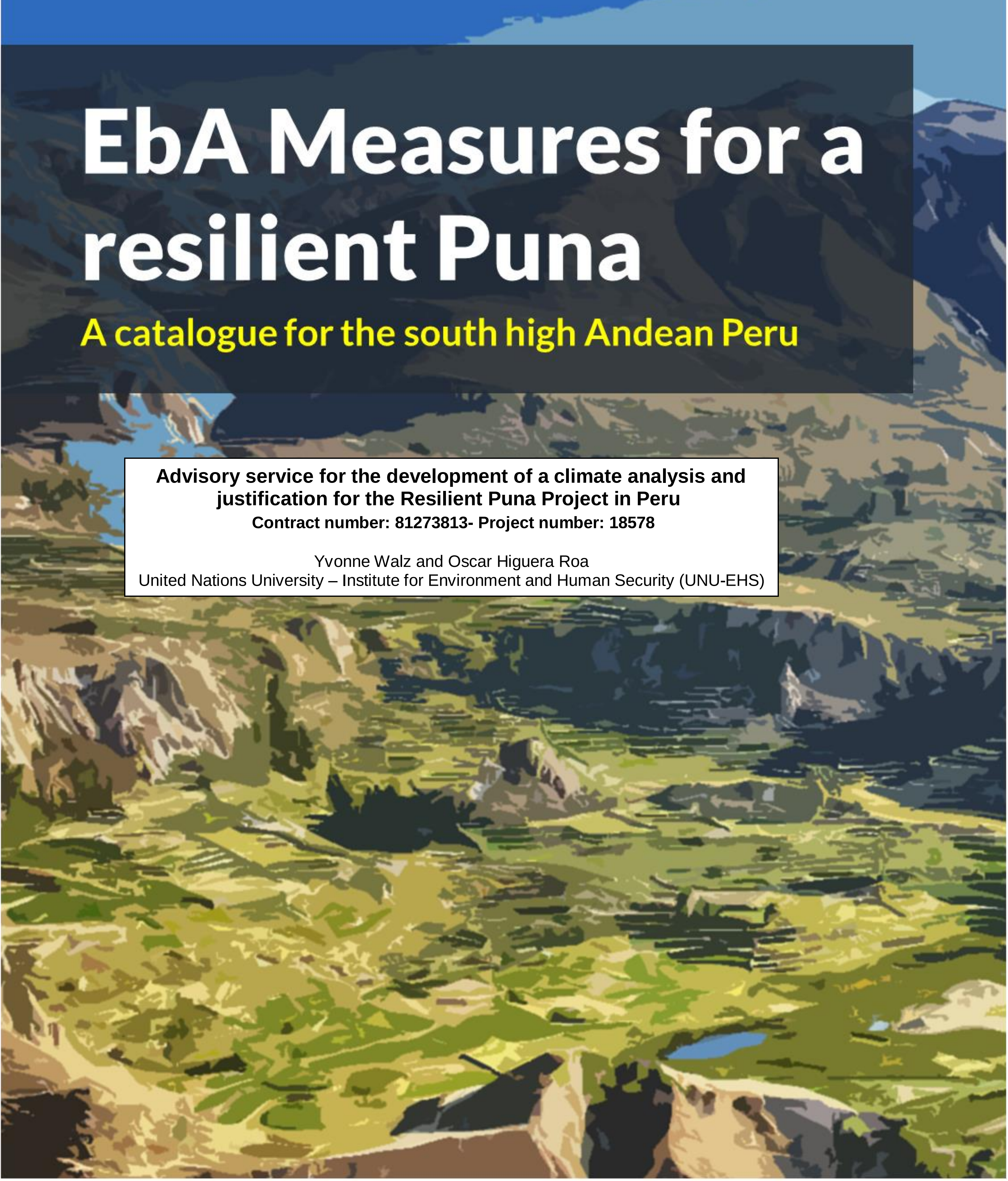

EbA Measures for a resilient Puna

A catalogue for the south high Andean Peru

Advisory service for the development of a climate analysis and justification for the Resilient Puna Project in Peru
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Introduction

This catalogue of Ecosystem-based Adaptation (EbA) measures has been compiled as an essential piece of information to respond to the results of the "Core Climate Risk Analysis for the GCF feasibility study" (UNU-CONDESAN_CoreClimateRisk Analysis_DRAFT0608). While this climate risk analysis identifies and elaborates on the main drivers of risks, this EbA catalogue has been compiled to have a set of potential measures for risk reduction. This EbA catalogue has been compiled specifically for the south high Andean region of Peru based on desktop research and information provided by stakeholders of the respective region. This EbA catalogue presents the relevant information to derive targeted intervention measures in response to identified hotspots and their underlying drivers in the study area.

1. Ecosystem-based approaches

The ecosystem-based approach focuses on the conservation, sustainable use and restoration of ecosystems and their ecosystem services (ES) for the benefit of society.

It consists of multipurpose solutions that, compared to other technical and structural solutions, are more efficient in generating social, environmental and economic benefits. It is a widely applied and varied approach to issues such as disaster risk reduction (Eco-DRR), climate change mitigation and adaptation (EbA). These measures are helpful for climate risk mitigation, appropriate ecosystem management and sustainable socio-economic development planning. In addition, these measures generate multiple benefits such as biodiversity conservation, carbon sequestration, microclimate regulation, water regulation, and support for sustainable and resilient livelihoods.

An **EbA approach** is internationally defined as: "**the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change**" (CBD, 2019). In the context of the Resilience Puna project, this can be interpreted that climate-related risks such as the risk of fodder or water provision will be reduced through targeted management of the ecosystem. However, ecosystem-based approaches should not stand alone but be considered an integral part of a broader adaptation strategy, which includes many other sectors, such as policy, finance, housing and infrastructure.

In general, EbA measures are based on the benefit that human communities derive from biodiversity and ecosystem services and the use of those in adapting to climate change. The most relevant ecosystems and its services that are pressured by climate change in the project region are grasslands used for livestock, glaciers for water provision, *bofedales* to store water, and agricultural land to provide crops. In order to adapt to climate change, **EbA measures include a wide range of ecosystem management activities that increase climate resilience and reduce the climate change vulnerability in people and ecosystems**. These measures could entail, for instance, the sustainable management of bofedales to secure water storage beyond the projected melting and disappearing glaciers. Next to managing ecosystems, their sustainability has to be ensured by integrating the perspective and context of the local population in the respective area. In addition to relying on the integrity and health of ecosystems, EbA measures are also:

- people-centred,

- participatory,
- implemented at a landscape scale,
- flexibly and adaptively managed,
- based on local and scientific knowledge,
- gender-sensitive,
- articulated to the local culture.

2. Puna eco-region

The southern high Andean region of Peru has a great variety of ecosystems and, at the same time, is threatened by increasing temperatures and higher variability of precipitation patterns due to climate change. Depending on the humidity, temperature, and altitude conditions, the landscape can be categorized into different eco-regions (Figure 1). In the case of the Puna eco-region, several ecosystems are present: grasslands, wetlands, peatlands, shrub meadows, scrublands, high Andean Forest, meso-Andean Forest, high Andean lagoons, and areas of few or null vegetation (bare lands), which are sensitive to climate change effects, such as an increase in the mean and maximum temperature, a decrease in average rainfall, variation in precipitation pattern or more recurrent heavy rainfall events.

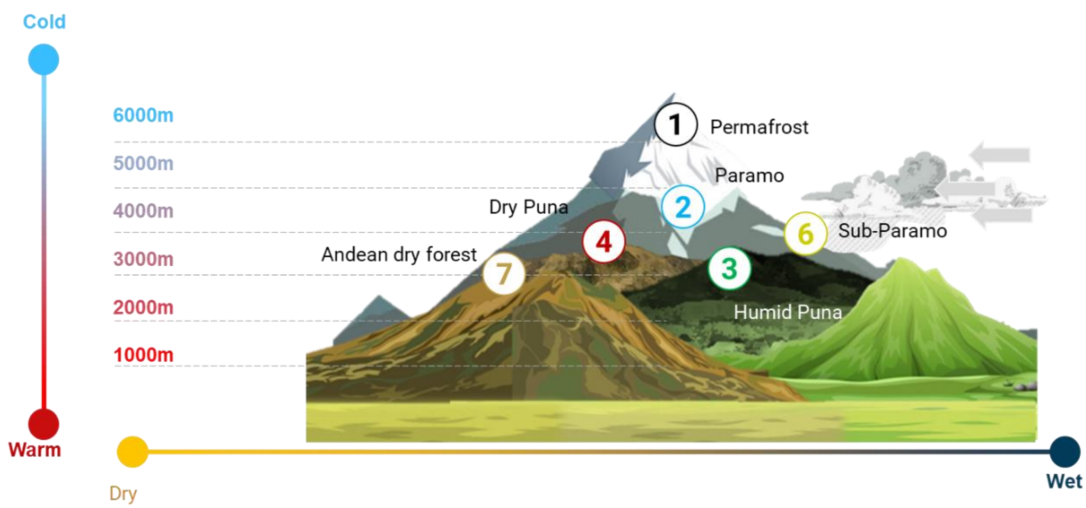

Figure 1. Andean Eco-regions (adapted from UNEP-Regional Office for Latin America and the Caribbean & Frankfurt School-UNEP Collaborating Centre for Climate and Sustainable Energy Finance [UNEP-ROLAC / FS-UNEP Centre], 2014)

3. Ancestral knowledge for climate change adaptation

In Andean communities with strong cultural roots, three elements are essential for any ancestral practice: control of the territory (*ayllu*), communal organization of work (*minka*) and following the calendar of communal festivities (Direccion Desconcentrada de Cultura de Cusco [DDCC], 2019).

Ancestrally, the high Andean communities of Peru have developed practices and knowledge for sustainably managing natural resources, which contribute to reducing their climate change vulnerability. These ancestral practices and knowledge express the human-nature relationship resulting from a social organization based on reciprocity and complementarity from the Andean world's values, beliefs, perceptions, rituals, festivities, and traditions. More than knowledge to face climate change, these practices reflect the profound vision of the Andean peoples that we are all part of the same "body" and, consequently, it is urgent to recover and maintain the harmony between humans and nature. (DDCC, 2019)

Therefore, from the local cosmovision, both water (*yakumama*) and soil and other elements of nature (*Pachamama*) are living entities (*kawsaqmi*) that should be valued, respected and protected. In this horizontal relationship with nature, the human communities are called to "nurture" the resources while allowing themselves to be "nurtured" by them in an ecological balance. (DDCC, 2019)

From that perspective, water can be harvested and bred. Harvesting water refers to water storage technologies, making its sowing in rainy seasons and cultivating it for the dry season. Water husbandry relates to systems that gradually feed springs to make their flow grow and remain stable throughout the year. (Moran et al., 2018)

There are several modalities of water harvesting, including the restoration of water sources. Primarily, they consist of storing rainwater *(Qucha ruway*), conserving springs (*Puquio waqaycha*y), planting "water mother plants" (*Yakupa mama*n) or "water-caller plants" (*Yaku qayaq*), wetlands formation (*Lliwas*), or maintenance of canals, reservoirs and water springs through water festivities (*Puqio laqa*y) (Sierra, 2018).

Similarly, in the maintenance of the cultivable areas (breeding of *chacras*), they not only require care at each stage of the crops but must be animated with rituals and festivities to foster productivity. (DDCC, 2019)

How were EbA measures selected?

Under the “Resilient Puna” project framework, the EbA measures selected for this catalogue result from a three-stage process (Figure 2), which combines a literature review and a participatory stakeholder consultation, including local experts. As an integral part of the project, the selected EbA measures are envisioned to be funded by the Puna Facility.

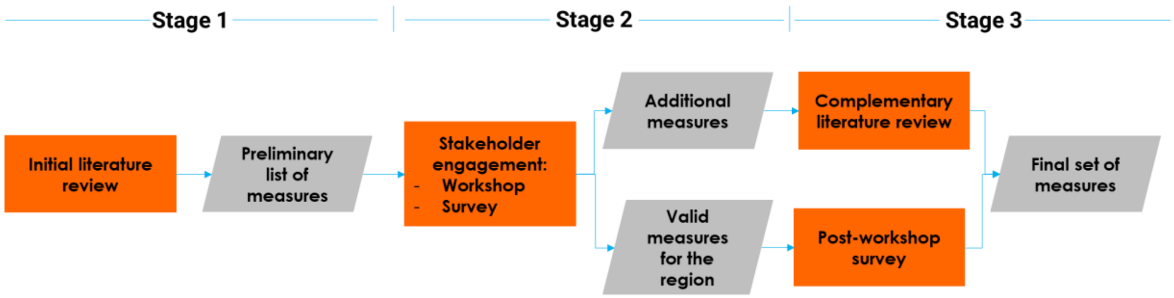

Figure 2. Methodology for developing the EbA catalogue (own elaboration)

The first stage consisted of a review of 36 publications (technical and scientific) related to EbA measures and nature-based ancestral practices in the region. In this stage, a preliminary group of measures was selected based on their recurrent applicability in the high Andean region and their relation to pre-identified climate-related risks, considering also the measures for the recovery of Andean ecosystems approved by the Peruvian government by ministerial resolution RM N°178-2019-MINAM.

The second stage involved local stakeholders through a participatory workshop accompanied by a preliminary survey. The profile of the stakeholders was technical experts from different relevant organizations with experience working in the target region (Puna areas of the south high Andes region of Peru). As an overview, thirty-six local stakeholders participated in the workshop, and the survey registered 20 responses. The objective of this stage was to validate the initial list of measures and get feedback on:

- successful experiences of these measures in the region
- the measures’ feasibility according to the context of each region
- particular constraints and limitations of each measure
- measures’ effectiveness in facing climate risks
- potential EbA measures to reduce risks of droughts and to maintain the level of agricultural production in the Puna area

The last stage consisted of integrating the comments received during the workshop and expanding the information about the selected and validated measures. In this stage, additional literature was reviewed to gather information on other measures mentioned during the workshop. As a result, 11 different sources were examined during this second review. At the same time, a post-workshop survey was sent to local stakeholders who participated in the workshop. Accordingly, 17 responses were received, expanding information on:

- measures’ applicability at the regional level
- measures applicability at the eco-region level
- potential applicability of one of these measures under the MERESE program (a national scheme of payment for ecosystem services- PES)

- additional measures to those selected at that level.

Then, each of the selected measures presented in this catalogue was suggested and validated by local experts as viable for the target region of the “Puna Resilient” project according to the socio-economic and climatic context of the high Andean communities of southern Peru. After this stage, the final set of measures was categorized. The measure categorization is presented in the next section of this document, and each measure is further described based on the reviewed literature.

How were the measures categorized?

The selected measures described in this catalogue were categorized using two filtering levels (Figure 3). The first level identified what qualifies as an EbA measure, using the five criteria of the Practical Assessment Framework (Friends of Ecosystem-based Adaptation [FEBA], 2017), adding a criterion (C3+) that reflects the use of biodiversity and ecosystem services to separate green options from non-green options (see Figure 3). As a result (Table 1), EbA measures were differentiated from other related measures, referred to in this project as nature-based practices (NbP), and soft measures. In this catalogue, NbP refer to actions that contribute to protecting and managing ecosystems sustainably while recovering some ecosystem services using natural features, elements, or processes favourably (e.g., soil infiltration capacity, non-native species, water condensation). Conversely to the EbA measures, the NbP modified the original ecological or biophysical conditions (e.g., topography, runoff and slope drainage) of the area where it is implemented to improve natural processes. Thus, the specific difference between EbA and NbP measures in this catalogue is that NbPs do not fulfill all FEBA qualification criteria in the context of the Puna ecosystem, as for the example of afforestation (NbP), which aims to establish a forested land, does not contribute to conservation, restoration or the sustainable management in the non-forested Puna ecosystem (e.g.grassland and bofedales). Also, in this catalogue, soft measures refer to cross-cutting actions and programmes that improve adaptation capacity and increase awareness of climate change impacts by promoting human behavioural change, social protection, financial schemes or sustainable governance styles.

The second level consisted of selecting locally valid adaptive actions for changing climate conditions and their impacts in the project region, such as glacier melting, increasing temperature and increasing variability of rainfall patterns, according to a validation process with local stakeholders. As a result (Table 2), locally viable EbA measures were described in detail in this catalogue. However, since EbA measures do not stand-alone, other complementary actions (i.e., NbP) were briefly described, and some cross-cutting soft measures were listed. These measures seem to support and enhance the EbA intervention, which still needs to be considered as part of an overall adaptation strategy for a selected region.

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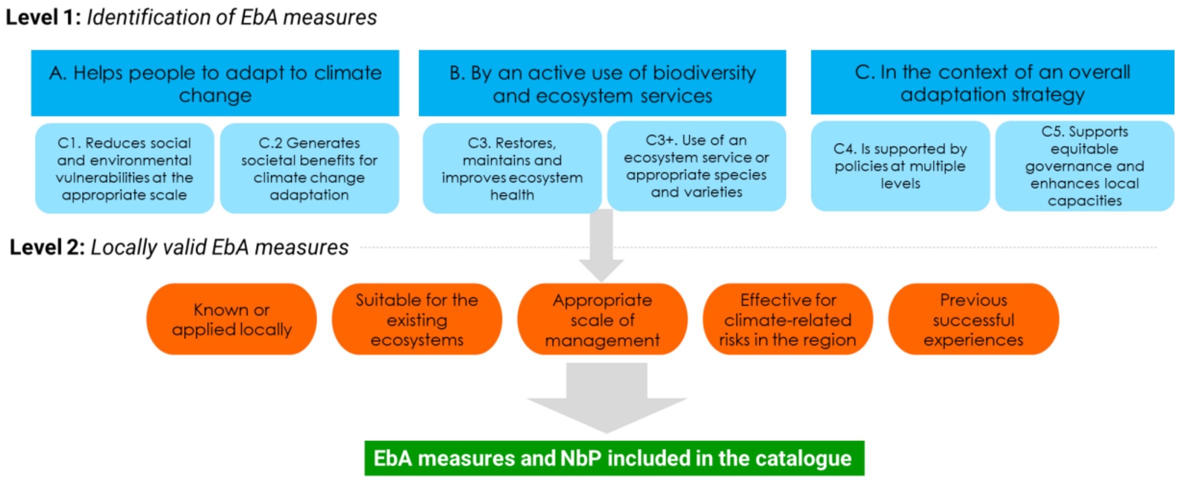

Figure 3. Categorization of the selected measures (adapted from FEBA, 2017)

** Note: Since EbA measures must be tailored to each context and the particular needs of the target groups, it is recommended to use the criteria part 2 of the Practical Assessment Framework (FEBA, 2017), as well as the principles and safeguards mentioned in the Voluntary Guidelines for design, planning and implementing EbA projects (CBD, 2019).*

Table 1. First level of measures' categorization

CRITERIA LEVEL 1: Identification of EbA measures								
	Measures	**Helps people to adapt**		**Active use of biodiversity and ecosystem services**		**Part of an overall strategy**		**Type**
		Reduction of social and environmental vulnerabilities	*Generates social benefits in the context of climate change adaptation*	*Resotre, maintains or improves ecosystem health*	*Use of an ecosystem service or appropriate species and varieties*	*Is supported by policies at multiple levels.*	*Supports equitable governance and enhances capacities*	
Identified from the concept note	Qochas/ micro-reservoirs	+	+	O	+	+	+	NbP
	Amunas/ Mamanteo	+	+	O	+	+	+	NbP
	Infilitration ditches	+	+	O	+	+	+	NbP
	Andenes/ Terraces	+	+	O	+	+	+	NbP
	Conservation and restoration of Bofedales	+	+	+	+	+	+	EbA
	Sustainable grassland management	+	+	+	+	+	+	EbA
	Agroforestry	+	+	+	+	+	+	EbA
	Reforestation with native species	+	+	+	+	+	+	EbA
	Crop diversification	+	+	+	+	+	+	EbA
	Creation of conservation areas	+	+	+	+	+	+	EbA
	Conservation agriculture	+	+	+	+	+	+	EbA
	Eco- and agrotourism	+	+	+	+	+	+	EbA
	Fitotoldos (greenhouse)	+	+	x	+	+	+	NbP
	Homestead gardens	+	+	O	+	+	+	NbP
	Irrigation management	+	+	O	+	+	+	NbP
Identified during the stakeholders' workshop	Bioengineering for gully control	+	+	O	+	+	+	NbP
	Integrated soil fertility management (legumes and majadeo)	+	+	+	+	+	+	EbA
	Building capacity in rural communities	+	+	x	x	+	+	Soft
	Land-use planning and zoning	+	+	x	x	+	+	Soft
Identified from the pre-workshop survey	Camellones -Waru waru	+	+	+	+	+	+	EbA
	Slow-forming terraces	+	+	O	+	+	+	NbP
	Afforestation	+	+	O	+	+	+	NbP
	Environmental monitoring and hydrological stations	+	+	x	x	+	+	Soft
	Fog-catcher	+	+	O	+	+	+	NbP
Identified from literature	Filtering galleries	+	+	O	+	+	+	NbP
	Breeding of small animals	+	+	x	+	+	+	NbP
	Kunka kunka trenches	+	+	O	+	+	+	NbP
	Transofmation of agri-products	+	+	x	x	+	+	Soft
	Training in flora and fauna management	+	+	x	x	+	+	Soft
	Environmental technical assistance	+	+	x	x	+	+	Soft
	Training in climate change and riks management	+	+	x	x	+	+	Soft
	Environmental awareness campaings	+	+	x	x	+	+	Soft
	Exchanging knowledge experiences	+	+	x	x	+	+	Soft
	Early-warning systems	+	+	x	x	+	+	Soft

Note: Comply (+), not comply (x), slightly modifies original ecological conditions (O)

Table 2. Adaptive actions included in the catalogue

CRITERIA LEVEL 2: Locally valid adaptive actions						
Adaptive actions	**Known or applied locally**	**Suitable for the existing ecosystems**	**Appropriate scale of management**	**Effective for climate-related risks in the region**	**Previous successful experiences**	**Result**
Based on:	*The workshop working session*	*The post-workshop survey and literature*	*Literature*	*The workshop working session and literature*	*The workshop working session*	
Conservation and restoration of Bofedales	+	+	+	+	+	Included
Sustainable grassland management	+	+	+	+	+	Included
Agroforestry	+	+	+	+	+	Included
Reforestation with native species	+	+	+	+	+	Included
Crop diversification	+	+	+	+	+	Included
Creation of conservation areas	+	+	+	+	+	Included
Conservation agriculture	+	+	+	+	+	Included
Eco- and agrotourism	+	+	+	+	+	Included
Integrated soil fertility management (legumes and majadeo)	+	+	+	+	+	Included
Camellons/ Waru-waru	+	+	+	+	+	Included
Qochas/ micro-reservoirs	+	+	+	+	+	Included
Amunas/Mamanteo	+	+	+	+	+	Included
Infilitration ditches	+	+	+	+	+	Included
Andenes/ Terraces	+	+	+	+	+	Included
Fitotoldos (greenhouse)	+	+	—	+	+	Included
Homestead gardens	+	+	—	x	x	No included
Irrigation management	+	+	—	+	+	Included
Bioengineering for gully control	+	+	—	+	+	Included
Slow-forming terraces	+	+	+	+	+	Included
Afforestation	+	+	+	+	+	Included
Fog-catcher	+	+	—	x	x	No included
Filtering galleries	+	+	—	x	x	No included
Breeding of small animals	+	+	—	x	x	No included
Kunka kunka trenches	+	+	+	x	x	No included

Note: Comply (+), not comply (x), not appropriate/ small scale (—)

Selected EbA options

As an overview, this section starts by presenting four summary tables which respectively show: the applicability of the selected EbA measures by region (Table 3), the relevance of the EbA measures by ecosystem (Table 4), the climate variability and intermediate impacts addressed by each EbA measure (Table 5), the appropriate land-use for each EbA measure (Table 6), and the benefits generated by the different EbA measures (Table 7). Finally, the section continues with a detailed description of each EbA measure.

Table 3. Applicability of the EbA measures per region

EbA MEASURE	REGION			
	APURIMAC	AREQUIPA	CUSCO	PUNO
Conservation and restoration of bofedales	+/-	+	x	+
Sustainable Grassland Management	+	+	+	+
Agroforestry	+	+	+	+
Reforestation with native species	+	+	+	+
Creation of conservation areas	+	+	+	+
Crop diversification	+	+/-	+	+/-
Eco- and agrotourism	+	+	+	+
Integrated Soil Fertility Management	+	+/-	+	+
Camellones (Waru-waru)	x	x	+	x
Conservation agriculture	+	+/-	+	+
Countorn farming	+	—	+	—

(+) applicable (x) not applicable (+/-) limited application (—) no information

***Source**: Post-workshop survey*

Table 4. Applicability of the EbA measures per ecosystem

EbA MEASURE	ECOSYSTEM						
	Glaciar and peri-glacier zone	Grasslands	Bofedal	Highandean forest	Mesoandean forest	Shrubland	Lagoons and wetlands
Conservation and restoration of bofedales		+				+	
Sustainable Grassland Management	+	+			+		+
Agroforestry	+		+	+	+		+
Reforestation with native species	+	+	+	+	+	+	+
Creation of conservation areas	+	+	+	+	+	+	+
Crop diversification	+	+	+	+	+	+	+
Eco- and agrotourism	+	+	+	+	+	+	+
ISFM	+		+	+	+		+
Camellones (Waru-waru)	+	+				+	+
Conservation agriculture	+	+	+	+	+	+	+
Countorn farming	+		+	+			+

***Source**: Post-workshop survey*

Table 5. Climate variability and intermediate impacts addressed by the EbA measures

EbA MEASURE	Climate variability			Intermediate impacts					SOURCES
	Decreasing annual precipitation	Increasing temperature	Heavy rainfall	Erosion	Landslides	Sudden increase in river flows	Deficit of water	Decreasing land productivity	
Conservation and restoration of bofedales	+	+	+	+	+	+	+		(HELVETAS Swiss Intercooperation, 2017)
Sustainable Grassland Management	+			+	+		+	+	(HELVETAS Swiss Intercooperation, 2017), (PACC, 2014)
Agroforestry		+	+	+			+	+	(HELVETAS Swiss Intercooperation, 2017), (PACC, 2014)
Reforestation with native species	+	+	+	+	+	+	+	+	(DDCC, 2019), (HELVETAS Swiss Intercooperation, 2017), (Palma, 2017)
Creation of conservation areas	+	+		+	+	+	+		(HELVETAS Swiss Intercooperation, 2017)
Crop diversification	+	+						+	(DDCC, 2019), (Palma, 2017), (UNEP-ROLAC / FS-UNEP Centre, 2014)
Eco- and agrotourism	+	+				+	+	+	(BMU, 2020), (Loehr et al., 2022)
Integrated Soil Fertility Management			+	+			+	+	(Liniger et al., 2011)
Camellones (Waru-waru)	+	+	+			+	+		(Moran et al., 2018;), (Gondard, 2006), (Valdez, 2006)
Conservation agriculture	+	+	+	+		+	+	+	(Liniger et al., 2011)
Countorn farming	+		+	+	+			+	(HELVETAS Swiss Intercooperation, 2017), (PDRS-GTZ, 2014), (DDCC, 2019)

Table 6. Appropriate land-use for each EbA measure

EbA MEASURE	Land-use: Croplands	Pasturelands (Grass- and Shrublands)	Forest lands	Bare lands	Glacier	Water bodies	SOURCE
Conservation and restoration of bofedales		+				+	(HELVETAS Swiss Intercooperation, 2017)
Sustainable Grassland Management	+	+					(HELVETAS Swiss Intercooperation, 2017), (PACC, 2014)
Agroforestry	+	+	+				(HELVETAS Swiss Intercooperation, 2017), (PACC, 2014)
Reforestation with native species		+	+				(DDCC, 2019), (HELVETAS Swiss Intercooperation, 2017), (Palma, 2017)
Creation of conservation areas		+	+		+	+	(HELVETAS Swiss Intercooperation, 2017)
Crop diversification	+						(DDCC, 2019), (Palma, 2017), (UNEP-ROLAC / FS-UNEP Centre, 2014)
Eco- and agrotourism	+	+	+	+	+	+	(BMU, 2020), (Loehr et al., 2022)
Integrated Soil Fertility Management	+	+					(Liniger et al., 2011)
Camellones (Waru-waru)	+						(Moran et al., 2018;), (Gondard, 2006), (Valdez, 2006)
Conservation agriculture	+						(Liniger et al., 2011)
Countorn farming	+						(HELVETAS Swiss Intercooperation, 2017), (PDRS-GTZ, 2014), (DDCC, 2019)

Table 7. Functions and benefits of each EbA measure

EbA MEASURE	BENEFIT- FUNCTIONS																									
	Increase in spring base flow rates	Water flow/runoff regulation	Infiltration and Aquifer recharge	Increasing water provision	Protection of wetlands and lagoons	Improvement of soil moisture	Erosion control	Slope stabilization	Maintenance of soil fertility	Carbon sequestration	Nutrients cycling / retention	Biodiversity conservation	Habitat provision for wildlife	Regeneration of vegetation cover	Contribution to food security	Crop yield improvement	Improvement of livestock production	Microclimate and temperature regulation	Prevention of crop failures	Enhancing aesthetic value of the landscape	Social cohesion	Recovery of cultural identity	Recreation and tourism values	Spiritual and religious value	Income improvement	SOURCE
Conservation and restoration of bofedales	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+		+	+		+	+		(HELVETAS Swiss Intercooperation, 2017)
Sustainable Grassland Management	+	+	+	+		+	+	+	+	+		+	+	+	+		+				+	+	+	+	+	(HELVETAS Swiss Intercooperation, 2017), (PACC, 2014), (Palma, 2017), (Rivera et al., 2014)
Agroforestry	+	+	+				+	+	+	+	+	+	+	+	+	+	+	+	+	+						(HELVETAS Swiss Intercooperation, 2017), (PACC, 2014), (DDCC, 2019)
Reforestation with native species	+	+	+	+		+	+	+		+		+				+		+						+		(DDCC, 2019), (HELVETAS Swiss Intercooperation, 2017), (Palma, 2017)
Sustainable camelids breeding	+	+	+	+	+	+	+	+		+		+	+	+				+		+			+	+		(DDCC, 2019)
Creation of conservation areas									+		+	+	+		+	+			+			+		+	+	(HELVETAS Swiss Intercooperation, 2017)
Crop diversification				+	+				+	+		+	+	+						+			+	+	+	(DDCC, 2019), (Palma, 2017), (UNEP-ROLAC / FS-UNEP Centre, 2014)
Eco- and agrotourism		+				+	+		+	+	+			+	+	+			+	+					+	(BMU, 2020), (Loehr et al., 2022)
Integrated Soil Fertility Management		+		+		+					+				+	+		+	+		+	+			+	(Liniger et al., 2011)
Camellones (Waru-waru)		+				+	+		+	+	+	+	+	+	+	+			+						+	(Moran et al., 2018), (Gondard, 2006), (Valdez, 2006)
Conservation agriculture		+			+	+	+	+	+		+				+	+									+	(Liniger et al., 2011)
Countorn farming		+			+	+	+	+	+		+				+	+									+	(HELVETAS Swiss Intercooperation, 2017), (PDRS-GTZ, 2014), (DDCC, 2019)

General description

The bofedales are dense vegetation grasslands, composed of sedges, small herbaceous semi-woody plants, and permanent or seasonal grasses, arranged as compact grass carpets, and developed on saturated peaty or permanently wet organic soils along the year (HELVETAS Swiss Intercooperation, 2017; Lorini, 2014; Rivera et al., 2014).

They are considered high altitude wetlands or permanently wet grasslands and one of the most important ecosystems of the Peruvian high Andean arid and semi-arid zones (HELVETAS Swiss Intercooperation, 2017). However, they are extremely fragile ecosystems due to their dependence on water, climate variation sensitivity, glacial retreat, and anthropogenic pressures such as mining, landscape fragmentation, road and dam construction, the introduction of exotic species, environmental pollution, overgrazing and drainage for expansion of productive activities (HELVETAS Swiss Intercooperation, 2017; MINAM, 2020).

The high biological diversity and ecological complexity of bofedales make them one of the most productive ecosystems on the planet. Besides that, Bofedales are also an important sink of carbon and other pollutants (HELVETAS Swiss Intercooperation, 2017).

Scale:

- At the District level
- At the Community level

Activities

- Planting of bofedal patches to increase coverage
- Terroir transplanting for border maintenance
- Water management: constructing small drains from the center to the drier patches
- Enclosure with stone or compacted soil barriers
- Establishment of rotational grazing
- Establishment of fallow areas
- Grazing closure in rainy seasons
- Restrict access for cows, sheep, goats, horses, donkeys, pigs and mules.
- Replacement and maintenance of fences

Requirements & enabling conditions

- Communal agreements and management rules
- Organized community workforce

Functioning

On the one hand, bofedales retain rainwater and regulate runoff flows caused by irregular rainfall, maintaining soil moisture. Soil moisture, in turn, facilitates the regeneration of grasslands or forest species, which helps to contain the effects of rising temperatures and high evapotranspiration.

On the other hand, reclaimed pastures help to improve water infiltration, storage and supply for human consumption and livestock. They also prevent and regulate floods and droughts, retaining excess water from rainfall and snowmelt. At the same time, they avoid the excessive dragging of sediments, thus reducing the risk of mass movement in the lowlands and controlling erosion processes. Pasture regeneration also decreases overgrazing pressure and contributes to the recharge of downstream springs. (HELVETAS Swiss Intercooperation, 2017)

In general, grazing should be limited to camelids, and camelids should replace the husbandry of sheep, goats and cattle.

In any case, the bofedal management should consist of physical interventions and address the social and cultural dimensions of the community where it is implemented by generating the necessary knowledge to manage the bofedal properly and disseminating good practices among farmers (HELVETAS Swiss Intercooperation, 2017).

Potential barriers

- Soil salinization
- Dewatering of patches
- Free and uncontrolled animal grazing
- Drying up due to strong winds
- Growth of undesirable species
- Low local acceptance due to the replacement of the livestock type

Limitations and trade-offs

- Applicable only on large land extensions to properly manage rotational grazing and regenerate pastures.
- The total area must have an appropriate carrying capacity to support local livestock activity.
- Resting plots (fallow lands) unused for one or two years
- Lack of fodder in rainy seasons

Previous experiences

- Arequipa: Water harvesting and irrigation of natural pastures for aquifer recharge and improvement of natural pastures in the Chiuchilla; Chalhuanca; Tolconi; and Reserva Nacional Salinas y Aguada Blanca

Supporting references for describing this EbA: (HELVETAS Swiss Intercooperation, 2017; Lorini, 2014; MINAM, 2020; Rivera et al., 2014)

General description

Natural grasslands cover about 70% of the agricultural area of the high Andean regions. However, to recover their productive and regulating capacity, it is necessary to rationally manage natural grasslands (Rivera et al., 2014).

Sustainable grassland management aims to recover and expand pasture areas, increase water infiltration, and control erosion associated with overgrazing. By planning the use of grasslands, vegetation cover is maintained and managed sustainably. (HELVETAS Swiss Intercooperation, 2017)

Grassland cover protects the soils from evaporation and runoff eroding effects while enhancing carbon sequestration, soil porosity and water retention (DDCC, 2019). Therefore, sustainable grassland management is key to climate change adaptation in pastoral communities.

For the Puna region, replacing other types of livestock such as sheep, goats, or cattle by alpacas and llamas are a fundamental part of this measure, considering that South American camelid livestock are the best adapted to ecological zones above 3,800 m.a.s.l. (Ramos, 2010). Unlike other livestock species in the Andes, these camelids graze without unrooting the pasture, and given their padded hooves, they do not break or compact the soil. Also, llamas and alpacas feed on pastures where agriculture is not feasible, and are complementary in grazing areas. While llamas prefer high pastures on slopes, alpacas prefer short pastures in plain areas, broadening local livelihood options (DDCC, 2019; Lichtenstein, 2010). Since llamas and alpacas consume much lower water than other livestock species, recovering their population can help to adapt to future water shortages. (DDCC, 2019)

Scale

- At the community level

Activities

- Closure of pastures
- Introduction and replanting of natural grasses
- Control of undesirable plants and invaders species
- Fencing using local resources (e.g., stones, adobe, sheds, walls, etc.)
- Irrigation
- Manure fertilization
- Establishment of rotational grazing
- Transplanting and reseeding of grasses
- Introduction of grass varieties for pasture enhancement
- Establishment of corrals

Requirements & enabling conditions

- Estimate the carrying capacity and bearing capacity of the soil
- Planning the phenological calendar
- Establishment of communal agreements and monitoring mechanisms
- Sandy loam soils, with good depth and rich in organic matter

Functioning

Well-maintained grasslands retain rainwater in their systems and facilitate its infiltration into aquifers, regulating base flows in spring areas. Likewise, grasslands reduce runoff and contain sediment dragging during heavy rainfall events. The soil maintains its moisture and facilitates the recovery of pasture cover, given its capacity to retain and temporarily store water. (HELVETAS Swiss Intercooperation, 2017)

The grassland cover has a “sponge effect” consisting of intercepting water in rainy seasons while attenuating runoff overflows, holding it for long periods, and releasing it later on in times of low water (Programa de Adaptación al Cambio Climático [PACC], 2014).

Sustainable grassland management also prevents harmful agricultural practices such as overgrazing, pasture burning, intensive livestock farming, and agricultural encroachment to higher elevations (HELVETAS Swiss Intercooperation, 2017). Moreover, soil compaction due to animal overloading is avoided through the sustainable management and recovery of grasslands. Together, all of that allows the soil to recover and improve its infiltration capacity over time. (HELVETAS Swiss Intercooperation, 2017)

The main forage species used for sustainable grassland management are Chilligua (*Festuca dolichophylla*), Cora cora (*Carex ecuadorica*), Totorilla (*Scirpus rigidus*), Layo (*Gomphrena meyeniana*), and Sillu sillu (*Alchemilla pinnata*), and Kunkuna (*Distichia muscoides*) (Rivera et al., 2014).

Potential barriers

- Lack of land ownership
- Physiography (flat plots are prone to cold waves)
- Soil texture
- Insufficient extension of pastureland
- High costs linked to the materials (fences) and labor required
- Weak community organizations

Limitations and trade-offs

- Isolated paddocks from one to three years
- Introduction of non-native species
- Conflicting with conservation land use or a different kind of livestock farming.

Previous experiences

- Sowing and water harvesting in the micro-watersheds of Huacrahuacho, Cusco and Mollebamba, Apurimac (PACC Peru)
- Water harvesting in the Ccatccamayo micro-watershed, Cusco (Jesús Obrero Association - CCAIJO).
- Arequipa: Chalhuanca, Tolconi, Tocra, Tarucani, Pusa pusa, Callalli, and Pulpera.

Supporting references for describing this EbA: (DDCC, 2019; HELVETAS Swiss Intercooperation, 2017; Lichtenstein, 2010; Palma, 2017; PACC, 2014; Ramos, 2010; Rivera et al., 2014)

General description

Agroforestry refers to the introduction of perennial species in agricultural systems (crops and animal production) in the same productive unit (HELVETAS Swiss Intercooperation, 2017). It consists of the deliberate planting of trees and shrubs in agricultural systems to obtain the benefits of tree-crop interaction in the plot (DDCC,2019). This complementary interaction between forest and non-forest cover helps control erosive processes, increase water infiltration and regulate runoff, and reestablish other beneficial ecological processes for agricultural activity (e.g., pollination, pest control, disease prevention, nutrient recycling).

In general, agroforestry can mitigate the impacts of land-use change by providing multipurpose plots. Well-managed agroforestry systems can contribute to food security, water security, fuelwood provision, agro-biodiversity recovery, climate change mitigation, increased soil productivity and improved incomes for smallholders.

Agroforestry systems can range from simple and spread to complex and dense systems, and they are grouped into agroforestry, silvopastoral, agrosilvopastoral, and multipurpose forestry (Liniger et al., 2011).

It embraces various practices such as alley cropping, living fences, multi-story cropping, intercropping, multi-cropping, home gardens, parkland systems, windbreakers, improved fallows, etc. (Liniger *et al*., 2011).

Functioning

The introduction of trees and shrubs in agricultural or livestock systems can create favorable conditions for adaptation to climate change and mitigate the impacts of other natural processes.
On the one hand, trees can act as windbreaks while mitigating the effect of heavy rains and retaining runoff and sediment drag (DDCC, 2019). On the other hand, it favors the maintenance of soil quality by improving porosity, bulk density and water infiltration capacity (HELVETAS Swiss Intercooperation, 2017).
Similarly, the shade generated by the forest cover and vegetation mass retains humidity in the plot and generates

Scale

- At the household level
- At farm level
- At the community level
- At the landscape level
- At watershed level

Activities

- Training in agroforestry
- Identification of agroforest species
- Design of the agroforestry system
- Establishment of nursery
- Establishment of the agroforestry system
- Maintenance

Requirements & enabling conditions

- Agro-ecological knowledge of the region
- Plot zoning
- Species with rapid growing and good rooting
- Local capacity for organizing community work

Potential barriers

- Land tenure
- The slope of the plot
- Plot size
- Seeds availability

Limitations and trade-offs

- Reduced livestock presence on the plot during the first years after establishing the system
- Forest cover might attract birds and other animals that harm the crops

a favorable microclimate for temperature changes (HELVETAS Swiss Intercooperation, 2017).
Besides favoring biodiversity by attracting fauna and serving as a habitat for various species, well-managed agroforestry systems also help control pests and crop diseases (Liniger *et al*., 2011). Additionally, agroforestry systems can have high carbon sequestration rates, improving soil fertility while avoiding pressure on natural forests (HELVETAS Swiss Intercooperation, 2017).

Among the most common species used in agroforestry are: *Queña, Qolle, Retama, Mutuy, Quishuar, Chachacomo, Alisom Chilca, Capulí,* combined with fruit trees (PACC, 2014).

- Excess humidity might favor the spread of fungi diseases
- Hindering animal traction plowing

Previous experiences

- Apurimac: Pacobamba
- Cusco: Jullicunca, Cuyuni.

Supporting references for describing this EbA: (DDCC, 2019; HELVETAS Swiss Intercooperation, 2017; Liniger et al., 2011; PACC, 2014)

General description

Crop diversification consists of growing several types of agricultural products on the same plot, alternating or combining varieties of plants (native if possible), optimizing horizontal and vertical land space and nutrients and soil properties. (UNEP-ROLAC / FS-UNEP Centre, 2014).

Its purpose is to avoid crop losses, increase crop yields, and generate additional income in the short term (UNEP-ROLAC / FS-UNEP Centre, 2014). Furthermore, crop diversification allows rural communities to adapt to climate change through conservation, sustainable use and equitable distribution of the benefits derived from this activity (Palma, 2017).

Scale

- At farm level
- At the household level

Activities

- Staggered planting
- Crop rotation (muyuys or laymes)
- Mix planting of varieties and species (Chagru chagru)
- Polyculture
- Seed selection and preparation
- Dispersion of chacras (farming plots)
- Establishment of fallow lands (Taya, Wachu, Chuki)
- Cultural, biological and ecological recovery of agrobiodiversity
- Creation of seed banks

Functioning

The diversification of crops in their different possibilities aims to reduce risks of failure crops due to climate variability while recovering soil nutrients and agrobiodiversity. Furthermore, this measure seeks to reduce the dependence on external inputs and agrochemicals and provide crop resistance to climate events (DDCC, 2019).

Then, by mitigating economic losses, contributing to food security and protecting the natural resource base for agricultural activity, crop diversification supports local livelihoods and helps farming communities adapt to climate change (Palma, 2017).

Crop diversification can be done in the following ways (DDCC, 2019; Palma, 2017):

- planting in two or more different periods
- rotating planting areas
- mixing crop types within each plot
- mixing crop varieties and crop species in the same plot

Requirements and enabling conditions

- Combination of empirical, ancestral and scientific knowledge
- There are existing native crops in the region
- Access to local markets
- Price of native products in the market

Potential barriers

- Access to markets
- Access to crop information and harvesting technologies
- Alternative crops available
- Product prices
- Credit constraints
- Farmland fertility

- using plants with varying heights in the same plot
- mixing short-cycle crops with longer-cycle crops
- sowing the same species or crop variety in dispersed fields at different times and altitudes
- recovering the cultural, biological and ecological richness of local agricultural biodiversity (cultivation of native species)
- promoting seed exchanging and the knowledge about their cultivation

- Land and water access and control

Limitations and trade-offs

- More indigenous crops have less integration in the markets
- More allocation of working hours without significant income increase
- Not suitable for small farmers nor geographically isolated farm-households

Previous experiences

- Agrobiodiversity Management Models that Promote Food Sovereignty -ABISA.

Supporting references for describing this EbA: (DDCC, 2019; Palma, 2017; UNEP-ROLAC / FS-UNEP Centre, 2014)

General description

Reforestation is the replacement, reestablishment or recovery of forest cover in places where the forest has been degraded (HELVETAS Swiss Intercooperation, 2017).

It consists of reestablishing a native forest by planting and diversifying forest species (trees and shrubs) similar to the original cover (Palma, 2017).

By planting native species, reforestation intends to avoid the spreading and dominance of *Eucalyptus globulus* and *Pinus patula*. Likewise, in headwaters and the vicinity of springs, it is intended to replace the presence of *Eucalyptus globulus* with “water callers” native species (DDCC, 2019).

Forests are relevant safety nets for communities to cope with climate impacts such as droughts, floods, abrupt temperature changes and rainfall variation. Moreover, many forest products are resilient to these impacts, playing an important role in local livelihoods. For example, in case of a crop failure, forests provide timber, fuelwood, fruits and non-timber products for income (HELVETAS Swiss Intercooperation, 2017).

For adaptation purposes, reforestation must be done with the following native trees locally referred to as “water callers”: Lloque (*Kageneckia lanceolata*), Molle (*Schinus molle*), Tara (*Caesalpinia spinosa*), Huaranhuay (*Tecoma sambucifolia*), Aliso (*Alnus acuminata*), Q’olle (*Buddleja coriacea*), Capulí (*Prunus serotina*), Chachacomo (*Escallonia resinosa*), Nogal (*Juglans neotropica*), Intimpa (*Podocarpus glomeratus*), Tayanka (*Baccharis sp.*) and Queña (*Polylepis racemosa*).

Scale

- At watershed level
- At the landscape level
- At the district level

Activities

- Identification and delimitation of potential reforestation areas
- Seedling nursery production
- Site preparation and site clearing (removing competitive vegetation)
- Gradually removal of Pinus and Eucalyptus individuals (if it applies)
- Plantation design and arrangement
- Hole opening
- Planting and replanting
- Pruning, fertilizing and irrigation works
- Fencing
- Declaration of a communal reserve

Requirements and enabling conditions

- Proper environmental conditions for trees propagation (connectivity, slope, moisture, precipitation, temperature, etc.)
- Community-led management
- Permanent technical assistance
- Existing native forest patches or relicts

Functioning

This measure harnesses the benefits generated by trees, such as:

- protecting the soil from water and wind erosion;
- regenerating soil through the recycling and fixation of nutrients and carbon;
- regulating microclimate and stabilizing sudden temperature changes;
- holding soil and environmental moisture;
- intercepting, capturing, infiltrating and regulating rainwater;
- mitigating effects of heavy rains and prolonged droughts.

Using the native species listed above, help face climate-related risks because of their characteristics. For example, they intercept, condense, and infiltrate water, making them tolerant to dry conditions. Also, they have high soil retention capacity and effectively fix nutrients in the soil (nitrogen or carbon). Moreover, these plants provide hardwood, food and fruits, medicines, fertilizers, dyes, pesticides, foliage, and fodder, contributing to local livelihoods. (DDCC, 2019)

Potential barriers

- Land ownership
- Degradation status of the forest relict
- Lack of communal agreements
- Limiting soil conditions (pH, fertility, compaction, salinity)
- Local labor availability

Limitations and trade-offs

- High costs associated with nursery production, plantation establishment, and silvicultural management
- Benefits will be evident after three or five years.

Previous experiences

- Conservation and restoration of the Atiquipa hills, Arequipa
- Recovery of deforested areas in the Versalles micro-watershed and Chancamayo micro-watershed, Cusco.
- Puno: Zona de Capazo, Maso Cruz, Intimpa (Santuario Nacional de Ampay)
- Arequipa: Acomayo, Canas, Occoruro, Chumivilcas, Espinar and Huaran-Calca

Supporting references for describing this EbA: (DDCC, 2019; HELVETAS Swiss Intercooperation, 2017; Palma, 2017)

General description

It consists of a set of physical, social and institutional actions oriented to maintain and restore areas with a high ecological value that are under threat by human activities (HELVETAS Swiss Intercooperation, 2017).

Ecosystems in conservation areas are legally protected, with regulations for land use varying depending on the protective status and the agreement made with the local communities. Therefore, the success of conservation areas depends strongly on compliance with protection measures, which is why monitoring and incentives for conservation or penalties for transgressions are usually part of conservation schemes (Andrade & Rhodes, 2012; Hockings et al., 2014).

Conservation areas can be Natural Protected Areas, possibly linked to international schemes and Regional, Municipal and Private Conservation Areas.

This measure can be implemented for grasslands, forests, and wetlands alike, preserving biodiversity and providing services by this ecosystem. Hydrological ecosystem services are of particular interest for conservation in the Puna region, alongside grazing and the provision of fuel (Blancas et al., 2018).

Functioning

Within the framework of national administration, conservation areas under Peru's national natural protected area system can be classified as National Parks, National Sanctuaries, Historic Sanctuaries, National Reserves, Communal Reserves, Landscape Reserves, Protected Forests, Wildlife Refuges and Hunting Reserves. Also, as part of the establishment process, areas that could qualify as conservation areas can be classified as temporary Reserved Zones while their suitability is assessed. The national authority for this process lies with the Service of Natural Protected Areas (SERNANP). Additionally, regional governments can submit proposals to establish a Regional Conservation Area, complying with the requirements regulated in Presidential Resolution No. 205-2010-SERNANP, to SERNANP (SERNAP, 2022).

Scale

- At the communal level
- At the district level
- At watershed level
- At the landscape level

Activities

- Identifying suitable areas and area sizes necessary to sustain ecosystem
- Zoning priority areas within potential protected areas, as well as buffer zones
- Drawing up a community, private or other types of agreements for measure implementation
- Possible additional measures: installation of fences, monitoring to ensure compliance, capacity building, awareness campaigns, participatory monitoring.

Requirements and enabling conditions

- Study on the conservation value of the biodiversity and ecosystem services of the targeted area, following the national regulations established in the National System of Natural Areas Protected by the State (SINANPE)
- Community support for the measure

Since the early 2000s, privately or communally protected areas have also become more common in Peru, the legal framework for which are Private Conservation Areas (ACPs) (Law No. 26834), Conservation Concessions (CCs), and Ecotourism Concessions (CEs) (Law No. 29763) (Shanee et al., 2020). In addition, conservation areas can also be established in schemes linked to international recognition of the conservation and biodiversity importance (e.g., Ramsar, Biosphere Reserves, Conservation Corridors).

Within conservation areas, zones of different protection levels can be established. Monitoring and pre-agreed penalties for transgression can promote adherence to the rules for the protected area. In addition, installing landmarks can help maintain recognizable boundaries of the conservation area, facilitating protection efforts.

Potential barriers

- Community disagreement on land management
- Conflicting interests
- Complex land-tenure
- Complex institutional and legal environment

Limitations and trade-offs

- Long-term implementation of conservation measures must be ensured, e.g., through sanctions and penalties for transgressions
- Trade-offs between nature conservation and human land-use

Previous experiences

- Puno: Santuario Nacional de Ampay, ACR Ausangate
- Cusco: ACR 3 cañones, ACR Ausangate, ACP Qosqo Ccaharina
- Arequipa: RN Salinas y Aguada Blanca, Valle de los Volcanes Geopark

Supporting references for describing this EbA: (Andrade & Rhodes, 2012; Blancas et al., 2018; HELVETAS Swiss Intercooperation, 2017; SERNAP, 2022)

General description

Given that ecotourism is an environmentally and culturally educational activity through nature-based experiences and is sustainably managed for the benefit of local communities (Weaver, 2001), it can be considered an EbA measure. With a similar approach, but focusing on agricultural landscapes, cultural traditions and values associated with it, agrotourism can be helpful for adaptation purposes in the context of the high Andean region of Peru (Rundel & Palma, 2000).

Since the landscape beauty and wildlife is the main attraction for eco- and agrotourism, this measure can provide income for local communities and help fund measures to conserve biodiversity. In general, the net effect of this type of tourism is positive, protecting nature and contributing to sustainable economic development (Buckley, 2021) while respecting host cultures.

By managing visitor flow in a way that limits ecosystem degradation and wildlife disturbance but generating local alternative incomes sufficiently, tourism can work as an EbA long-term (Barros et al., 2015; BMU, 2020).

Eco- and agro-tourism should aim at an active approach in which the activity contributes positively to ecosystem integrity, local development and cultural promotion. Hence, visitor satisfaction, service quality and the environmental and social-economic impacts of the touristic operations should be monitored to ensure the long-term success of such ventures (Sangpikul, 2011).

Functioning

The functions of ecotourism are to protect natural areas, maintain biodiversity, educate visitors and local communities, generate income and support local economies, involve local communities and provide short-, medium- and long-term benefits (Weaver, 2001). Consequently, eco- and agrotourism can help tackle various causes of vulnerability and restore ecosystem services, mitigating climate change effects (Loehr et al., 2022).

Scale

- At Farm level
- At the Community level
- At the District level
- At the Regional level

Activities

- Identification of attractions
- Market segmentation study
- Development of tourism products
- Establishment of tourism infrastructure and facilities
- Marketing campaigns to attract visitors
- A social and environmental management plan
- Ecosystem restoration or wildlife reintroduction
- Training and educational program
- Long-term quality control

Requirements and enabling conditions

- Management plan to minimize visitor impact on ecosystems
- Pre-existing inventories of biodiversity, cultural, natural resources

Potential barriers

- Lack of funding to build tourism infrastructure and marketing
- Difficulty in attracting sufficient overnight tourists to make ecotourism economically profitable

The area's attraction points must be identified to market eco- and agrotourism successfully. For example, grass- and wetlands in the Andes have been marketed to birdwatchers due to their high bird biodiversity (Hennessey, 2008). Furthermore, pre-existing and potential infrastructure for tourism must also be considered, e.g., access roads, overnight accommodation and attraction experiences such as information centers in conservation areas (Bezuhla, 2020). Rehabilitation and maintenance of ancestral structures or cultural patrimonies can significantly add value to the visitor experience and improve the measure's positive impact.

Tourism management should also consider limiting and directing visitors to minimize their impact on the environment (Barros et al. 2015). Then, estimating the carrying capacity and following an environmental management plan is essential. In general, sustainable eco- and agrotourism often target higher-end tourist groups to generate sufficient income from tourism without accommodating high visitor numbers that could degrade ecosystems (Wang et al., 2021).

Fruthermore, branding is an important factor for ecotourism organizations' competitiveness in the tourism market (Huang et al., 2019), as well as, developing rural-urban links for communities to access tourism markets and diversify livelihoods (Bidwell & Murray, 2019).

- Conflict of interests among stakeholders (Wang et al., 2021)

Limitations and trade-offs

- Visitors, especially in high numbers, can degrade ecosystems
- Losses can be incurred if visitor numbers or – spending is too low
- New jobs created in tourism can distort local livelihoods and lifestyles

Previous experiences

- Puno: SN Ampay
- Arequipa: Valle de los Volcanes (agrotourism), Valle del Colca (ecotourism)

Supporting references for describing this EbA: (Barros et al., 2015; Bezuhla, 2020; Bidwell & Murray, 2019; BMU, 2020; Buckley, 2021; Huang et al., 2019; Loehr et al., 2022; Sangpikul, 2011; UNEP-ROLAC / FS-UNEP Centre, 2014; Wang et al., 2021; Weaver, 2001)

General description

This measure combines different methods of soil fertility amendment, taking into account all farm resources. Integrated Soil Fertility Management (ISFM) can regenerate degraded soils and maintain soil fertility by maximizing organic fertilizer sources, minimizing the loss of nutrients and carefully using complementary inorganic fertilizers. It aims to use sustainably and efficiently available nutrient resources harnessing low-cost techniques such as organic fertilization, manuring, composting, nitrogen-fixing crops, seed priming and water harvesting. Mineral fertilizers can be used only when strictly necessary and using micro fertilization. (Liniger et al., 2011)

In the context of the project, two techniques are envisioned: “majadeo” and “green manure”.

The "majadeo" is an ancestral practice of soil fertilization from the herds. The process starts with herd grazing, in which the animals are guided to feed on specific plots of land designated to be eaten flush in less than four hours. By grazing the herd, the cattle sleep for several days in a single site and then plant crops there, taking advantage of the fresh manure on the ground. (CIP et al., 1995)

Green manure is a specific crop that is grown for the purpose of being placed on the soil while it is still green. This type of crop is usually planted in the unoccupied land between the main crops. While growing, they act as a soil cover, preserving the soil structure with their root system, preventing erosion and nutrient washing, suppressing weed growth and enriching the soil with nitrogen. Once incorporated into the soil, the plant residues decompose and become a natural fertilizer that can be placed under the soil or on the soil surface. The most frequently used green manure is leguminous plants due to their high nitrogen fixing capacity that favors soil fertilization. Because these plants are fast-growing and adapt to different climatic conditions and soil types, they are used to protect the soil and maintain its organic content, and in some cases, to replenish the vegetative cover. (Rosenfeld & Rayns, 2011)

Functioning

Scale

- At Farm level
- At the Community level

Activities

- Manuring (e.g., majadeo), composting and organic fertilization
- Planting nitrogen-fixing crops (e.g., legumes and forage grass)
- Seed priming
- Water harvesting
- Micro-dosing of mineral fertilizers

Requirements and enabling conditions

- Mixed crop-livestock systems
- Low requirement of expertise
- Low workload requirement
- Low-cost techniques easily affordable for poor farmers

Potential barriers

- Limited or decreasing water availability
- Availability and access to inputs (manure, compost, etc.)
- Access to financial services and micro-credits
- Land-tenure

Limitations and trade-offs

ISFM fosters the regeneration and recovery of soil properties by increasing the soil organic matter (SOM) and biomass, improving the water holding capacity and soil moisture, and fixing nitrogen and other nutrients in the soil, resulting in more climate-resilient crops. (Liniger et al., 2011)

Harnessing the characteristics of manure and compost, ISFM reduces reliance on external inputs, enhances soil fertility, and recovers farm resources, which is relevant for the livelihoods of small-scale farmers. Besides that, the seed priming reduces germination time and ensures more uniform plan establishment, resulting in more insect- and fungus resistance crops. Furthermore, nitrogen-fixing crops such as leguminous plants, alfalfa, white clover, barley, and oats have two beneficial effects: on the one hand, it incorporates nitrogen into the soil, and on the other hand, provides fodder and food. Additionally, all these practices foster the soil's biological activity while improving the soil's properties. (Liniger et al., 2011)

In exceptional cases, micro-fertilization or "micro-dosing" of mineral fertilizers can be applied at plant sowing or in an emergency as a top dressing not to stop nutrient mining nor accelerate the decomposition of organic matter. (Liniger et al., 2011)

- Applicable in areas with low and rapidly declining soil fertility
- Unsuitable for rangelands
- Applicable in flat to hilly areas (transport is a heavy burden on steep slopes)
- Spatial competition with other crops due to intercropping or rotational crops
- Long-term lasting
- Source of weeds and some pests.

Previous experiences

- Cusco: Andenes
- Puno: Illpa

Supporting references for describing this EbA: (Centro Internacional de la Papa [CIP] et al., 1995; Liniger et al., 2011; Rosenfeld & Rayns, 2011)

General description

The *waru-waru* system or *camellones* are a millenary practice in some cultures of the Andean altiplano region (Valdez, 2006). It modifies the relief by raising embankments interspersed with canals to improve water-soil-climate-plant-human interaction (Moran et al., 2018;).

This agriculture technique favors conditions for root and plant development by improving soil features such as porosity, infiltration capacity, and aeration (Gondard, 2006). In addition, the water retains nutrients such as nitrogen, coming from sediments rich in algae and organic remains of plants and animals that favor crop yield (Moran et al., 2018;).

The waru-waru system is employed primarily in areas with agricultural restrictions due to temporarily waterlogged soils, poorly drained lands, or areas affected by frequent frosts (Moran et al., 2018;).

Functioning

The *camellones* or embankments are raised using cutting sods (champas) from the excavated material of the canals placed on nutrient-poor soils, forming a "bed" or platform surrounded by water (Kendall & Rodríguez, 2009; Moran et al., 2018).

The canals have aquatic vegetation surrounding the platforms that allows regular nutrient replenishment after continuous harvesting (Kendall & Rodríguez, 2009).

While the platforms are used for planting crops, the water around them creates a micro-climate that mitigates temperature changes favoring plant development (Moran et al., 2018;) by maintening moisture in the ridges and regulating drainage (Kendall & Rodríguez, 2009).

The thermo-regulating effect of the water allows coping with frost events by absorbing heat from solar irradiation during the day and subsequently releasing it at night (Kendall & Rodríguez, 2009). The larger is the area occupied by the waru-waru, the greater is its capacity to regulate the micro-climate in the area (Moran et al., 2018;).

Likewise, the canal system allows counteracting floods while storing water for dry seasons or summers (Moran et

Scale

- At the community level
- At the landscape level

Activities

- Plot planning
- Site preparation
- Bench construction
- Soil conditioning
- Crop planting
- Channel maintenance

Requirements and enabling conditions

- Knowledge about soil characteristics and hydraulics
- Community organizing for work

Potential barriers

- Highly labor-intensive
- Land tenure
- Plot size

Limitations and trade-offs

- Might foster agricultural encroachment into natural areas
- Viable for areas with restricted agricultural activities and low agricultural potential
- Limited to flat plots, permanently or frequently flooded, with poor drainage conditions.

Previous experiences

al., 2018;). Therefore, waru-waru systems are measures that help to ensure agricultural production and livelihoods in the altiplano.

There are two types of platforms frequently used with variable dimensions and monticules number: *camellones (rounded crest)* or *banks (trapezoidal).* The platform type will depend on the plot's purpose, plot extension, and on-site hydrological and edaphic conditions. (Gondard, 2006)

- Puno: Ácora, Atuncolla, Paucarcolla, Huata, Coata, and Capachica.

Supporting references for describing this EbA: (Gondard, 2006; Kendall & Rodríguez, 2009; Moran et al., 2018; Valdez, 2006)

General description

Conservation Agriculture is a farming system that aims to improve and make more efficient use of natural resources through integrated management of soil, water and biological resources (Liniger et al., 2011).

Combining multiple minimum tillage techniques, this measure is based on three fundamental principles: minimum soil disturbance, permanent soil cover and crop rotation (Liniger et al., 2011).

In general, once sufficient vegetation has provided sufficient soil cover, conservation agriculture works on a wide range of farming conditions:

- Areas with high or low precipitation rates
- Various agro-ecological zones
- Different levels of soil degradation
- Mono- and multi-cropping systems
- Systems limited by the labor shortage, remoteness or low external-input

Functioning

By minimizing soil disturbance through reduced or zero tillage and direct seeding, conservation agriculture favors soil life while increasing soil organic matter. As a result, soil's porosity increases, enhancing its water retention capacity, which boosts biological activity and improves productivity (Liniger et al., 2011).

On the other hand, having a permanent soil cover with either cover crops or mulch leads to multiple positive effects such as the incorporation of organic matter and nutrients into the soil, protection from raindrop splash and direct solar radiation, reduced evaporation losses, reduced runoff, and better plant germination rate and growth (Liniger et al., 2011).

Regarding crop rotation or intercropping allows the replenishment of nutrients in the soil while reducing risks of

Scale

- At farm level

Activities

- Direct seeding or planting
- Weed maintenance
- Manual tillage
- Mulching (spread of vegetative organic residues over the soil)
- Establishment of the cover crop (e.g., legumes)
- Training

Requirements and enabling conditions

- Land user's mindset
- More economical and less labor-intensive than conventional tillage systems
- Communal agreements
- Supportive institutional mechanisms for the conversion

Potential barriers

- Requirement of specific material input and technical know-how
- Lack of finance access or support to acquire equipment and tools
- Limited labor for weeding
- lack of access to, and use of, external inputs.

Limitations and trade-offs

- In the initial years, intensive weed control and management will be required.

pests, diseases, weed infestation and failure due to climate-related conditions (Liniger et al., 2011).

Essentially, the farming systems should aim to reduce agrochemical pesticides application, machine use, and mineral fertilization as much as possible. By that, conservation agriculture will help to increase crop yields and yield reliability while reducing labor requirements, leading to more sustainable farming (Liniger et al., 2011).

- It is not recommended for root crops instead cereal and legumes.
- Suitable for crops on non-steep slopes (<16%)
- Unsuitable for poorly drained, compacted or shallow soils

Previous experiences

- Cusco: Urubamba

Supporting references for describing this EbA: (Liniger et al., 2011)

General description

Contour farming is a practice with various techniques, which in general prevent the loss of topsoil on slopes affected by erosive effects (HELVETAS Swiss Intercooperation, 2017). It manages crops on contour lines by furrowing perpendicular to the terrain slope to reduce the runoff velocity and thus its dragging capacity.

Unlike intensive hillside farming, whose furrows are parallel to the slope accelerate erosive effects, contour furrows contain the runoff by being arranged transversely or obliquely to the hill (HELVETAS Swiss Intercooperation, 2017).

Functioning

Contour furrows are local adaptation measures in scenarios of the high variability of precipitations in which seasonal, concentrated, and intense rainfall occurs, triggering erosive processes. Likewise, furrows allow retaining moisture in the soil for contexts with considerable drought periods. (HELVETAS Swiss Intercooperation, 2017)
When soils are well-drained, and slopes are gentle (<6%), it is more convenient to use strip cultivation which consists of establishing two types of crops: one of protective type with denser vegetation and one of a shorter cycle (PDRS-GTZ, 2014).

The dimensions and shapes of the furrows depend on the crop, rainfall intensity, changes in topography, soil permeability and slope (DDCC, 2019). However, it is recommended that the furrow slope does not exceed 2% to favor infiltration and decrease water erosion (HELVETAS Swiss Intercooperation, 2017).

In this way, contour farming also contributes to correcting poor agricultural practices while reducing landslide risks and the effects caused by heavy rainfall. By improving water infiltration into the soil, reducing erosion, maintaining the fertile soil layer and retaining nutrients, contour furrows increase crop yield and plot productivity. (HELVETAS Swiss Intercooperation, 2017)

Scale

- At the community level
- At the district level

Activities

- Site preparation
- Delineation of the furrows
- Furrows establishment
- Seeding and planting
- Maintenance (slope and bank correction)

Requirements and enabling conditions

- Agreements with land-owners
- Easy to build and implement

Potential barriers

- Unclear land tenure
- Limited local labor
- Only possible with manual plowing

Limitations and trade-offs

- The furrows might be destroyed during harvesting activities, sometimes implying to re-build the system.
- Not feasible for no deep soils or with lower infiltration capacity (clay soils)
- Limited to a max.100m length
- Effective on slopes between 5-18%

Previous experiences

- Cusco: San Salvador district, Farmer communities of Ccamahuara and Siusa

Supporting references for describing this EbA: (HELVETAS Swiss Intercooperation, 2017)

Lessons learned for the effective EbA implementation in Peru

The following lessons learned for the effective implementation of EbA measures were collected from the experiences in Nor Yauyos Cochas (UNEP, 2019), Sierra Azul (Varillas, 2019) and other EbA measures in mountain ecosystems in Peru (UNEP et al., 2014).

In the EbA Project planning

- Adequate site selection considering ecological, socio-economic, cultural and operational criteria. For example, the percentage of the local population that depends on ecosystem services.
- Promote interactive and open dialogues between local traditional knowledge and external researchers.
- Establish multidisciplinary teams with local and external experts to diagnose social and environmental impacts.
- Follow a participatory approach that empowers and actively involves communities in the project.
- Anchor the design, planning and further implementation of the measures with the communities' ancestral culture and ways of living.
- Involve and work coordinately with the different actors in the territory. Especially make partnerships with local governments that can sustain the measures in the future.
- The measure should generate concrete and tangible benefits in the area where they are implemented (e.g., local water and food security) to increase the measure's sustainability and local buy-in.
- Add value to the ecosystem by measures that support the value chains of products or services (e.g., ecotourism).

In the EbA project implementation

- Build trust and common understanding with local communities.
- Have an adaptive management approach that can adjust the project implementation as knowledge about the measure advances.
- Consult the community and its forms of organization permanently to secure the measures' implementation.
- Ensure local ownership of the EbA measure and build local capacity for its long-term implementation.
- Work with the local population following a learning-by-doing (action learning) approach.
- Harness local talents that facilitate the connection between technical knowledge and local knowledge.
- Set up easy-to-apply and simple monitoring systems.
- Promote a paradigm shift in managing natural resources toward an integrated view of the territory and revaluing the usefulness of nature-based solutions.

For replicating and scaling the EbA Project

- Implement the measures gradually, starting with a specific EbA measure toward more integrated actions in the territory.
- Encourage the replicability of measures through technical-scientific and testimonial evidence of the generated benefits.
- Interventions should be tailored to the reality of each context instead of an automatic replication of a measure.

- Promote public investment in this type of project that supports basin-wide interventions.
- Establish a National Program that catalyzes, facilitates, integrates, promotes and supports investments in projects of this type.

Avoiding maladaptation risks

Like any other anthropogenic action, adaptation measures - including EbA measures- can have unintended and adverse effects on communities and ecosystems at climate risk (Work et al., 2019). These adverse and inadvertent effects of an adaptive measure are known as maladaptation (Ranasinghe et al., 2021; Rizvi & van Riel, 2018).

Maladaptation is a process (A. K. Magnan et al., 2016) in which the climate risk conditions of a system are worse than conditions before implementing an adaptive measure. However, maladaptation can also affect non-climate risk factors such as environmental pressures (A. Magnan, 2014), inequality, injustice, poverty (Jones et al., 2015), and migration (Schipper, 2020). Hence, maladaptation can erode the affected system's resilience, sustainability, and development options (Juhola et al., 2016).

Because maladaptation occurs at different spatial scales and time frames in a dynamic and interconnected manner, maladaptive actions can affect the target as well as the non-target entities, or both, or society at large, including future generations (Granberg & Glover, 2014; A. Magnan, 2014; A. K. Magnan et al., 2016).

Maladaptation develops in four ways: by increasing social and ecological sensitivity, by increasing the probability or severity of the hazard, by increasing the exposure of the affected system to threats, or by decreasing its adaptive capacity (Butterfield, 2019; Jones et al., 2015; Juhola et al., 2016). As a result, maladaptation may aggravate existing risk conditions, exacerbate expected risk factors, or introduce new ones into the affected system.

Some maladaptive effects may include (Barnett & O’Neill, 2010; Hallegatte, 2009; Jones et al., 2015; A. Magnan, 2014; A. K. Magnan et al., 2016; Schipper, 2020) :

- Increasing emissions of greenhouse gases
- Burdening of the most vulnerable to climate impacts
- Locking development options and path-dependency
- Conflicts with other climate actions or development strategies
- Displacing or reinforcing environmental pressures and degradation trends
- Marginalization and inequal changing in livelihood strategies
- Changing social structures and dynamics

Ultimately, maladaptation progressively diminishes well-being conditions and sustainable development options and compromises opportunities to prosper (IPCC, 2014; A. K. Magnan et al., 2016; Wise et al., 2014).

Since adaptation measures are not isolated processes, the drivers of maladaptation are of different natures: economic, institutional, social, environmental, and cultural (Jones et al., 2015; Musker, 2015; UNEP, 2021). Furthermore, maladaptation risks can occur because of failures in the planning and implementation of the adaptive measure and changes in local conditions. Therefore, adaptive measures must avoid the generation of these drivers and the development of maladaptive outcomes as much as possible.

Maladaptation risks can be avoided by having multi-sectoral, pluri-actor and long-term planning and flexible, timely, and proactive implementation of adaptive measures with various benefits for the systems involved (IPCC, 2022). An adaptive management approach, robust and permanent monitoring system, a landscape perspective, and other safeguards mentioned in the Voluntary Guidelines (CBD, 2019) help minimize maladaptation risks.

Other measures to support EbA

This section is divided into two parts. The first part presents a brief description of measures considered nature-based practices which can complement the EbA measures previously described. The second part lists other interventions, namely soft measures that can integrally complete the intervention.

Nature-based practices

Nature-based Practices (NbP) refer to actions that contribute to protecting and managing ecosystems sustainably while recovering some ecosystem services using elements of the natural environment favourably. Conversely to the EbA measures, the NbP slightly modified the ecological or biophysical conditions of the area in which it is implemented to improve natural processes.

Similar to the previous section, this section summarizes in tables the applicability at the regional level (Table 8), the applicability at the ecosystem level (Table 9), climate variability and intermediate impacts addressed (Table 10), the appropriate land-use for each NbP (Table 11), and the various benefits each NbP provides (Table 12).

Table 8. NbP applicability per region

NbP	REGION			
	APURIMAC	AREQUIPA	CUSCO	PUNO
Bioengineering for gully control		+	+	
Qochas/Rustic micro-reservoirs	+	+	+	+
Amunas/Mamanteo		+		
Infiltration ditches			+	+
Andenes/terraces			+	
Irrigation management	+		+	+
Slow-forming terraces			+	
Fitotoldos	+	+	+	
Afforestation	+		+	

Source: *Post-workshop survey*

Table 9. NbP applicability per ecosystem

NbP	Eco-region: Glaciar and peri-glaciar zone	Pasturelands	Bofedal	Highandean forest	Mesoandean forest	Shrubland	Lagoons and wetlands	Source
Bioengineering for gully control	+	+	+	+	+	+		(Polster, 2003), (Georgi and Stathakopoulos, 2006).
Qochas/Rustic micro-reservoirs	+	+	+	+			+	(HELVETAS Swiss Intercooperation, 2017)
Amunas/Mamanteo	+	+	+	+			+	(Moran et al., 2018;), (HELVETAS Swiss Intercooperation, 2017)
Infiltration ditches				+	+			(HELVETAS Swiss Intercooperation, 2017)
Andenes/terraces				+	+			(HELVETAS Swiss Intercooperation, 2017)
Irrigation management		+	+	+	+	+		(DDCC, 2019), (HELVETAS Swiss Intercooperation, 2017)
Slow-forming terraces		+	+	+				(HELVETAS Swiss Intercooperation, 2017)
Fitotoldos	+	+	+	+	+	+		(PEJ-PA, 2009)
Afforestation		+	+	+	+	+	+	(Liniger et al., 2011), (WOCAT, 2013)

Table 10. Climate variability and intermediate impacts addressed by each NbP

NbP	Climate variability			Intermediate impacts					SOURCE
	Decreasing annual precipitation	Increasing temperature	Heavy rainfall	Erosion	Landslides	Sudden increase in river flows	Deficit of water	Decreasing land productivity	
Bioengineering for gully control	+		+	+	+	+	+		(Polster, 2003), (Georgi and Stathakopoulos, 2006).
Qochas/Rustic micro-reservoirs	+	+	+	+	+	+	+	+	(HELVETAS Swiss Intercooperation, 2017), (Moran et al., 2018;), (PACC, 2014)
Amunas/Mamanteo	+			+	+	+	+		(HELVETAS Swiss Intercooperation, 2017), (Moran et al., 2018;),
Infiltration ditches	+		+	+	+	+	+	+	(HELVETAS Swiss Intercooperation, 2017), (Palma, 2017), (Rivera *et al.*, 2014)
Andenes/terraces		+	+	+	+		+	+	(DDCC, 2019), (HELVETAS Swiss Intercooperation, 2017), (Masson Meiss, 1994), (Moran et al., 2018;), (UNEP-ROLAC / FS-UNEP Centre, 2014)
Irrigation management	+	+		+	+		+	+	(PDSR-GTZ, 2014)
Slow-forming terraces	+		+	+	+		+	+	(HELVETAS Swiss Intercooperation, 2017)
Fitotoldos			+						(PEJ-PA, 2009)
Afforestation		+	+	+	+	+			(Liniger et al., 2011), (WOCAT, n.d.)

Table 11. Appropriate land-use for each NbP

NbP	Land-use						SOURCE
	Croplands	Pasturelands (Grass- and Shrublands)	Forest lands	Bare lands	Glacier	Water bodies	
Bioengineering for gully control	+	+	+	+			(Polster, 2003), (Georgi and Stathakopoulos, 2006).
Qochas/Rustic micro-reservoirs		+		+	+	+	(HELVETAS Swiss Intercooperation, 2017), (Moran et al., 2018;), (PACC, 2014)
Amunas/Mamanteo	+	+	+	+	+	+	(HELVETAS Swiss Intercooperation, 2017), (Moran et al., 2018;),
Infiltration ditches	+		+				(HELVETAS Swiss Intercooperation, 2017), (Palma, 2017), (Rivera *et al.*, 2014)
Andenes/terraces	+	+					(DDCC, 2019), (HELVETAS Swiss Intercooperation, 2017), (Masson Meiss, 1994), (Moran et al., 2018;), (UNEP-ROLAC / FS-UNEP Centre, 2014)
Irrigation management	+	+					(PDSR-GTZ, 2014)
Slow-forming terraces	+	+	+				(HELVETAS Swiss Intercooperation, 2017)
Fitotoldos	+	+	+	+	+		(PEJ-PA, 2009)
Afforestation	+	+	+	+			(Liniger et al., 2011), (WOCAT, n.d.)

Table 12. Benefits and functions of each NbP

NbP	BENEFIT- FUNCTIONS																									SOURCE
	Increase in spring base flow rates	Water flow/runoff regulation	Infiltration and Aquifer recharge	Increasing water provision	Protection of wetlands and lagoons	Improvement of soil moisture	Erosion control	Slope stabilization	Maintenance of soil fertility	Carbon sequestration	Nutrients cycling / retention	Biodiversity conservation	Habitat provision for wildlife	Regeneration of vegetation cover	Contribution to food security	Crop yield improvement	Improvement of livestock production	Microclimate and temperature regulation	Prevention of crop failures	Enhancing aesthetic value of the landscape	Social cohesion	Recovery of cultural identity	Recreation and tourism values	Spiritual and religious value	Income improvement	
Bioengineering for gully control		+			+	+	+	+			+	+	+	+				+		+			+			(Polster, 2003), (Georgi and Stathakopoulos, 2006).
Qochas/Rustic micro-reservoirs	+	+	+	+	+	+	+					+	+	+	+		+	+	+	+	+	+	+	+	+	(HELVETAS Swiss Intercooperation, 2017), (Moran et al., 2018), (PACC, 2014)
Amunas/ Mamanteo	+	+	+	+		+	+					+		+		+		+	+		+	+				(HELVETAS Swiss Intercooperation, 2017), (Moran et al., 2018)
Infiltration ditches	+	+	+	+	+	+	+	+	+		+			+		+				+	+	+				(HELVETAS Swiss Intercooperation, 2017), (Palma, 2017), (Rivera *et al.*, 2014)
Andenes/terraces		+	+				+	+	+		+			+	+	+		+	+	+	+	+	+		+	(DDCC, 2019), (HELVETAS Swiss Intercooperation, 2017), (Masson Meiss, 1994), (Moran et al., 2018), (UNEP-ROLAC / FS-UNEP Centre, 2014)
Irrigation management		+		+		+	+		+		+			+	+	+		+	+						+	(PDSR-GTZ, 2014)
Slow-forming terraces		+			+	+	+	+			+			+	+	+										(HELVETAS Swiss Intercooperation, 2017)
Fitotoldos															+				+		+	+			+	(PEJ-PA, 2009)
Afforestation	+	+	+	+	+		+	+	+	+			+	+				+		+			+		+	(Liniger et al., 2011), (WOCAT, 2013)

General description

This measure entails the combination of engineering design principles with biological and ecological concepts to control erosion, sedimentation and flooding naturally. Working together with nature, a soil bioengineering method uses engineering science for calculations and design complementary structures (e.g., crib walls or log revetments) to speed up the recovery process by reestablishing native plant communities, ecological processes and ecosystem services. (Eubanks & Meadows, 2002)

To repair and recover holes, slips, gullies, and slumps on slopes and streambanks, different combinations of native plants, logs, rocks, plant fillers and in some cases, geomembranes are used through various techniques (Polster, 2003). For instance, branch packing, brush filling and layering, brush mattress, living fences, log breakwaters, stonewalls, joint planting, live crib walls, live fascine, plant rolls, tree revetment, trench packs and vegetated geogrid (Eubanks and Meadows, 2002).

These methods provide several essential functions for adapting to the climate change effects. For example, the recovery of vegetation cover reduces the impact of heavy rains and their consequent removal of debris while maintaining soil moisture during drier conditions. Likewise, the vegetation cover and its roots favor water retention that regulates runoff, while the surface plants trap sediments and nutrients. In addition, on steep slopes, the root system allows soil consolidation and prevents landslides. (Eubanks and Meadows, 2002; Polster, 2003).

Scale

- At the site level
- At the landscape level

Enabling conditions

- Low cost and low maintenance
- Feasible in areas with limited access
- Prior community agreement not to use or access the area
- Simple and fast installation
- Consent of the landowner

Potential barriers

- Requirement of advanced knowledge in botany, horticultural, hydrology, soil, engineering and construction
- Local availability of seedlings and cuttings of different species
- Material locally available (e.g., stones, trunks, posts)
- Intensive and skilled labor required
- Unclear land tenure

Previous experiences

- Cusco: Quispicanchis

Supporting references for describing this NbP: (Eubanks & Meadows, 2002; Georgi & Stathakopoulos, 2006; Polster, 2003)

General description

Qochas are rustic reservoirs in natural depressions or lagoons of pre-Inca origin (Moran et al., 2018;), by erecting a dam of compacted earth to store rainwater to cope with the decrease of the resource in the dry months (PACC, 2014; Rivera et al., 2014).

Qochas are usually built in the headwaters of watersheds with irregular rainfall regimes (Moran et al., 2018;). Their purpose is to store water in times of abundant rainfall to regulate the flow of streams, recharge aquifers and provide water in times of low water (Moran et al., 2018;). In addition, the stored water is used to feed springs and wetlands (Rivera et al., 2014) for irrigation of high-altitude crops such as potatoes, barley, pastures and watering for livestock and human consumption (Moran et al., 2018;).

Given the high evaporation rates in the area, Qochas also have a thermo-regulating effect that maintains the surrounding humidity and promotes the growth of fresh and edible grasses for livestock (DDCC, 2019). In this way, Qochas serve to cope with both climate change effects and non-climatic pressures. For example, reduced and irregular seasonal precipitation and variation in rainfall patterns; increased temperature ranges (increased maximum and decreased minimum temperatures); overgrazing, burning of grasslands, soil compaction, and other poor agricultural practices (HELVETAS Swiss Intercooperation, 2017; PACC, 2014).

Scale

- At the Household level
- At the Community level

Enabling conditions

- Knowledge of water potential of the area (current and future), soil structure, aquifer recharge capacity, hydro-geological connectivity and geology
- Community commitment

Potential barriers

- Peat and sandy soils increase land preparation costs
- Complex land availability and –tenure
- Social conflicts within communities
- Lack of free and dedicated personnel for long-term maintenance

Previous experiences

- Cusco: micro-watersheds of Huacrahuacho, Espinar, Sur de Cusco, Ccatcca, Salca Calca, Canas and Quescay
- Apurimac: Abancay, and Grau province, in the district of Pataypampa
- Arequipa: Chiuchilla micro-basin, RN Salinas y Aguada Blanca, Tolconi (Chachas Castilla)

Supporting references for describing this NbP: (HELVETAS Swiss Intercooperation, 2017; Moran et al., 2018; PACC, 2014; Rivera et al., 2014)

General description

Amunas are a pre-Hispanic system for recharging aquifers artificially (HELVETAS Swiss Intercooperation, 2017; Moran et al., 2018;). Built on a permeable bed, the amunas retain, channel, infiltrate and store subsurface and surface water (HELVETAS Swiss Intercooperation, 2017).
Through a network of channels, water from rainfall or snowmelt is captured (between December and April) in the upper part of the watersheds and conducted to aquifer infiltration areas which are fractured, porous and rocky surfaces connected to springs in lower areas (Moran et al., 2018;). The above feeds existing downstream springs in the drier months (August to October) during planting activities (Moran et al., 2018;).

Since amunas contribute to regulating the hydrological regime, it is an appropriate adaptation measure in the face of increasing drought. By improving soil moisture in the recharge zone, an amuna favors grasslands regeneration and regulates evapotranspiration rates, and thus helps cope with the temperature increase effects of climate change (HELVETAS Swiss Intercooperation, 2017).

Additionally, the channels promote pasture regeneration and intercept runoff on slopes, controlling erosion and preventing landslides (HELVETAS Swiss Intercooperation, 2017).

Scale

- At the community level
- At the district level

Enabling conditions

- Well organized communities
- Hydro-geological and hydrological studies
- Tangible benefits in the short and medium-term
- Linking to local traditions (e.g., The Water festival)

Potential barriers

- Conflictive local social dynamics
- Unclear land tenure or land owned by people outside the community
- Lack of local labour
- Length of the amuna
- High rehabilitation and maintenance costs (at least seven maintenances in the year)

Previous experiences

- Arequipa: Tolconi (Chachas Castilla)

Supporting references for describing this NbP: (HELVETAS Swiss Intercooperation, 2017; Moran et al., 2018)

General description

The Inca terraces (*pata pata*) is a pre-Hispanic technology consisting of making cuts on steep slopes (10%-35%) to establish arable surfaces (HELVETAS Swiss Intercooperation, 2017; UNEP-ROLAC / FS-UNEP Centre, 2014). By modifying steep slopes in this way, resources such as water, soil, space and even climate are efficiently used in agricultural practices (DDCC, 2019; Llerena et al., 2004).

Made from gravel, soil and organic matter and supported by stone or compacted earth walls, the terraces are built following the sinuosity of the contour line (DDCC, 2019). Due to their perpendicular orientation to the slope, terraces reduce runoff erosion, maintain soil moisture and generate a suitable microclimate for crops (HELVETAS Swiss Intercooperation, 2017). Besides that, terraces are frequently built from East to West, with the front facing North, to make the stones of the walls absorb heat by solar irradiation during the day, and subsequently released at night, creating a favorable microclimate for the development of crops and mitigating the risk caused by frost (HELVETAS Swiss Intercooperation, 2017). Altogether create good conditions for agriculture that increase land productivity.

The almost flat shape in the form of platforms and its staggered layout allows efficient use of the runoff that infiltrates and passes to the next platform below and ultimately, significantly reduces the need for irrigation water (HELVETAS Swiss Intercooperation, 2017).

Scale

- At the community level
- At multi-household level

Enabling conditions

- Knowledge about site features (e.g., soil type, relief, precipitation regime, runoff, solar exposure, and local material availability)
- Topographic study
- Knowledge about the ancestral construction techniques
- Strong local organization

Potential barriers

- Lack of stones or other materials locally.
- Hindering conditions such as rocky formations, gullies, changes in slope orientation or soil stoniness.
- Labor-intensive maintenance

Previous experiences

- Arequipa: Colca Valley
- Puno: Pusalaya

Supporting references for describing this NbP: (DDCC, 2019; HELVETAS Swiss Intercooperation, 2017; Masson Meiss, 1993; Moran et al., 2018; UNEP-ROLAC / FS-UNEP Centre, 2014)

General description

These are excavations of a rectangular or trapezoidal section built on slopes following contour lines to intercept, retain and store runoff during rainy seasons (Rivera et al., 2014).

By shortening the length of the slope, infiltration ditches have a dual purpose; to retain and infiltrate rainwater and reduce soil dragging due to runoff effect (HELVETAS Swiss Intercooperation, 2017). Therefore, infiltration trenches should be located on moderate to steep slopes (10% to 40%) and where precipitation is concentrated in short periods (Palma, 2017).

The water deposited in the ditches infiltrates the soil and, at the same time, moistens the subsoil of the plot (Rivera et al., 2014). This effect allows the recharge of aquifers, control erosion on slopes and regenerate vegetation cover in the area of the ditches (HELVETAS Swiss Intercooperation, 2017).

The ditch dimensions are given by the volume of precipitation falling in the catchment area, which should be less than or equal to the catchment and absorption capacity of the entire ditch (Rivera et al., 2014).
It begins with the delineation and leveling of the ditches, followed by ditches' excavation and shaping, and finally, the refinement of the trench once the runoff has passed. Furthermore, maintenance activities consist of cleaning the material carried away by the water from the ditch (Rivera et al., 2014).

Scale

- At multi-household level
- At the community level
- At micro-watershed level

Enabling conditions

- Know about hydrological conditions and soil properties of the area.
- Communally owned land
- Social organization and community commitment

Potential barriers

- High maintenance costs
- Limited local labor
- Labor-intensive maintenance

Previous experiences

- Cusco: Micro-watershed of Huacrahuacho

Supporting references for describing this NbP: (HELVETAS Swiss Intercooperation, 2017; Palma, 2017; Rivera et al., 2014)

General description

Irrigation management is the water supply to plants in a timely and effective manner according to the plant's water requirement, topography, climatic conditions, soil characteristics, and irrigation method (PDRS-GTZ, 2014).

For an irrigation management system to be effective and make efficient use of water, irrigation must be applied and reach the root zone of the plants (PDRS-GTZ, 2014).

Existing irrigation systems are either surficial or pressurized. While the former is more economical and takes advantage of gravity, the latter is more uniform and efficient but requires special equipment and installations (PDRS-GTZ, 2014).

In general, irrigation application (when properly applied) increases crop yields, facilitates seed germination, eliminates weed proliferation, and modifies relative air humidity, avoiding damage from frost or high temperatures (PDRS-GTZ, 2014).

In contrast to traditional irrigation systems (e.g., contour, furrows, flooding, irrigation ditches, openings), technical irrigation (sprinkling, drip, micro-drip) improves the humidity, nutrients, aeration and biological activity in the root zone, avoiding fungal diseases in crops (PDRS-GTZ, 2014).

Scale

- At farm level

Enabling conditions

- Differences in the topographical level that favor irrigation
- Water sources with acceptable quality to be used for irrigation.

Potential barriers

- It might accelerate salinization, nutrient wash out or erosion processes
- Some methods are labor-intensive or expensive for small farmers
- Some methods require an expert design

Previous experiences

- Apurimac: Talavera y Pachaconas
  Arequipa: Canas y Valle interandino

Supporting references for describing this NbP: (PDRS-GTZ, 2014)

General description

The slow-forming terraces are a soil conservation measure, which consists of gradually forming embankments on agricultural land due to soil accumulation (HELVETAS Swiss Intercooperation, 2017).

Through stone walls (*pircas*) placed perpendicular to the slope, accompanied by a furrow that drains water and retains soil, the embankments are formed progressively without removing soil (PDRS-GTZ, 2014). In this way, the slope is reduced and divided into different strips over time, reducing runoff velocity, laminar erosion, sediments dragging, and gullies formation while improving soil infiltration, capturing nutrients and thus improving agricultural production on slopes (HELVETAS Swiss Intercooperation, 2017).

In this way, slow-forming terraces reduce the effects of heavy rains and retain soil moisture in crops during the dry season (HELVETAS Swiss Intercooperation, 2017).

In addition to controlling erosion and counteracting seasonal water deficit, slow-forming terraces are also useful for correcting poor agricultural practices such as hillside farming or grazing on slopes (HELVETAS Swiss Intercooperation, 2017).

Scale

- At the site level
- At the household level
- At the community level

Enabling conditions

- Consent of the landowner
- Social organization and community commitment

Potential barriers

- Soil stoniness (<30%)
- Slope (<25%)
- Local availability of materials (e.g., stones).
- Local labor availability
- Permanent maintenance required

Previous experiences

- Apurimac: Caraybamba
- Arequipa: Cotahuasi and Colca
- Cusco: Cuyuni, Jullicunca and Carhuayo
- Puno: Cuyo and Sandia

Supporting references for describing this NbP: (HELVETAS Swiss Intercooperation, 2017; PDRS-GTZ, 2014)

General description

The Fitotoldos are structures made of adobe walls with a transparent roof that allow, like a glass greenhouse, to control the technical and environmental conditions (temperature, relative humidity, luminosity) for vegetable production. Solar radiation (heat) is stored in the adobe walls and released during cold nights, regulating sudden temperature changes. (PEJ-PA, 2009)

The soil must be prepared according to the plants' requirements and be free of any plant material or organic impurities. At the same time, each sub-division must be arranged to take maximum advantage of the sun (PEJ-PA, 2009).

Given that part of the high Andean population (i.e., women, elder) have difficulties for open farming, fitotolds are an alternative measure to contribute to family agriculture and food security (PEJ-PA, 2009). Moreover, to produce fresh and healthy vegetables for a balanced and nutritious diet, and with the option of selling the surplus locally, fitotoldos reduce the vulnerability of rural communities' livelihoods to the effects of climate change.

Scale

- At household level

Enabling conditions

- Easy management and maintenance
- Involves the whole family
- No demand for a large land extension

Potential barriers

- Water access
- Access to materials
- Financing of the structure
- Labor-intensive

Previous experiences

- Apurimac: Cotabambas and Abancay
- Arequipa: Tuti
- Cusco: San Sebastian
- Puno: Ajoyani

Supporting references for describing this NbP: (PEJ-PA, 2009)

General description

Afforestation consists of planting trees or shrubs in places where no forests were originally (InforMEA, 2022). Preferably, plantations should use native species appropriate to the environmental and climatic conditions of the area and adapt to the specific site conditions (slope, stone cover, climate, etc.) (WOCAT, 2013).

Afforestation aims to increase the vegetation cover (forest cover) of an area without intending to imitate the composition and functioning of a native forest necessarily. Likewise, afforestation objectives are to protect the land against erosion processes, avoid degradation of hilly slopes, provide firewood for households and timber as an alternative income for the local community, and mitigate the effects of strong winds, torrential rains or frosts as well as a mean for carbon sequestration (WOCAT, 2019).
Furthermore, by increasing vegetation density with forest cover, afforested plots reduce runoff, control erosion, favor aquifer recharge and in some cases, attract fauna and protect biodiversity (Liniger et al., 2011).

Scale

- At the landscape level
- At the district level
- At the community level
- At micro-watershed level

Enabling conditions

- Communal agreement
- Institutional support
- Community organizing for work

Potential barriers

- High costs of establishment
- Labor intensive
- Land tenure

Previous experiences

- Apurimac: “Sacha Tarpuy” orest management programme

Supporting references for describing this NbP: (InforMEA, 2022; Liniger et al., 2011; WOCAT, 2013)

Other interventions (soft measures)

Other cross-cutting measures and “soft” options targeting improved governance styles and social and individual behavioural change are listed below:

+ Organizational strengthening of rural communities.
+ Ancestral land management (zoning) and livelihood planning.
+ Environmental and hydro-meteorological monitoring stations.
+ Transformation of products (livestock, fibre, food, etc.).
+ Training and skill development in fauna and flora management.
+ Environmental technical assistance.
+ Training in climate change adaptation and risk management.
+ Environmental awareness campaigns.
+ Social exchange on ecosystem management experiences.
+ Establishment of monitoring and early warning systems.
+ Participatory monitoring program.

PES Scheme

Payment for ecosystem services (PES) is a market-based instrument for conserving and restoring nature (IPBES, 2022). PES are flexible, targeted and incentive-based mechanisms that promote the sustainable use of biodiversity and ecosystems through an effective financing scheme (EC, 2012).

In practice, PES often involves a series of payments to land or natural resource managers in return for a guaranteed and enhanced flow of ecosystem services (Smith et al., 2013) (Figure 4). Through PES agreements, users or beneficiaries of an ecosystem service pay to individuals or communities whose management practices favour the provision of ES (EC, 2012). The basic idea is that whoever maintains or improves the sources of services (i.e. ecosystems) should be paid for doing so (Fripp, 2014).

Payments are made by the beneficiaries (individuals, communities, businesses or government) by putting a price on the ecosystem service or services (Smith et al., 2013). Those services refer to the various benefits derived from the natural environment (Fripp, 2014). Examples include the supply of food, water and timber; regulation of climate and flood risk; opportunities for recreation, tourism and education; and essential underlying functions such as carbon sequestration.

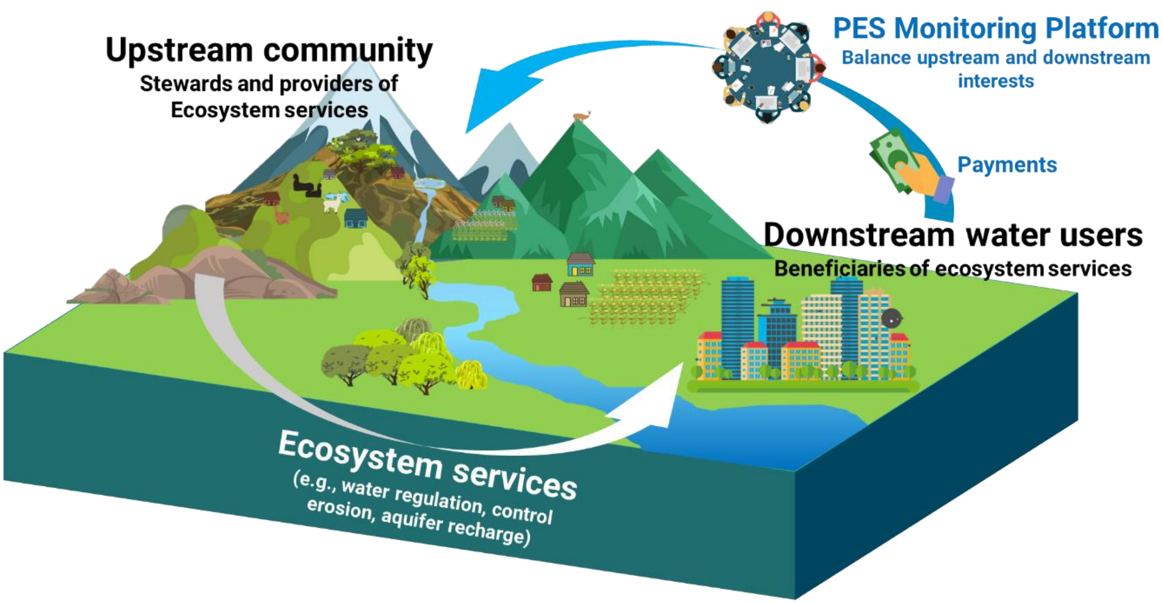

Figure 4. The PES Concept

MERESE mechanism (ES-related Water and Sanitation)

Since 2014, the National Superintendence of Sanitation Services (SUNASS), in cooperation with the Ministry of Environment and public utilities companies (EPS), has implemented a series of norms as part of the Mechanisms of Rewards for Ecosystem Services (MERESE) (Peruvian Law No 30215). This mechanism, applicable at the basin and national level, aims to mobilize funds from downstream users, through a percentage of the water tariff, to upstream providers to conserve water resources and the headwater streams. In addition, the Framework Law for the Management and Supply of Sanitation Services was introduced in 2016 to regulate the provision and access on a national level to promote sustainable and quality services that protect the environment and the user.

Markets and payments for ecosystem services can be classified into four main groups:

- Biodiversity protection.
- Watershed services[1].
- Climate regulation and carbon sequestration.
- Marine and coastal protection.

A Payment for Ecosystem Services (PES) is characterized by:

- Being a voluntary transaction
- Clearly defining the environmental service or a form of land use that ensures that service
- Acquire by at least one consumer of the environmental service.

Elements of a MERESE remuneration agreement:

- Ecosystem Service (ES) Contributor: a natural or legal person, public or private, who contributes to the conservation, sustainable use and recovery of the sources of ES through technically viable actions.
- ES payer: natural or legal person, public or private, who obtains an economic, social or environmental benefit, and pays the fees for the ES.
- Location: description of the ecosystem area where the MERESE is implemented
- Actions: specific actions to which the contributors commit themselves concerning maintaining and improving the provision of specific ES.
- ES: identification of the ES in terms of expected social, economic and environmental benefits (mentioned above)
- Payment: economic recognition of the contributors and modalities of retribution
- Financing strategy
- Monitoring: specific actions for monitoring compliance with the agreement
- Registration: single registry of MERESE initiative.

Establishment steps of a hydrologic MERESE initiative

1) Design the hydrologic MERESE initiative
    a. Rapid Hydrological Diagnostic
    b. Intervention Plan
    c. Stakeholder Analysis
    d. Good governance platform
    e. Hydrologic monitoring system
2) Identifying and estimating the tariff
    a. Optimized Master Plan (PMO)
    b. Water tariff assessment and approval by the population
    c. Tariff incorporation in the water bill
    d. Collection of contributions
3) Execution (4 modalities)

[1] Water generation, water regulation, sediment control, chemical water quality

a. Public investment projects[2]
b. Procurement of goods and services
c. Agreements with communities
d. Agreements with private funds

Lessons learned and best practices

Montoya-Zumaeta et al. (2021) describe four critical elements for preparing an effective incentive-based conservation scheme:

- Spatial targeting: prioritize interventions on high-ES density areas (Wünscher et al., 2008) and those under major threat (Alix-Garcia et al., 2008).
- Payment differentiation: landholders are paid variable rates according to the levels or costs of ES provision, especially in heterogeneous groups (Engel, 2016).
- Conditionality: effective monitoring is required to validate compliance as well as the sanction of non-compliance (Sommerville, 2009; Tacconi, 2012; Wunder et al., 2018).
- Customization of payment modalities: identify the most suitable mode of payment for the scheme among the various existing options: cash vs in-kind vs mix; collective community-based vs individual landowner agreements; ex-ante vs ex-post results; and short-term vs long-term contracts.

[2] "Guidelines for the formulation of Public Investment Projects in Biodiversity and Ecosystem Services" (approved by Directorial Resolution No. 006-2015-EF/63.01), which facilitate the formulation of investment projects for the recovery of natural infrastructure. Legal basis: Law 28611.

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