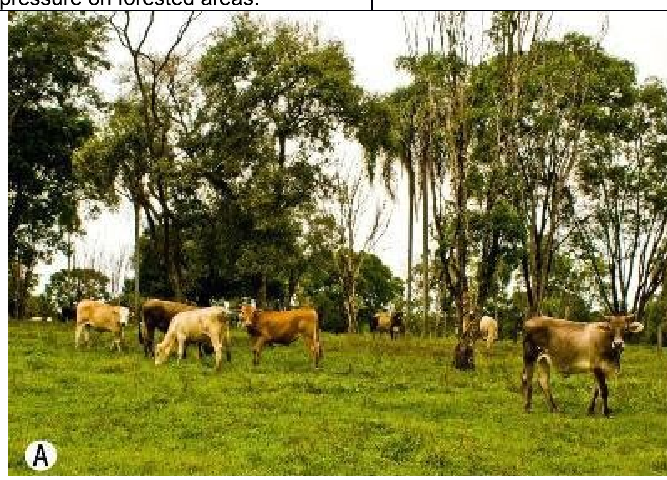
Annex 22: Description of EbA, water and resource-efficient technologies

The following table describes some of the EbA, water and resource-efficient measures or technologies that could be financed through the project's financial mechanisms. Benefits and co-benefits for each measure are also explained.

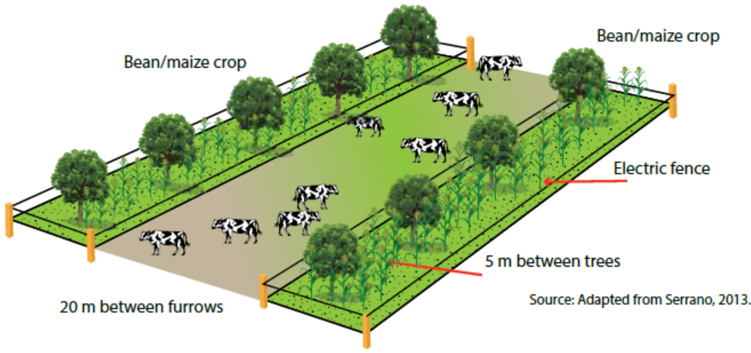
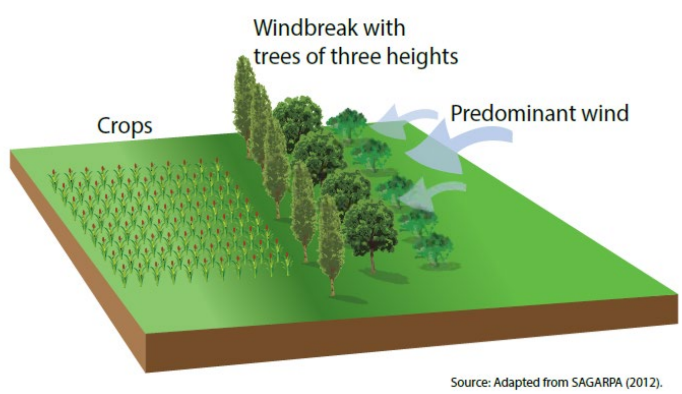
EbA / water and resource efficient technologies	**Description**	**Benefits and co-benefits**
EbA measures/technologies		
1. Establishment of **agroforestry systems** for natural shade or using diversified living fence arrangements (Somarriba et al. 2014, The World Bank Group, CIAT, CATIE (2014)	• Agroforestry systems can be defined as an integrated approach to the production of trees and of non-tree crops or animals on the same piece of land. • In the context of this proposal, agroforestry systems to protect water recharge zones refer mainly to **shade-grown coffee**. In some countries (e.g. El Salvador) these agroforestry systems are the only/main type of tree cover in water recharges zones. • This measure refers to both the **recovery** of existing agroforestry systems and the **establishment** of new ones, through **improved agroforestry practices** such as the renewal of coffee plantations with coffee varieties resistant to new climate conditions, pests and diseases, the inclusion of fruit trees for income diversification, or the inclusion of shade trees species with commercial value[1] for the transition from full-sun coffee cultivation to shade-grown coffee. • Dispersed trees in pastures is a common **silvopastoral** system in the region. It can be considered part of the adaptation actions, but not in critical areas for regulation of the water flow, as they provide less soil protection.	Agroforestry can improve the resilience of agricultural production to current climate variability as well as long-term climate change through the use of trees for intensification, diversification and buffering of farming systems. In particular, benefits include: • Improved binding of soils by roots, thereby preventing erosion and maintaining topsoil during erratic, heavy rainfall. • Increased provision of food – even under conditions such as drought – thereby increasing food security. • Increased soil fertility as a result of nutrient-rich leaf litter and nitrogen fixation. • Increased availability of fodder for increased resilience of animal husbandry. • Increased incomes through product diversification (e.g. firewood, wood and fodder), certification, and payments / compensation for ecosystem services. [2]Yields of agroforestry systems have been found to be more than 100% higher than those of slash and burn practices. An evaluation of shade-grown coffee in Peru found that yields were five times higher (2.3 t/ha) on plots using agroforestry systems than on plots without those systems (Brack, 2004). A mixed field with maize, squash and beans as well as fruit trees can generate a gross annual revenue of US$ 3000/ha (SAGARPA, 2012). Agroforestry systems may also achieve an annual carbon accumulation rates of between 0.87 and 1.85 t/ha (Etchevers and others, 2005).
	 Source: J. Avelino, Cirad	

[1] Such as *Cordia alliodora*

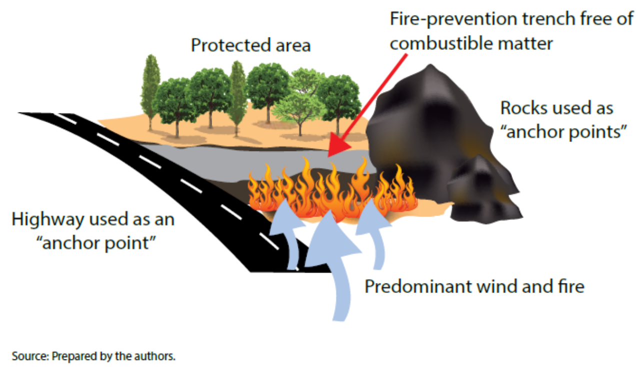
[2] UNEP-ROLAC and Frankfurt School (2014) Microfinance for Ecosystem-based Adaptation: Options, costs and benefits.

EbA / water and resource efficient technologies	Description	Benefits and co-benefits
2. Silvopasture systems using diversified living fence arrangements or individual trees[3]	• It's a system/technique for livestock production in which animals interact with timber species either through browsing or by eating the tree forage after it has been cut. The aim is to diversify the production (Ojeda and others, 2003). • To counteract the deterioration of land dedicated to livestock, it is necessary to avoid overgrazing. To achieve this, the area must be divided into sections that allow moving the cattle herd from one section to another to allow grass recovery, avoid excessive soil compaction and the formation of gullies. • The adaptive measure is based on the planning and construction of fences that allow a more sustainable use of the land, but also, those fences should incorporate multiple-use trees that meet similar objectives to those of agroforestry systems mentioned in the previous section, wood, fodder, fruits and firewood, and thus reduce the pressure on forested areas.	• Diversified production associated with restoring arboreal vegetation in livestock areas is the main benefit of this system. • This allows small producers not only to improve the conditions in their environment but also to reduce the risk of financial loss to which they are frequently exposed. • Some models may generate a benefit-cost ratio of 1.31 and a net present value of US$ 213 per year per hectare if during the first two years an incentive equivalent to the opportunity cost of the land is offered while the trees grow (Murgueitio, 2000).
	 Source: Geraldo Coelho 2015	
3. Agrosilvopastoral systems[4]	• These systems combine techniques that associate tree species (forest or fruit) with livestock and crops on • the same land. The aim is to promote significant ecologic and economic interaction by ensuring sustained yields with less environmental impact. • The adaptive measure is based on the incorporation of isolated trees located directly in grazing areas, which provide shade, wood, firewood, fruits, or fodder, with a distance that allows the correct development of the grass. • It is necessary to prevent livestock from damaging planted trees, whether by feeding, browsing or transit in the area, especially in the first years of their development. For this purpose, barriers should be built around each planted tree, using materials available on the farm, such as wood waste, bamboo poles or similar material.	• Benefits in the diversification of production and in the improvement of ecosystem services (Same as above). • Between 60% and 70% of plant biomass may be used in livestock feed without creating a conflict regarding production for human consumption. If nitrogen-fixing trees are used, soil fertility increases and an animal food supplement is obtained (Iglesias and others, 2011). • 1 ha of an agrosilvopastoral system made up of guava, maize and a tropical forage named naranjillo (*Trichanthera gigantean*) reported an internal rate of return of 21% and a net present value of US$ 1087 per hectare. This system was 7% more profitable than an agroforestry system composed of guava, banana and maize (Chaparro, 2005).

[3] UNEP-ROLAC and Frankfurt School (2014) Microfinance for Ecosystem-based Adaptation: Options, costs and benefits.
[4] UNEP-ROLAC and Frankfurt School (2014) Microfinance for Ecosystem-based Adaptation: Options, costs and benefits.

EbA / water and resource efficient technologies	Description	Benefits and co-benefits
	 Source: UNEP-ROLAC and Frankfurt School 2014	
4. Windreaks[5]	• Windbreaks comprise one or more rows of trees and shrubs of different heights placed perpendicular to the prevailing wind direction with the aim of reducing the force of the wind close to the ground and its mechanical action on crops, pasture and livestock. That way, they curb wind erosion and help regulate climate conditions on farms. • They may also be used as living fences, since they also provide benefits such as climate regulation and landscape improvement. • Windbreaks are recommendable in regions whose topography is characterized by steep slopes and frequent, intense winds. • They are of particular interest in locations with low precipitation and more intense winds during the winter or dry environments, where it is necessary to conserve moisture and regulate climate conditions.	• Strong winds may cause 70% to 100% of a crop to be lost or damaged, especially in the case of bananas, sugar cane, vegetables and fruit trees. Windbreaks may reduce wind speed by 60% to 80% (SAGARPA, 2012). • There is 0.38 cm soil loss in a crop protected by a *Gliricidia sepium* and *Paspalum conjugatum* barrier, compared with 4.20 cm for an unprotected crop (Altieri and Nicholls, 2000). • These barriers also help regulate soil and air temperatures, reduce evapotranspiration and improve the distribution of soil moisture and the provision of such marketable products as fruits, seeds, timber and firewood. • The trees increase the economic value of a property and improve the aesthetics of the landscape, while favouring biodiversity and reduce the pressure on the forests (Ojeda and others, 2003).
	 Source: UNEP-ROLAC and Frankfurt School 2014	

[5] UNEP-ROLAC and Frankfurt School (2014) Microfinance for Ecosystem-based Adaptation: Options, costs and benefits.

EbA / water and resource efficient technologies	Description	Benefits and co-benefits
5. Firebreaks	• Firebreaks are a common practice in the context of ecosystem restoration and conservation and sustainable forest management to prevent forest fires from spreading before they damage ecosystems, croplands or infrastructure. • In Guatemala and Honduras, firebreaks are also part of the practices to manage the Pine beetle outbreak.	• Firebreaks protect material, agricultural and ecosystem services; hence their benefit is related to their effectiveness at providing protection. E.g., a 400 m firebreak would protect 1 ha of forest. • Firebreaks construction could represent an opportunity for generate temporal incomes and dissemination of the benefits of ecosystem services and other adaptation measures
	 Source: UNEP-ROLAC and Frankfurt School 2014	
6. Mixed-plant nursery	• Mixed-plant nurseries are agronomic facilities where plants are germinated and cultivated under controlled conditions of light and moisture. • Their main purpose is to reproduce resilient native species for reforestation or restoration (see Measures 1, 2, 3 and 4) and can contribute to diversify income through the sale of high-quality timber or fruit trees (such as avocado).	• Rehabilitating the forest ecosystem where the nursery is established decreases the pressure on timber resources, contributes to recover soil fertility and to retain moisture. • Mixed nurseries are an opportunity for green business in combination with restoration, sustainable forest management and agroforestry systems: E.g. 13,500 timber trees, 6,750 fruit trees, and other purposes species (such as ornamental plants), after a period of three years, could generate an approximate income of US$ 31,000.
	 Source: Gavin Kingcome Photography	

<table>
<tr><th>EbA / water and resource efficient technologies</th><th>Description</th><th>Benefits and co-benefits</th></tr>
<tr><td rowspan="2">7. Soil conservation through superficial drainage</td><td>

- The construction of drains (contour trenches) for soil conservation that is proposed is an action that must be characterized by the simplicity of its construction.
- It is suggested that they be manually constructed channels where family labour is used, and ancestral knowledge, if possible.
- Like the previous measure, the selection of sites where to build them may require initial technical assistance. In addition, its success in the medium and long term will depend on the maintenance that is applied.

</td><td>

- Contour trenches significantly decrease the risk of crop loss due to flooding. A trench 300 m long can protect the production of one ha of land If cultivated with maize, the production would have a value of at least US$ 1800 a year. They also promote infiltration and groundwater recharge.
- One linear metre of a 0.6 m x 0.6 m trench can catch 360 l of water per rain event.
- Consequently, a 100 m trench could infiltrate up to 36000 l of water.
- The organic sediment that is deposited in the trenches may serve for soil conditioning and lower fertilizer expenses.
- The ridges are formed with perennial endemic vegetation that is used to produce firewood and that attracts insects and native fauna, contributing to pest control and natural pollination.

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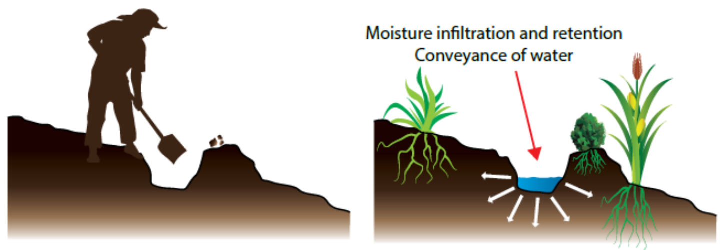


Source: Adapted from http://plantwater.freeservers.com.

Source: UNEP-ROLAC and Frankfurt School 2014

</td></tr>
<tr><td>8. Agricultural terraces[6]</td><td>

- Agricultural terraces are an ancient Andean technique that consists of making cuts in steep slopes to form contour ridges and establish cultivation surfaces that are supported by stone walls. Terraces are positioned perpendicular to the flow of water to reduce erosion, retain soil and moisture and thus generate a microclimate conducive to crop growth.
- Its main purpose is to increase the amount of cropland, while reducing the slope of the hillsides and thus preventing landslides that might affect structures, dwellings and crop areas that are downstream.
- They may be built at any altitude range with slopes between 10% and 35%, and require a large investment of labour.
- They are particularly useful on hill or mountain sides with eroded soils for the purpose of increasing the agricultural area and preventing landslides.

</td><td>

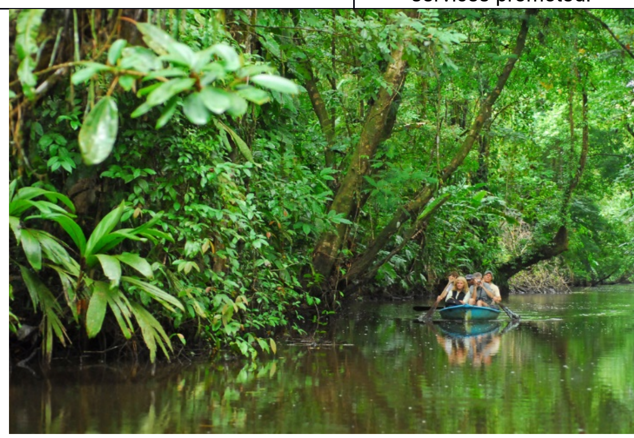
- Agricultural terraces raise productivity considerably.
- After terraces were restored in a project in Peru the first yields increased by between 43% and 65% for potatoes, maize and barley compared with conventional hillside cultivation (Altieri, 1999).
- Annual soil loss for potato crops declined from 20 t/ha on hillside crops to 1 t/ha on terraces with contour channels (Chow and others, 1999).
- Terraces have a highly beneficial economic effect. With the increased yields, the investment is recouped in the first year after construction, and net revenue generated over the following ten years is twice as high as that from conventional hillside cultivation (Rist and San Martín, 1993).

</td></tr>
</table>

[6] UNEP-ROLAC and Frankfurt School (2014) Microfinance for Ecosystem-based Adaptation: Options, costs and benefits.

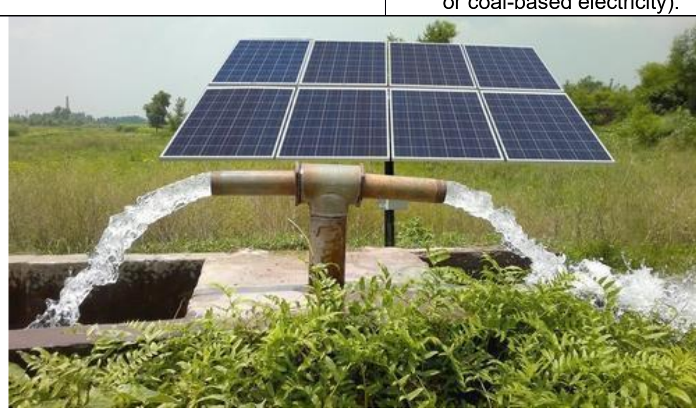
EbA / water and resource efficient technologies	Description	Benefits and co-benefits
	 Source: Mario R. Martínez Menes, Erasmo Rubio Granados y Carlos Palacios Espinosa 2018	
9. Soil conditioning[7]	• Soil conditioning involves applying a series of techniques to restore organic matter, nutrients, biological activity and other essential elements for agricultural production to their optimal state. • It is achieved through organic fertilization, physical and biological means as well as better practices such as crop rotation or diversification. • It is recommended for farms where the natural characteristics of the soil, like proper drainage, fertility and nutrient balance, have been lost due to inadequate farming practices, excessive fertilizer and herbicide use or erosion resulting from climate factors. • Soil chromatography can be used to determine nutrient content and to evaluate the results of restoration projects.	• Conditioning restores the soil's equilibrium and thus raises yields and lowers production costs. • When comparing maize cultivation with and without adequate soil management, production differences of up to 5000 kg/ha can be found (García, 2000). • In southern Brazil, a comparison of infiltration rates in soils with conventional agriculture and in those with no-till agriculture found 20 and 45 mm/h, respectively (FAO, 2005). • Natural soil regeneration processes, typical of an ecological succession, may be observed when farmers maintain a mosaic of plots under cultivation and leave others fallow (Altieri and Nicholls, 2004).
	  Source: Gardening Know How, Nikki Tilley / The Windshield Masters Agra	

[7] UNEP-ROLAC and Frankfurt School (2014) Microfinance for Ecosystem-based Adaptation: Options, costs and benefits.

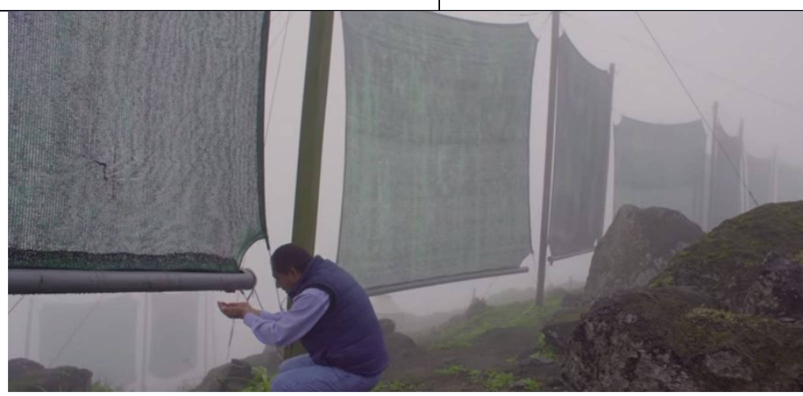
EbA / water and resource efficient technologies	**Description**	**Benefits and co-benefits**
10. Ecotourism	• Economic development tool based on conserving and sustainably using existing ecosystem services and making them available to visitors. • In the context of this proposal, low-scale local tourism in natural ecosystems or in agricultural areas (agrotourism) that allows visitors to appreciate nature, and the values and cultural traditions associated with it, and purchase sustainable products, could be promoted.	• Ecotourism projects promote the conservation of natural areas and agroforestry systems while safeguarding their biological and cultural diversity. • Local population is benefited with around 30% of jobs generated by ecotourism projects. • This type of tourism is based on local resources, is low impact and offers socio-economic benefits to the populations responsible for conserving the goods or services promoted.
	 Source: Linking Tourism & Conservation, Gabriella Bancheri	
Water and resource-efficient technologies		
11. Efficient biomass stoves (Lambe & Ochieng 2015, Soluciones Prácticas 2015)	• The different models of efficient biomass stoves are made with local supplies. They use less biomass (firewood) than traditional stoves to obtain energy and eliminate smoke from the kitchens. • While there is a long history of improved cookstove programs in Central America, many of these initiatives have not been adopted in a sustained way, due to the poor performance of cookstoves in the field, the absence of quality standards, and the lack of attention to the needs of the end users. Hence, evaluation of previous programs will be important for the design of the measure.	• Maintenance of soil fertility (The charcoal obtained serves to restore the soil, which increases its productivity) • Reduced greenhouse gas emissions (The efficient combustion of the gasifier reduces the emissions of CO_2 in 3 tons per family unit per year) • For people who cook indoors with wood in an unventilated or partially ventilated space, the introduction of efficient biomass stoves is a significant health benefit.
	 Source: IADB, Becky Williams, Flickr, CC BY-NC 2.0	

EbA / water and resource efficient technologies	Description	Benefits and co-benefits
12. Firewood drying and charcoal production (CATIE 2015)	• This measure consists of using solar and half orange ovens to obtain dry firewood and charcoal, respectively, with better quality standards. The half orange ovens, built with bricks, guarantee a process of carbonization more efficient and economic than the artisanal production, based on pits dug in the ground. • The experience in Nicaragua shows that dry firewood and quality charcoal could be part of profitable value chains.	• Half-orange ovens increase the production yield by 10% and produce higher quality charcoal. • The reduction of smoke and risk of burns improve the working conditions of the producers. • Dry firewood produces less smoke and has fewer biological attacks and consequently can be sold at a higher price. It also reduces transport costs. • The collection of wood for drying and the production of coal allows controlling its legal origin, if it comes from forests with authorized management plans.
	 Source: Finnfor, CATIE	
13. Rainwater collection - small reservoirs[8]	• This practice consists of collecting rainfall from ground surfaces using micro-catchments to divert or slow runoff so that it can be stored before it can evaporate. • The second option consists of collecting flows from a river, storm or other natural watercourse which can be stored and used to improve soil moisture.	• Reservoirs support the restoration of natural ecosystems and agriculture due to increased relative humidity and access to water. • Carbon capture through increased tree cover and soil conservation. • A 500 m^3 reservoir can meet the water needs for 80 animals or up to 2500 m^2 of vegetable crops during a period of low water levels. Placement in the marketplace of the 60,000 vegetable plants produced (if sold on the market for US$ 0.60 each) would be equivalent to an annual income of US$ 3,000 to 5,000 (SAGARPA, 2009).

[8] UNEP-ROLAC and Frankfurt School (2014) Microfinance for Ecosystem-based Adaptation: Options, costs and benefits.

EbA / water and resource efficient technologies	Description	Benefits and co-benefits
	 Source: UNAFOR	
14. Rainwater harvest systems from rooftops (GWP Centroamerica 2017b)	• This basic technology involves the collection of rainwater from rooftop catchments and diversion to a storage reservoir (tank) for later use.	• The availability of water within the household implies an average saving of 30% of women's time (INCAP, 2016), which can represent between four and five hours a day depending on the place (PAHO 2010).
	 Source: Rain Water Systems, abraingutters.blogspot.com	
15. Solar photovoltaic water pumping systems (Chandel et al. 2015, Foster & Cota 2014)	• This technology convert sunlight into electricity to pump water for community water supply and irrigation. • They are relatively simple, reliable, cost competitive, and low maintenance. • There is a good match between seasonal solar resource and seasonal water needs (dry season).	• Reduction of expenses: There have been dramatic price reductions in PV modules over the past decade, by over 80%, while prices for competing gasoline or diesel fuel have risen by over 250%. • Reduced greenhouse gas emissions (minimizes the dependence on diesel, gas or coal-based electricity).
	 Source: Euro Solar System	

EbA / water and resource efficient technologies	Description	Benefits and co-benefits
16. Drip irrigation (Netherlands Water Partnership 2005)	• This technology involves dripping water onto the soil at very low rates. • Drip irrigation reduces water consumption and loss of soil and nutrients. • Simplified systems that use local supplies can have very low investment costs.	Benefits include: • Erosion prevention and maintenance of soil fertility • Increased resilience to drought due to efficient use of scarce water resources (decrease in water consumption by up to 70%). • Increased quality and quantity of products due to efficient use of fertilizers and controlled supply of nutrients with irrigation water. • Increase in income of up to 35% due to improvements in productivity.
	 Source: El País 2019	
17. Ceramic filters to purify water (CF+S 2006)	• This is a technology to eliminate microbiological components of water. • An experience developed in Nicaragua shows the importance of quality controls and training for local manufacturers.	• Given the reduction in availability of drinking water in the proposal area, and its degree of contamination, it is considered a complementary measure of adaptation. • Increase in local labour sources and incomes • Reduction of diarrheal diseases
	 Source: Motojeros 2011	

EbA / water and resource efficient technologies	Description	Benefits and co-benefits
18. Fog catchers[9]	• Fog catchers are a system that uses plastic meshing held in place by frames to intercept fog banks formed by clouds in mountain zones and valleys. The water droplets contained in the fog bump up against the threads in the meshing, accumulate and fall, by the force of gravity, into a gutter that conveys the water to a deposit. • These systems are used on farms or settlements lacking alternative sources of water and where the climate favours fog formation. Therefore, it is a low-cost, alternative source of water for rural populations in mountain zones and highlands.	• A comparative study on the efficiency of fog catchers in nine regions of Chile reports monthly volumes between 51 and 184 liters per square metre of Raschel mesh. The study estimated that water supplied with fog catchers costs 34% less than water from tank trucks (FAO, 2000). • Fog does not affect or use traditional supplies such as wells, rivers or lakes, thus promoting the ecological equilibrium of surface and groundwater bodies. • Stored water can be used for reforestation programmes and fire control or for small orchards, with subsequent benefits to the ecosystem or the household economy.
	 Source: Movimiento Peruanos Sin Agua	
19. Infiltration pits for water retention[10]	• Infiltration pits are generally 0.5 m wide, 0.5 m deep and 2 m long. They are dug 4 to 6 m apart along the contour lines on inclined landscapes with the purpose of retaining water in the soil for a prolonged period and increase infiltration and groundwater recharge. • They also help maintain soil moisture, contribute to the accumulation of rainwater for irrigation and enhance the growth of native or reforested vegetation. In fields with steep slopes, they slow the runoff, preventing erosion and potential landslides. • Infiltration pits are used in arid or semi-arid regions where precipitation is irregular, particularly on hill or mountain sides with no vegetation in order to reforest or establish orchards.	• Infiltration pits promote ecosystem restoration by controlling erosion on hill and mountain sides and retaining water. • A project with 650 pits/ha in a 250 ha field obtained an average water harvest of approximately 8 m^3 per pit (5200 m^3/ha) per year, with annual precipitation of 800 mm (Cota and others). • Constructing pits for a perennial tree field improves the production of fruit and timber products owing to increased soil moisture. The same function may help promote the succession of native species.

[9] UNEP-ROLAC and Frankfurt School (2014) Microfinance for Ecosystem-based Adaptation: Options, costs and benefits.
[10] UNEP-ROLAC and Frankfurt School (2014) Microfinance for Ecosystem-based Adaptation: Options, costs and benefits.

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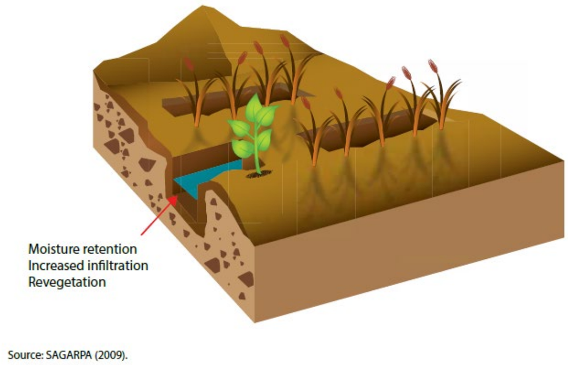
<tr><th>EbA / water and resource efficient technologies</th><th>Description</th><th>Benefits and co-benefits</th></tr>
<tr><td></td><td colspan="2">

Source: UNEP-ROLAC and Frankfurt School 2014</td></tr>
<tr><td rowspan="2">20. Biodigester[11]</td><td>• A biodigester system utilizes organic waste, particularly animal and human excreta, to produce fertilizer and biogas. It consists of an airtight, high-density polyethylene container within which excreta diluted in water flow continuously and are fermented, anaerobically, by microorganisms present in the waste.
• The processed manure is an organic, pathogen-free fertilizer that is rich in nitrogen, phosphorus and potassium.
• Biodigester systems may be implemented in any rural or urban area with sufficient space and a sufficiently large number of animals to generate at least 100 kg of manure a day. They are particularly useful on family farms that have livestock as a source of organic matter, cultivation areas on farms where fertilizer can be used and living quarters that can use biogas.</td><td>• Under optimal conditions, some 3 to 4 l of fertilizer are produced per kg of excreta, and its systematic use restores poor and infertile soils and increases yields.
• A controlled experiment in Brazil found that a 60 m^3/ha dose of effluent applied to lettuce crops surpassed the results of mineral fertilization in terms of height, number of leaves, diameter and fresh mass of the lettuce (Chiconato, 2013).
• For a 10 m^3 system, assuming that chemical fertilizers are completely replaced with the effluent and that biogas is used for cooking, the potential savings is US$ 350 per month.
• The utilization of biogas diversifies or replaces energy sources for household consumption (1 m^3 of biogas replaces 0.5 kg of LP gas).
• The biogas produced by a 5 m^3 system is sufficient to cook for three to four hours a day. This has positive effects for the health of the users and the ecosystem by replacing the burning of dung or firewood (Ferrer and others, 2009).</td></tr>
<tr><td colspan="2">
Source: La Prensa Libre 2016</td></tr>
</table>

[11] UNEP-ROLAC and Frankfurt School (2014) Microfinance for Ecosystem-based Adaptation: Options, costs and benefits.